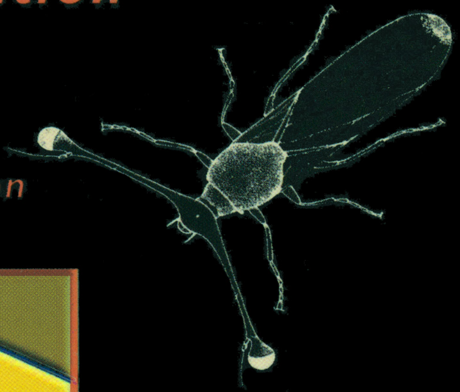



Rice-Feeding Insects and Selected Natural Enemies in West Africa

Biology, Ecology, Identification



E.A. Heinrichs and Alberto T. Barrion



Illustrated by Cris dela Cruz and
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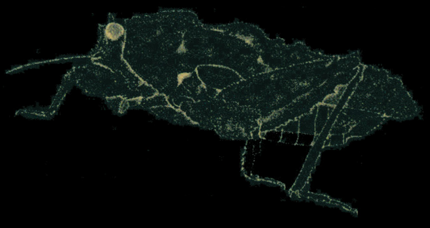

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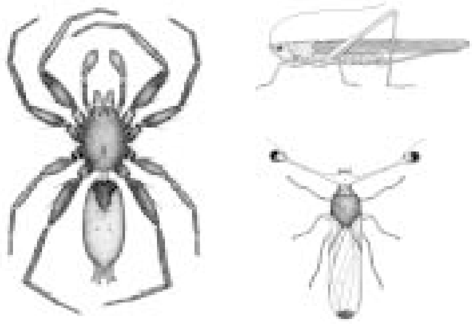

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IRRI, the world's leading international rice research and training center, was established in 1960. Located in Los Baños, Laguna, Philippines, with offices in 11 other Asian countries, IRRI focuses on improving the well-being of present and future generations of rice farmers and consumers in developing countries, particularly those with low incomes. It is dedicated to helping farmers produce more food on limited land using less water, less labor, and fewer chemical inputs, without harming the environment.

WARDA, established in 1971, with headquarters in Côte d'Ivoire and three regional research stations, is an autonomous intergovernment research association of African member states. Its mission is to contribute to food security and poverty alleviation in sub-Saharan Africa (SSA), through research, partnerships, capacity strengthening, and policy support on rice-based systems, and in ways that promote sustainable agricultural developement based on environmentally sound management of natural resources. WARDA hosts the African Rice Initiative (ARI), the Regional Rice Research and Development Network for West and Central Africa (ROCARIZ), and the Inland Valley Consortium (IVC).

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Foreword

Rice, the daily food of nearly half the world's population, is the foundation of national stability and economic growth in many developing countries. It is the source of one quarter of global food energy and—for the world's poor—the largest food source. It is also the single largest use of land for producing food and the biggest employer and income generator for rural people in the developing world. Rice production has been described as the single most important economic activity on Earth. Because rice occupies approximately 9% of the planet's arable land, it is also a key area of concern—and of opportunity—in environmental protection.

Rice cultivation is the dominant land use in Asia, but it is now playing an increasingly important role in Africa as well. In West and Central Africa—the most impoverished regions on earth according to the Food and Agriculture Organization (FAO)—rice is grown under subsistence conditions by about 20 million smallholder farmers who are shackled to slash-and-burn farming and who lack rice varieties that are appropriate to local conditions. FAO statistics show the demand for rice in these regions is growing by 6% a year (the fastest-growing rice demand in the world), largely because of increasing urbanization. As a result, current rice imports into these regions amount to more than US$1 billion a year.

African rice farmers face many abiotic and biotic constraints in their quest to increase rice production. In conjunction with the introduction of the New Rice for Africa (NERICA), increasing yields will require a reduction in losses to insects and other stresses. As cropping intensity and cultural practices are changed to meet production needs, particularly in West Africa, it will be important to avoid the problem of increased pest pressure. To develop effective pest management strategies, it is essential to properly identify and to understand the biology and ecology of insect pests and the arthropods that help regulate their populations.

This book provides the first comprehensive taxonomic keys of the West African rice-feeding insect species and their natural enemies. It describes their presence and abundance in the different climatic zones (humid tropical zone, the Guinea savanna, and the Sudanian savanna) and rice ecosystems (upland, rainfed lowland [inland swamps], irrigated lowland, deepwater/floating, and mangrove swamps) in West Africa. For each species, the authors provide available information on geographical distribution, description and biology, habitat preference, and plant damage and ecology.

This book effectively utilizes the unique knowledge and expertise of two sister institutes—WARDA—the Africa Rice Center and the International Rice Research Institute (IRRI). The biology and ecology section is based on studies conducted at WARDA and articles (much of it gray literature) published by West African national programs and foreign scientists, mostly French. The taxonomic keys were constructed by A.T. Barrion, formerly of IRRI, who used the insects and spiders collected in West Africa by E.A. Heinrichs, formerly of WARDA. This book should prove to be an important tool for developing effective pest management strategies that will aid in improving rice production in West Africa.

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Director General, IRRI

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We acknowledge the significant input of a number of scientists who provided taxonomic identifications and made critical reviews of the manuscript. Dr. J.A. Litsinger, Dixon, CA, USA; Dr. B.M. Shepard, Department of Entomology, Clemson University; and Dr. C.M. Smith, Department of Entomology, Kansas State University, Manhattan, KS, USA reviewed the entire manuscript. Dr. Andrew Polaszek, Department of Entomology, The British Museum of Natural History, London, UK, reviewed the section on Natural Enemies of West African Rice-Feeding Insects.

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ALBERTO T. BARRION

Introduction

Côte d'Ivoire, West Africa

Rice in Africa

Rice, an annual grass, belongs to the genus *Oryza*, which includes 21 wild species and 2 cultivated species, *O. sativa* L. and *O. glaberrima* Steud. (Table 1). Chang (1976a,b) has postulated that when the Gondwanaland supercontinent separated, *Oryza* species moved along with the separate land sections that became Africa, Australia, Madagascar, South America, and Southeast Asia. Of the wild *Oryza* species, *O. barthii* A. Chev., *O. brachyantha* A. Chev. et Roehr, *O. eichingeri* Peter, *O. glaberrima*, *O. longistaminata* Chev. et Roehr, and *O. punctata* Kotschy ex Steud. are distributed in Africa. *O. glaberrima*, until recent times, the most commonly grown cultivated species in West Africa, is directly descended from *O. barthii*. *O. sativa*—the most prominently cultivated species in West Africa today—was probably introduced from Southeast Asia. A Portuguese expedition in 1500 introduced *O. sativa* into Senegal, Guinea-Bissau, and Sierra Leone (Carpenter 1978). In many areas of West Africa, rice growing began after about 1850 with expansion occurring to the present time (Buddenhagen 1978). Many *O. sativa* cultivars were introduced into West Africa during the World War II when rice was grown to feed the military (Nyanteng 1987).

Although rice is an ancient crop in Africa, having been grown for more than 3,500 years, it has not been effectively managed to feed the number of people that it could (IITA 1991). Rice has long been regarded as a

Table 1. Species of *Oryza*, chromosome number, and original geographical distribution (Chang 1976a,b; Vaughan 1994).

Species	Chromosome number (2n=)	Distribution
Cultivated		
O. glaberrima Steud.	24	West Africa
O. sativa L.	24	Asia
Wild		
O. alta Swallen	48	Central and South America
O. australiensis Domin	24	Australia
O. barthii A. Chev.	24	West Africa
O. brachyantha Chev. et Roehr.	24	West and Central Africa
O. eichingeri Peter	24, 48	East and Central Africa
O. grandiglumis (Doell) Prod.	48	South America
O. granulata Nees et Arn. ex Watt	24	South and Southeast Asia
O. glumaepatula Steud.	24	South America and West Indies
O. latifolia Desv.	48	Central and South America
O. longiglumis Jansen	48	New Guinea
O. longistaminata Chev. et Roehr.	24	Africa
O. meridionalis Ng	24	Australia
O. meyeriana (Zoll. et Mor. ex Steud.) Baill.	24	Southeast Asia and China
O. minuta Presl. et Presl.	48	Southeast Asia and New Guinea
O. nivara Sharma et Shastry	24	South and Southeast Asia, China
O. officinalis Wall ex Watt	24	South and Southeast Asia, China, New Guinea
O. punctata Kotschy ex Steud.	24, 48	Africa
O. ridleyi Hook. f.	48	Southeast Asia
O. rufipogon W. Griff.	24	South and Southeast Asia, China
O. perennis	24	South and Southeast Asia, China, Africa
O. schlechteri Pilger	24	New Guinea

rich man's cereal in West Africa because cultivation technology is not efficient and production costs are high. Even so, diets have changed and rice has become an important crop in West Africa. Increasing demand and consumption in West Africa have been attributed to population and income growth, urbanization, and the substitution of rice for other cereals and root crops. Its rapid development is considered crucial to increased food production and food security in the region. Nyanteng (1987) and WARDA (2000) have reported on the trends in consumption, imports, and production of rice in the 17 nations of West Africa (Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo). Rice consumption is increasing faster than that of any other food crop in the region. In all West African countries except Ghana, rice is now among the major foods of urban areas. In rural areas, rice is a major food crop in nine countries of the region.

The quantity of rice consumed in West Africa has increased faster than in other regions of the continent. West Africa's share of the total African rice consumption increased from 37% in 1970 to 59% in 1980 to 61% in 1995 (Fig. 1; WARDA 2000). Rice consumed in West Africa increased from 1.2 million t in 1964 to 3.5 million t in 1984 to 5.6 million t in 1997 (Fig. 2; WARDA 2000).

Average per capita rice consumption in West Africa peaked at 27 kg yr^{-1} in 1992 and settled down to 25 kg yr^{-1} by 1997, still more than double that of 1964 (Fig. 3; WARDA 2000). Per capita consumption in 1997 was 6.4, 18.2, and 8.1 kg yr^{-1} in Central, East, and Southern Africa, respectively (WARDA 2000). Annual per capita rice consumption in 1996 varied widely among West African countries from 9.64 kg in Chad to 114.36 kg in Guinea-Bissau (Fig. 4; FAO 1999).

The increase in rice consumption in West Africa has been partially met by increased domestic production. In 1995, 41% of African rice was produced in West Africa (Fig. 5; FAO 1999). Average annual production increased in this region from 1.8 million t in 1964 to

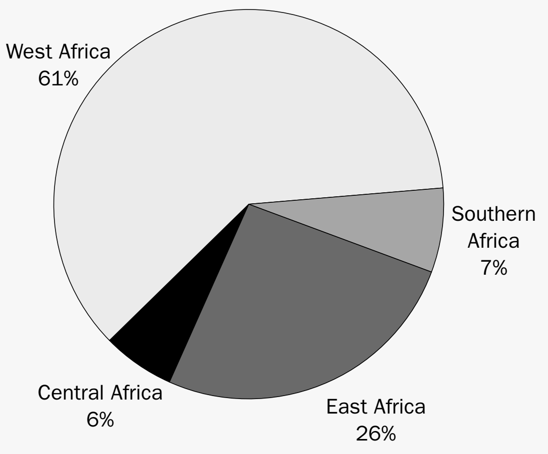

Fig. 1. Rice consumption in Africa, by region, in 1995 (WARDA 2000).

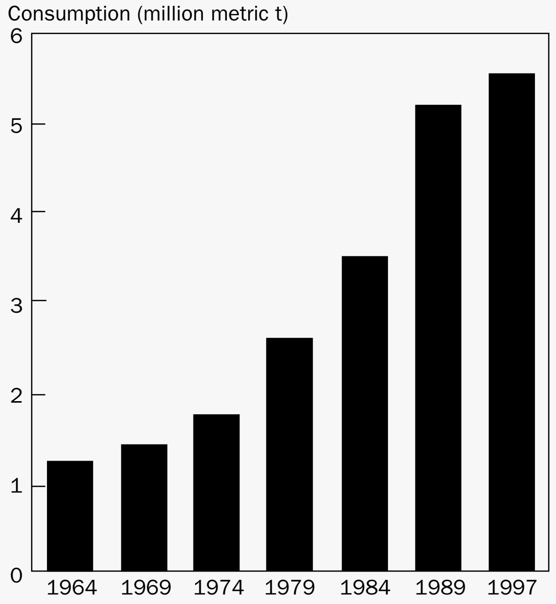

Fig. 2. Rice consumption, in million metric t per year, in West Africa, from 1964 to 1997 (WARDA 2000).

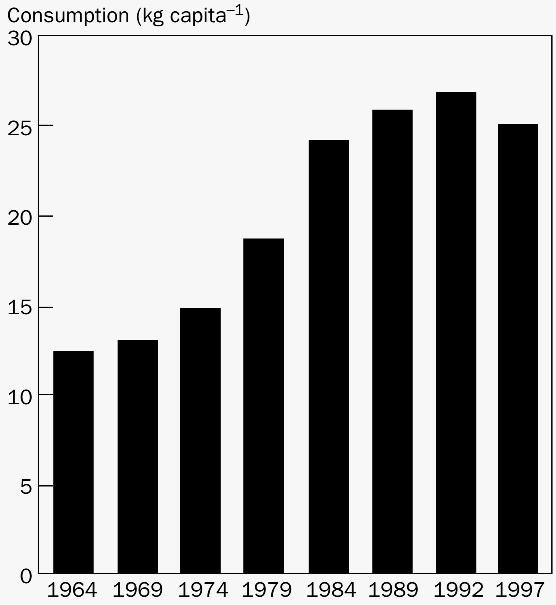

Fig. 3. Annual per capita rice consumption, in kilograms, in West Africa, from 1964 to 1997 (WARDA 2000).

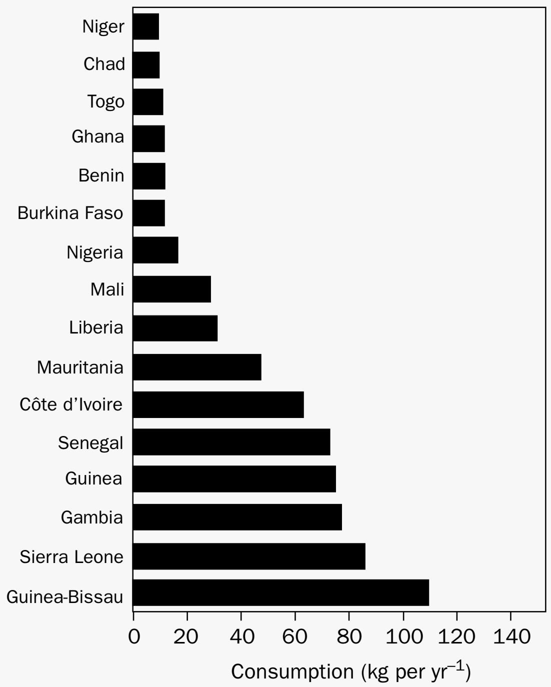

Fig. 4. Annual per capita rice consumption, in kilograms, for West African countries in 1996 (FAO 1999).

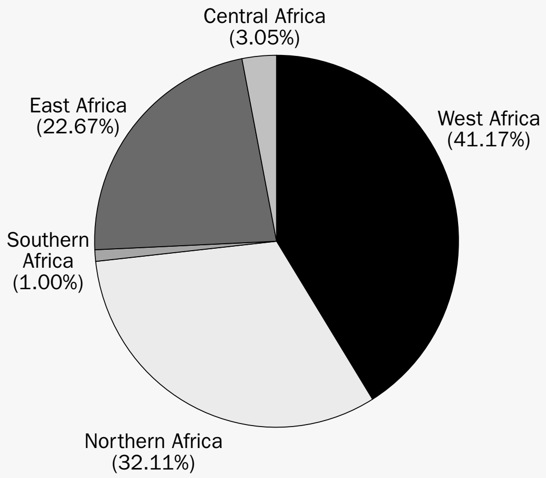

Fig. 5. Rice production in Africa, by region, in 1995 (FAO 1999).

2.7 in 1974 and 3.7 in 1984. By 1998, production rose to 7.6 million t in West Africa, increasing at a growth rate of 5.6% during the 1983–95 period. Production in 1998 ranged from 16,693 t in Gambia to 3.26 million t in Nigeria (Fig. 6; FAO 1999).

Much of the increase in rice production is related to an increase in area cropped to rice and some to an increase in grain yield. In 1998, the area of rice harvested in sub-Saharan Africa was 7.26 million ha with 64% (4.69 million ha) of the area in West Africa and 8, 25, and 3% in Central, Eastern, and Southern Africa, respectively. The rice area cultivated increased from 1.7 million ha in 1964 to 2.7 million ha in 1984, and 3.3 million ha in 1990. West African rice area in 1998 ranged from 14,232 ha in Benin to 2.05 million ha in Nigeria.

Rice in West Africa is grown in five general environments categorized by water management (Terry et al 1994). Forty percent of the rice is grown under upland conditions, whereas rainfed lowland, irrigated,

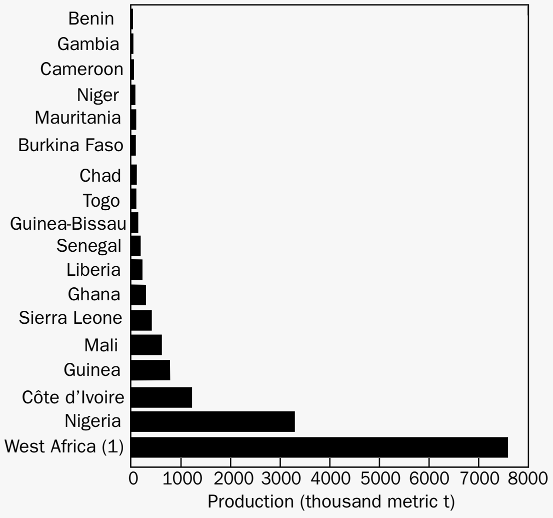

Fig. 6. Annual rice production in West African countries in 1998 (FAO 1999).

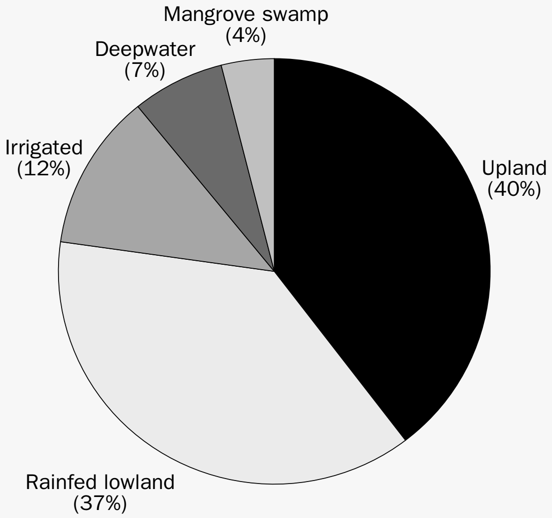

Fig. 7. Distribution of West African rice, by environment (Matlon et al 1998).

deepwater rice, and mangrove swamp account for 37, 12, 7, and 4% of the rice land area, respectively (Fig. 7; Matlon et al 1998).

Rice yields in the uplands are low, resulting in low overall yields for all African environments: 1.62, 0.77, 1.90, and 1.05 t ha^{-1} in West, Central, East, and Southern Africa in 1997, respectively. Average West African rice yields vary greatly, ranging in 1996 from 1.06 t ha^{-1} in Togo to 3.94 t ha $^{-1}$ in Mauritania (Fig. 8; WARDA 2000).

To meet demand, many West African countries import rice. The average quantity of rice imported annually increased from 0.4 million t in 1964 to almost 1.8 million t in 1984, growing to 2.5 million t in 1995 (Fig. 9; WARDA 2000). Senegal, Côte d'Ivoire, and Nigeria ranked among the top rice importers in the world with more than 300,000 t annually during the 1980s. In 1990, these countries imported 336,000; 284,000; and 216,700 t of rice, respectively. In 1995, these countries imported 420,000; 404,247; and 300,000 t of rice, respectively (WARDA 2000).

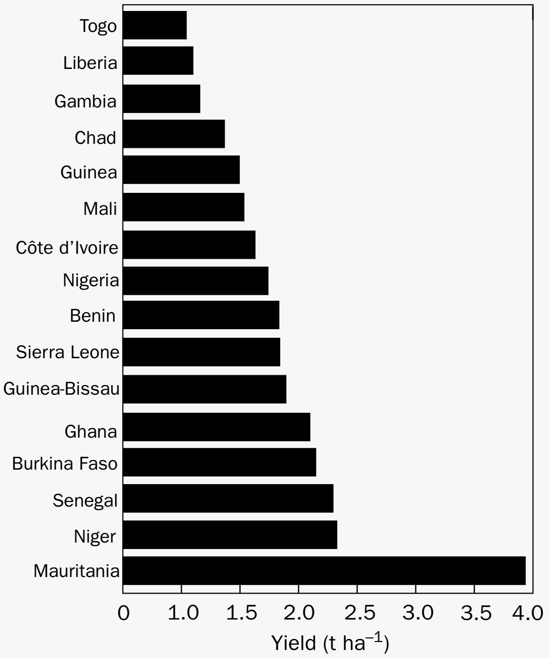

Fig. 8. Rice yields (t ha^{-1}) of West African countries in 1996 (WARDA 2000).

Total consumption of rice in West Africa increased at the rate of 4.75% annually from 1983 to 1995 (WARDA 2000). Considering the levels of production and consumption, an acute demand for rice in West Africa continues. Thus, it is evident that demand for rice is to be met through domestic intensification of rice cultivation by increasing yield and the area planted to rice. Increasing yield will require a reduction in losses to insects and other stresses. As cropping intensity and cultural practices are changed to meet production needs, it will be important to avoid the problem of increased pest pressure that can occur as a consequence of replacing traditional practices. In Asia, insect pest problems increased, often dramatically, with the introduction of new plant types. At first, the modern varieties were considered more susceptible to pests, but later research showed that changes in cropping systems and cultural practices were more important. The traditional cultural practices seem to provide a certain degree of stability in which the natural enemies of rice pests appear to play a major role (Akinsola 1982). It is important that changes to modern rice culture provide for maintenance of the current stability through an integrated approach to pest management.

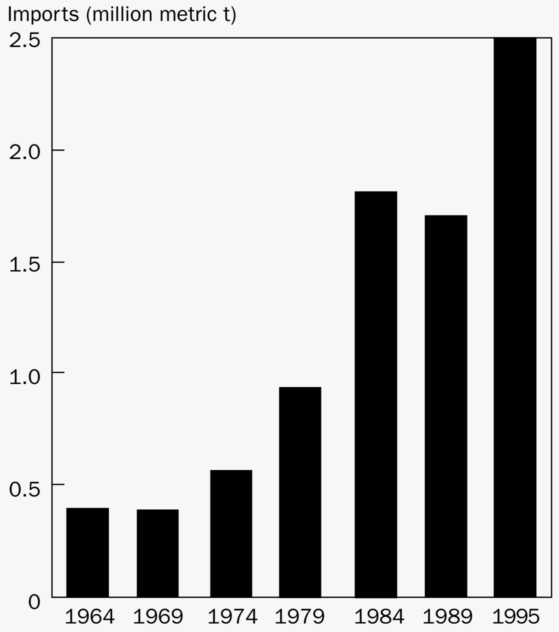

Fig. 9. Annual West African rice imports from 1964 to 1995 (WARDA 2000).

Rice-feeding insects

The rice plant is an ideal host for a large number of insect species in West Africa. All parts of the plant, from the root to the developing grains, are attacked by various species. In the world, there are about 800 insect species that can damage rice in the field or in storage, but the majority of the species that feed on rice are of minor importance (Barrion and Litsinger 1994). In West Africa, about 10 species are of major importance but the economic damage caused by these species varies greatly from country to country, from field to field, and from year to year. These species include the stem borers, *Chilo zacconius* Bleszynski (Fig. 92), *Diopsis longicornis* Macquart (Fig. 98), *Maliarpha separatella* Ragonot (Fig. 88), and *Sesamia calamistis* Hampson (Figs. 84–85); caseworm, *Nymphula depunctalis* (Guenée) (Fig. 86); African rice gall midge, *Orseolia oryzivora* Harris and Gagne (Figs. 95–97); hispid beetle, *Trichispa sericea* Guerin-Meneville (Figs. 281–282); termite species, *Amitermes evuncifer* Silvestri, *Microtermes* sp., and *Odontotermes* sp.; leaffolder, *Marasmia trapezalis* (Walker) (Fig. 89); and the grain-sucking bugs, *Aspavia armigera* (Fabricius) (Fig. 396). In addition, species distribution and abundance vary among rice ecosystems within a given location. For example, some species are primarily upland rice feeders while others are more numerous and damaging under lowland conditions. Some species may be abundant in all rice-growing environments. Rice-feeding insects are dynamic and their relative importance changes with time due to changes in rice production practices, climate, yield, and varieties—and, in many cases, due to undetermined factors. The infestation of the rice crop by different species is related to the growth stage of the plants. Insects feed on all parts of the rice plant throughout the rice-growing regions of the world. Rice insect communities occurring in West Africa are very similar to those in Asia. In fact, most of the genera that feed on rice in Asia also occur on rice in West Africa. However, the species, in most cases, are different.

Climatic zones and rice ecosystems as habitats

The presence and abundance of rice-feeding insect species vary distinctly among the different climatic zones and rice ecosystems in West Africa. The climatic zones consist of the humid tropical zone, the Guinea savanna, and the Sudanian savanna (Sahel). These areas, respectively, correspond to the southern coastal areas with slight changes in temperature and long, heavy monomodal rains (more than 2,400 mm annually); the mid-region of bimodal rains (1,000–1,200 mm per year) separated by a short dry spell and a long dry season; and the northern zone with a strong daily and seasonal temperature fluctuation and very short monomodal rains (less than 800 mm per year) (Fig. 10; Akinsola and Agyen-Sampong 1984).

Generally, insect pests are most severe in the humid tropical and Guinea savanna zones (Table 2). Whiteflies and locusts are not a problem in the humid zone while several species occurring in the humid tropical and Guinea savanna have not been reported in the Sudanian savanna. In Nigeria (Table 3; Alam 1992), rice bugs are more abundant in the humid tropical and savanna zones than in the Sudanian savanna. Termites are more common in the two savanna zones than in the humid tropical zone. Stem borers are generally common in all climatic zones.

The various rice ecosystems in West Africa consist of the upland, rainfed lowland (inland swamps), irrigated lowland, deepwater/floating, and mangrove swamps (Fig. 7). Andriesse and Fresco (1991) describe a classification system for rainfed rice.

Agyen-Sampong (1982) reports on the relative occurrence of rice insect species in the different rice ecosystems (Table 4). Stem borers are common in all ecosystems, but the abundance of a given species generally varies from upland to irrigated fields. *Scirpophaga* spp. (Fig. 87) and *Maliarpha separatella* Ragonot (Fig. 88) are most abundant in lowland fields while *Sesamia* spp. (Figs. 84–85), *Chilo zacconius* Bleszynski (Fig. 92), and *C. diffusilineus* (J. de Joannis) (Figs. 93–94) are most abundant under upland conditions. The caseworm and whorl maggots occur

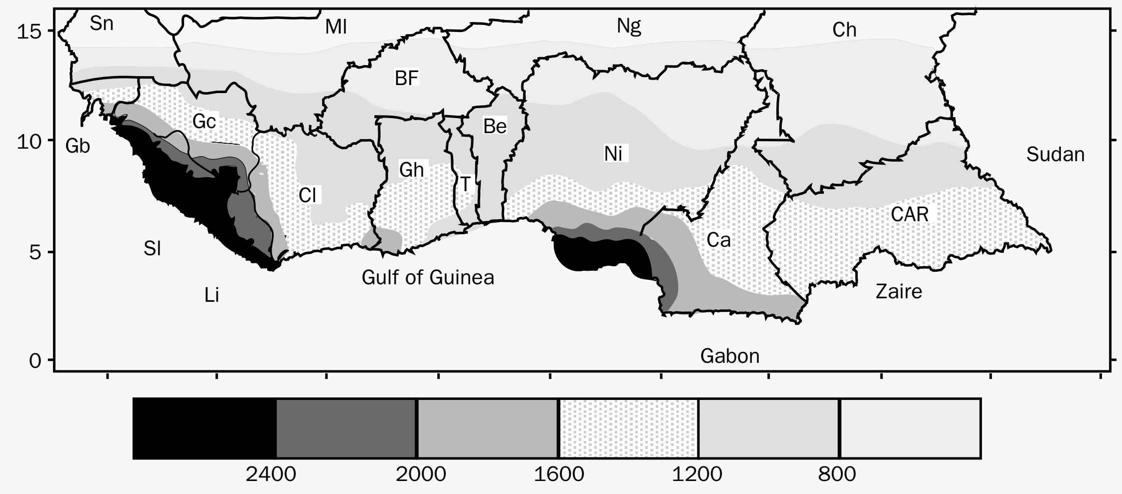

Fig. 10. Annual rainfall (mm) in West Africa. Be = Benin, BF = Burkina Faso, Ca = Cameroon, Ch = Chad, CI = Côte d'Ivoire, Gh = Ghana, Gc = Guinea, Gb = Guinea-Bissau, Li = Liberia, Ml= Mali, Ng = Niger, Ni = Nigeria, CAR = Central African Republic, Sn = Senegal, SL = Sierra Leone, T = Togo (modified from Akinsola and Agyen-Sampong 1984).

Table 2. Prevalence of major insect pests of rice in the climatic zones of West Africa (Agyen-Sampong 1982, Alam et al 1984).

Species	Common name	Climatic zone		
		Humid tropical	Guinea savanna	Sudan savanna
Maliarpha separatella	White stem borer	++	++	+
Chilo zacconius	Striped stem borer	+	++	++
Chilo diffusilineus	Stem borer	++	++	+
Sesamia calamistis	Pink stem borer	+	+	–
Sesamia nonagrioides botanephaga	Pink stem borer	++	+	–
Diopsis longicornis	Stalk-eyed fly	++	++	++
Nymphula depunctalis	Caseworm	++	++	+
Orseolia oryzivora	Gall midge	+	++	++
Spodoptera sp.	Armyworm	+	+	+
Hydrellia sp.	Whorl maggot	++	+	–
Trichispa sp.	Hispa	+	+	–
Dicladispa sp.	Hispa	+	+	–
Marasmia trapezalis	Leaffolder	+	+	–
Aleurocybotus sp.	Whitefly	–	++	++
Aspavia sp.	Stink bug	++	++	+
Stenocoris claviformis	Alydid bug	++	++	+
—	Locust	–	+	+
—	Termite	++	++	++

++ = abundant, + = present, – = not reported.

only in flooded fields, while aphids and *Macrotermes* spp. termites only occur in upland fields.

Fomba et al (1992) and Agyen-Sampong and Fannah (1989) reported that *M. separatella* was the most predominant insect species in the mangrove swamp environment in Sierra Leone. Taylor et al (1990) reported grain yield losses of 82% due to rice yellow mottle virus in the mangrove swamps, but they did not determine the role of insects in transmission.

Deepwater rice is common in Mali, Niger, and Nigeria and Chaudhury and Will (1977) reported stem borers were the major insect pest noted among the numerous constraints to production. Akinsola (1980a) found that, in Mali, *M. separatella* larvae fed at 3 m below the water surface and that they infested an average of 60% of the stems.

In the irrigated Sahel region of Senegal, mites, whiteflies, and stem borers are the most important arthropod pests. Among the stem borers, *M. separatella* is most common (WARDA 1981).

Constraints to rice production

There are numerous and severe abiotic and biotic constraints to rice production in West Africa. Among the abiotic constraints, adverse soils (mineral excesses and deficiencies), soil structure, soil erosion, and water (too much and too little) are common and probably

Table 3. Relative occurrences of major rice insect pests in Nigeria, by ecosystem and climatic zone (Alam 1992).

Species	Common name	Ecosystem			Climatic zone		
		Upland	Rainfed lowland	Irrigated lowland	Humid tropical	Guinea savanna	Sudan savanna
Maliarpha separatella	White stem borer	+++	+++	+++	++	++	+
Chilo spp.	Striped stem borer	+	++	++	++	++	++
Sesamia spp.	Pink stem borer	++	+	–	++	++	++
Diopsis longicornis	Stalk-eyed fly	++	+	+++	++	++	+
Orseolia oryzivora	African rice gall midge	+	++	++	–	++	+
Spodoptera spp.	Armyworm	+	+	–	+	+	+
Aspavia armigera	Rice bug	+++	++	++	++	++	+
Stenocoris claviformis	Rice bug	+++	++	++	++	++	+
Nymphula stagnalis	Caseworm	–	++	++	+	++	+
Chnootriba similis	Epilachna beetle	++	+	+	+	+	+
Amitermes evuncifer (& others)	Termite	++	+	–	+	++	++
Marasmia trapezalis	Leaffolder	+	+	+	+	+	+
Hydrellia prosternalis	Whorl maggot	–	+	++	+	+	+

+++ = widely abundant; ++ = abundant ; + = present, and – = not recorded.

Table 4. Relative occurrence[a] of rice insect pests in different ecosystems of West Africa (Agyen-Sampong 1982).

Species	Common name	Uplands	Rainfed lowlands	Mangrove swamps	Irrigated lowlands
Scirpophaga spp.	Stem borer	+	++	+	++
Maliarpha separatella	White stem borer	+	++	+++	++
Chilo diffusilineus	Stem borer	++	+	++	+
Chilo zacconius	Striped stem borer	++	+	+	+
Sesamia spp.	Pink stem borer	++	+	+	+
Diopsis spp.	Stalk-eyed fly	+	++	++	+++
Nymphula depunctalis	Caseworm	–	++	+	+++
Orseolia oryzivora	Gall midge	–	++	+	+++
Nephotettix spp.	Green leafhopper	+	++	++	++
Cofana spp.	White leafhopper	+	++	++	++
Chnootriba similis	Ladybird beetle	++	+	+	+
Stenocoris spp. (& others)	Grain-sucking bug	++	+	+	++
Macrotermes spp. (& others)	Termite	++	–	–	–

[a] +++ = major, ++ = important, + = locally important/minor, – = negligible/nonexistent.

most important. Weeds, diseases, rodents, nematodes, birds, mites, and insects are among the biotic constraints.

Pests attack rice from the seedling stage through to harvest and in storage. There are few studies that quantify yield losses due to rice pests. However, Cramer (1967) (cited by Barr et al 1975) estimated that rice yield loss in Africa caused by a combination of insects, diseases, and weeds was 33.7%. Insects were estimated to contribute to 14.4% of that loss. Oerke et al (1994) estimated losses due to rice insects in all of Africa at 18%. Losses in countries having yields less than 1.8 t ha^{-1} (which include West Africa) were estimated to be 22%. Losses attributed to rice-feeding insects in Egypt, where yields were more than 3.5 t ha^{-1}, were estimated to be 13%. Considering the extent of yield losses attributed to birds, rodents, nematodes, and crabs in West Africa, it is assumed that the total loss due to pests is considerable and of great economic importance. Based on annual production of 3.4 million t of paddy rice in 1980-84 (FAO 1999), losses due to insects, weeds, and diseases amounted to about 1.1 million t of rice with an estimated value of US$600 million. Based on projected estimates of production increases (Nyanteng 1987), losses due to these three pests were expected to be about 1.3 million t by 2000. Although many insect species have been recorded to occur on rice in West Africa, their economic importance and role as pests are not well known. For some environments, within certain countries, little is even known about the species present. There is thus a need to survey the various rice ecosystems in West Africa to identify the species present and to determine their economic importance. This information will guide researchers as they develop effective integrated pest management strategies.

The yield loss estimates of Cramer (1967) were for Africa as a whole. Accurate information on rice yield losses attributed to pests in West Africa is not available. Litsinger (1991) discusses some qualifying factors regarding Cramer's methodology and the insecticide-check techniques used to generate the following loss data. Limited studies have indicated that control of rice insects alone can cause significant increases in rice production. Production increases of 10–20% were reported for mangrove swamp rice in Sierra Leone (WARDA 1981). In deepwater rice in Mali, a grain yield increase of 35% was obtained (Akinsola 1982), while protection of farmers' irrigated rice fields in Senegal increased yields by 3.3 t ha^{-1} (WARDA 1979).

Rice farmers in West Africa have been categorized into two groups based on crop protection perceptions (Akinsola 1982). Small-scale farmers (0.5–1.5 ha) are mainly concerned with pests (usually birds and weeds) that cause total crop loss and ignore the rest. They resort to cultural practices that are believed to reduce the level of infestation and shun purchased inputs such as pesticides. Occasionally, when sporadic pests reach outbreak proportions, these farmers seek help from extension workers (if available in their area). Yields are low (1.0–1.5 t ha^{-1}) for this farmer group and the yield-depressing effect of less observable insect feeding is often ignored. Brady (1979) stated that a 20% yield-reduction in a 6-t ha^{-1} crop is much more noticeable than a similar reduction in a 2-t ha^{-1} crop.

The second group consists of large-scale private and public sector farmers who use a middle level of crop protection technology. Protection is often routine and primarily consists of the application of pesticides that are, for the most part, recommended by manufacturers and applied on a calendar-based schedule rather than on a need basis as determined by economic thresholds. So, pesticides are often applied when pest levels do not justify their use.

Species in West Africa

Comprehensive surveys of rice-feeding insects have not been conducted in most West African countries. Most surveys have been limited in time and geographical range within a country. Greater elaboration of rice-feeding insects has been limited due to few local taxonomists and the difficulty of sending collected material to specialists and the surveyors' transportation costs. Entomologists working for international development agencies have conducted most of the extensive surveys in West Africa. Despite these constraints, a fairly comprehensive list of species has been compiled and many major rice-feeding insects have been identified.

Table 5 lists insects and mites that have been collected on rice in various West African countries. The comprehensiveness of the various surveys reported here varies greatly so if a species is not reported in a given country, it does not imply that the species is not there. It does mean that the species has not been reported in the literature surveyed for this report. Surveys conducted in Cameroon, Côte d'Ivoire, Guinea, Guinea-Bissau, Nigeria, and Senegal are the most comprehensive.

Insects belonging to 8 orders, 64 families, and nearly 330 species have been collected from rice fields in West Africa (Table 5). Orders represented by the most species are the Coleoptera (beetles, 107), Hemiptera (suborders Heteroptera and Homoptera, bugs, 119), and Lepidoptera (moths, 38). The most important Coleoptera are the defoliators such as the chrysomelids, *Chaetocnema* spp. (Figs. 275–280) and *Trichispa sericea* Guerin-Meneville (Figs. 281–282) and the coccinellid *Chnootriba similis* Mulsant (Fig. 261). The species in the Heteropteran suborder of the Hemiptera are mostly grain-sucking bugs of which about 70 species have been collected on rice in West Africa. The alydids, *Riptortus dentipes* (Fabricius) (Figs. 439–440) and *Stenocoris* spp. (Figs. 434–438) and the pentatomid, *Aspavia* spp. (Figs. 393–396) are most common. The order Lepidoptera also has numerous rice-feeding species. The stem borers, *Sesamia* spp. (Figs. 84–85), *Chilo* spp.(Figs. 90–94), and *M. separatella* Ragonot (Fig. 88) and the defoliators *Marasmia trapezalis* Walker (Fig. 89) and *N. depunctalis* (Guenée) (Fig. 86) are considered to be the most important lepidopterous insects in West Africa.

Three mite species have been reported to attack irrigated rice in Senegal (Table 5). Of the three, *Oligonychus senegalensis* Gutierrez and Etienne, is the most abundant (Etienne 1987), usually during dry periods. *Tetranychus neocaledonicus* has also been reported in Benin, Côte d'Ivoire, and Ghana.

Direct damage

Insects feed on—and can destroy—all parts of the rice plant, i.e., the roots, stems (culms), leaves, and panicles. Feeding occurs from the time of seeding through to harvest and into storage. They also cause indirect damage by predisposing plants to pathogens through feeding wounds and through the transmission of rice pathogens.

Root feeders

Root feeders are normally found in well-drained fields and are not a problem in irrigated environments. Because of their secretive behavior of feeding below the soil surface, infestations often go undetected and little is known about the economic importance of rice root feeders in West Africa.

These insects either suck sap from the roots or devour entire portions of the roots. The rice root mealybug *Trionymus internodii* (Hall) and the root aphid *Tetraneura nigriabdominalis* (Sasaki) have sucking mouthparts and suck sap from rice roots. Removal of

Table 5. Mite and insect species collected in rice in West Africa as based on a review of conventional and gray literature[a] and as based on the WARDA Arthropod Reference Collection (WARC) as of 1 Jul 1996.

	Country[b]													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
MITES														
ACARI														
Tetranychidae														
Oligonychus pratensis													+	
Oligonychus senegalensis													+	
Tetranychus neocaledonicus	+			+		+							+	
INSECTS														
COLEOPTERA														
Alleculidae														
Alogista sp.		+	+	+						+				
Apionidae														
Apion sp.			+	+						+				
Conapion sp.				+										
Cylas puncticollis	+													
Attelabidae														
Parapoderus fuscicornis				+								+		
Buprestidae														
Sphenoptera laplumei				+				+						
Carabidae														
Aulacoryssus sp.				+										
Calleida fasciata				+										
Carabus sp.		+		+										
Chlaenius sp.				+										
Colliuris sp.				+										
Hyparpalus conformis				+										
Hyparpalus holosericeus				+										
Lophyra luxeri		+		+										
Lophyra sp.		+		+										
Ocybatus discicollis			+	+										
Ophionea sp.				+										
Pachydinodes conformis				+										
Pheropsophus cincticollis				+										
Ropaloteres nysa				+										
Chrysomelidae														
Agonita sp.				+										
Altica indigacea		+		+			+							
Apophylia chloroptera				+		+			+			+		
Asbecesta cyanipennis				+			+							
Aspidomorpha dissentanea			+	+		+				+				
Aspidomorpha obovata		+		+										
Aulacophora foveicollis											+			
Aulacophora virula											+			
Cassida sp.				+										
Chaetocnema pulla		+		+						+				
Chaetocnema pusilla		+		+						+				
Chaetocnema sp.		+		+			+	+			+			
Chysispa viridicyanea		+		+									+	
Cryptocephalus sp. A	+	+	+	+	+	+	+	+	+	+	+			
Cryptocephalus sp. B				+										
Cryptocephalus sp. C				+										
Conchyloctenia nigrosparsa				+										
Dactylispa bayoni		+		+					+			+		
Dactylispa spinigera				+										
Diacantha albidicornis		+		+										
Dicladispa paucispina			+									+		
Dicladispa viridicyanea		+		+								+		
Dorcathispa bellicosa													+	
Gynandrophthalma sp.			+	+		+								
Lamprocopa occidentalis	+			+										
Lema armata				+								+		
Lema pauperata				+										
Lema rubricollis	+											+		
Lema sp. A			+	+										
Lema sp. B				+										
Leptaulaca fissicollis				+		+	+							
Medythia sp.				+										
Monolepta sp.				+		+		+						

continued on next page

Table 5 continued.

	Country^b													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
Ootheca mutabilis				+										
Oulema sp.			+	+										
Pachnephorus senegalensis												+		
Paropsides sp.				+										
Peploptera sp.				+										
Trichispa sericea		+	+	+						+	+	+	+	+
Coccinellidae														
Cheilomenes lunata		+		+			+	+						
Chnootriba similis	+	+	+	+		+	+	+	+		+		+	+
Epilachna reticulata			+	+										
Epilachna sp.			+	+										
Exochomus sp.		+	+	+										
Micraspis sp.		+	+	+	+	+	+	+	+	+	+	+		
Scymnus sp.				+										
Xanthadalia sp.				+				+	+					
Curculionidae														
Afroryzophilus djibai													+	
Eugnathus sp.				+										
Gasteroclisus sp.				+										
Mitophorus acerbus				+										
Sitophilus oryzae				+										
Lagriidae														
Chrysolagria cuprina				+				+						
Chrysolagria nr. *nairobana*				+										
Lagria villosa		+	+	+			+	+	+		+	+		
Lycidae														
Lycus proboscideus				+				+						
Lycus semiamplexus				+										
Lycus sp.				+	+						+			
Meloidae														
Cylindrothorax melanocephala				+							+			
Cylindrothorax spurcaticollis		+	+	+			+	+	+	+				
Cylindrothorax sp.			+	+	+									
Cylindrothorax westermanni			+											
Epicauta canescens											+			
Mylabris sp.			+	+										
Scarabaeidae														
Adoretus sp.				+					+		+			
Anomala sp.											+			
Bupachytoma sp.				+										
Gametis sanguinolenta				+										
Geotrupes auratus				+										
Geotrupes leaviatriatus				+										
Heteronychus nr. *licas*			+											
Heteronychus mosambicus											+	+	+	+
Onthophagus sp. A				+										
Onthophagus sp. B				+										
Pachnoda sp.				+										
Schizonycha sp.				+							+			
Trochalus sp.				+										
Dermaptera														
Forficulidae														
Diaperasticus erythrocephalus			+	+					+					
Diaperasticus sp.		+		+				+		+				
Doru sp.			+								+			
Diptera														
Agromyzidae														
Cerodontha orbitona						+								
Cecidomyiidae														
Orseolia oryzivora	+	+	+	+		+	+	+	+	+	+	+	+	+
Chloropidae														
Pachylophus sp.		+	+											
Pachylophus beckeri			+	+	+					+	+	+	+	
Chloropidae undet. gen.				+										
Chironomidae														
Chironomus sp.				+					+					
Diopsidae														
Diasemopsis meigenii				+		+								

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Table 5 continued.

	Country^b													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
Diopsis apicalis	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Diopsis collaris	+		+			+					+			
Diopsis lindneri				+		+								
Diopsis longicornis	+	+	+	+		+	+	+	+	+	+	+	+	+
Diopsis servillei			+											
Ephydridae														
Hydrellia prosternalis		+		+		+					+			
Notiphila sp.				+										
Paralimna sp.				+										
Psilopa sp.				+										
Muscidae														
Atherigona soccata		+												
Sciomyzidae														
Sepedon senegalensis	+			+										
Sepedon sp.				+										
Syrphidae														
Syrphus sp.				+										
HEMIPTERA														
Suborder Heteroptera														
Alydidae														
Mirperus jaculus				+			+	+						+
Mirperus varipes				+		+		+				+		
Riptortus dentipes				+		+	+	+			+			+
Stenocoris apicalis			+	+	+									+
Stenocoris claviformis		+		+					+		+	+		
Stenocoris elegans				+					+		+			
Coreidae														
Anoplocnemis curvipes				+						+				
Anoplocnemis tristator	+			+		+		+		+				
Clavigralla horrida				+		+								
Clavigralla sp. A		+		+						+				
Clavigralla sp. B				+										
Cletus bifasciata		+												
Cletus notatus				+								+		
Cletus sp.		+		+										
Gelastocoridae														
Nerthra grandicollis				+										
Lygaeidae														
Blissus sp.		+		+										
Cymodema sp.				+										
Cymoninus seychellensis									+					
Dieuches sp.												+		
Eromocoris ferus				+										
Geocoris amabilis				+		+			+				+	
Pachybrachius sp.		+		+						+				
Paromius sp.					+								+	
Nysius sp.				+										
Spilostethus rivularis				+										
Malachiidae														
Neochauliops lacinata									+					
Miridae														
Cyrtorhinus sp.				+										
Miridae undet. gen.				+										
Proboscidoris sp.				+										
Nabidae														
Stenonabis conspurcatus				+		+								
Ochteridae														
Ochterus sp.				+										
Pentatomidae														
Acrosternum sp.				+										
Acrosternum acutum						+				+				
Aethemenes chloris		+		+										
Aeliomorpha griseoflava				+										
Agonoscelis haroldi		+		+										
Agonoscelis versicolor		+	+	+										
Amaxosana punctata											+			
Andrallus sp.				+										
Aspavia acuminata				+		+				+		+		

continued on next page

Table 5 continued.

	Country[b]													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
Aspavia armigera			+	+	+	+	+	+	+		+		+	+
Aspavia brunnea				+						+			+	
Aspavia hastator				+										
Atelocera spinulosa												+		
Carbula difficilis				+						+				
Carbula pedalis	+			+						+				
Diploxys bipunctata				+								+		
Diploxys fallax				+	+									
Diploxys fisa				+										
Diploxys fowleri		+		+			+			+			+	
Diploxys senegalensis					+									
Dorycoris pavoninus				+			+	+						
Euschistus servus			+											
Mecidea af. *balachowskyi*													+	
Nezara viridula		+	+	+							+			
Piezodorus rubrofasciatus		+	+	+										
Pygomenida sp.				+										
Scotinophara sp.			+	+										
Scotinophara mixta				+		+	+	+				+	+	
Thyanta sp.			+											
Plataspidae														
Brachyplatys sp.				+										
Pyrrhocoridae														
Dysdercus melanoderes									+					
Dysdercus nigrofasciatus			+	+										
Dysdercus superstitiosus		+	+	+		+			+	+				
Dysdercus voelkeri				+										
Reduviidae														
Coranus pallidus		+		+						+				
Coranus sp.		+		+		+						+		
Coranus varipes		+		+										
Vestula obscuripes				+										
Scutelleridae														
Pharocosis annullis				+										
Sphaerocoris sp.				+										
Sphaerocoris annulus				+										
Suborder Homoptera														
Achilidae														
Ballomarius sp.									+					
Aleyrodidae														
Aleurocybotus indicus		+			+					+	+		+	
Aphididae														
Hysteroneura setariae										+	+			
Rhopalosiphum padi											+			
Rhopalosiphum rufiabdominalis													+	
Tetraneura nigriabdominalis												+		
Aphrophoridae														
Poophilus sp.				+			+	+			+	+		
Poophilus costalis				+							+			
Poophilus grisescens				+							+			
Cercopidae														
Locris atra									+					
Locris erythromela											+			
Locris maculata maculata		+		+			+	+	+	+	+			+
Locris rubens											+		+	
Locris rubra	+	+	+	+	+		+	+		+	+		+	+
Cicadellidae														
Balclutha sp.									+		+			
Carneocephala sagitifera										+				
Cicadulina sp.													+	
Cofana spectra	+	+		+			+	+		+	+			+
Cofana unimaculata	+	+		+			+	+	+	+	+			+
Deltocephalus schmidtgeni	+		+						+					
Doratulina remaudierei	+			+					+					
Exitianus capicola													+	
Macrosteles sp.				+							+			
Nephotettix afer				+			+	+			+			
Nephotettix sp.				+		+					+		+	

continued on next page

Table 5 continued.

	Country^b													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
Nephotettix modulatus	+			+		+	+	+	+		+		+	+
Recilia mica				+									+	
Recilia sp.				+										
Coccidae														
Pulvinaria elongata													+	
Pulvinaria saccharia													+	
Delphacidae														
Delphacoides aglauros													+	
Nilaparvata maeander	+		+	+		+	+				+		+	
Sogatella kolophon				+							+			
Sogatella nigeriensis													+	
Sogatodes (=*Tagosodes*) *cubanus*	+			+					+		+	+		
Derbidae														
Diostrumbus grahani											+			
Malenia sp.									+					
Proutista fritillaris											+			
Dictyopharidae														
Centromeriana sp.					+									
Philotheria discalis					+									
Pseudophanella regina				+								+		
Lophopidae														
Elasmoscelis etiennei					+								+	
Elasmoscelis trimaculata											+			
Meenoplidae														
Nisia nervosa			+	+	+	+					+			
Membracidae														
Leptocentrus nubianus					+									
Pseudococcidae														
Dysmicoccus brevipes											+			
Trionymus internodii											+		+	
Trionymus polyporus													+	
ISOPTERA														
Termitidae														
Amitermes evuncifer											+			
Microtermes sp.				+										
Odontotermes sp.				+										
LEPIDOPTERA														
Arctiidae														
Spilosoma maculosa			+											
Spilosoma punctulata			+											
Spilosoma scortilla	+		+	+		+			+		+		+	
Gelechiidae														
Brachmia sp.			+											
Hesperiidae														
Gegenes niso			+											
Parnara naso			+											
Pelopidas mathias			+	+										
Lymantriidae														
Laelia fracta			+											
Psalis pennatula			+											
Noctuidae														
Mythimna loreyi			+											
Sesamia calamistis	+	+	+	+	+	+				+	+		+	+
Sesamia nonagrioides botanephaga				+		+			+		+		+	+
Sesamia sp.			+	+					+					
Spodoptera cilium											+		+	
Spodoptera exempta							+						+	+
Spodoptera exigua			+											
Spodoptera triturata			+								+	+		
Pyralidae														
Adelphura sp.			+											
Ancyclolomia irrotata			+											
Chilo diffusilineus													+	+
Chilo partellus^c														
Chilo sp.				+					+					
Chilo zacconius	+		+	+		+			+	+	+	+	+	
Diatraea saccharalis			+											
Eldana saccharina				+										

continued on next page

Table 5 continued.

	Country^b													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
Epipages cancellalis			+											
Maliarpha separatella	+	+		+					+	+	+	+	+	+
Marasmia subtoenialis			+											
Marasmia trapezalis			+								+		+	+
Nymphula depunctalis (=*N. stagnalis)*	+		+	+	+	+			+		+	+	+	+
Nymphula sp.				+										
Saluria sp.			+											
Scirpophaga melanoclista			+	+						+	+		+	
Scirpophaga occidentella				+							+	+	+	
Scirpophaga subumbrosa						+	+			+				+
Scirpophaga sp.			+	+										
Satyridae														
Melanitis leda											+			
Melanitis leda helena													+	
Melanitis leda ismene											+			
ORTHOPTERA														
Acrididae														
Acrida sp.			+											
Acrida turrita			+			+								+
Catantops melanostictus					+	+								
Catantops sp.			+											
Cyrtacanthacris aeruginosa			+											
Duronia chloronata													+	
Eyprepocnemis senegalensis			+											
Gastrimargus africanus			+	+										
Hieroglyphus africanus			+											
Hieroglyphus daganensis			+			+					+		+	
Homoxyrrhepes punctipennis			+											
Ornithacris cyanea					+									
Orthochtha af. *bisulcata*													+	
Oxya hyla		+		+						+	+			
Paracimena tricolor			+	+										
Spathosternum nigrotaeniatum													+	
Spathosternum pygmaeum			+								+		+	
Trilophidia conturbata						+								
Zacompsa festa				+										
Gryllidae														
Euscyrtus bivittatus				+							+			
Gryllotalpidae														
Gryllotalpa africana	+	+		+		+			+		+			
Pyrgomorphidae														
Atractomorpha aberrans						+								
Atractomorpha gestaeckeri			+											
Chrotogonus hemipterus						+								
Pyrgomorpha vignaudi			+											
Zonocerus variegatus			+	+	+	+	+	+	+	+	+	+	+	+
Tetrigidae														
Dinotettix africanus												+		
Paratettix sp. A			+											
Paratettix sp. B			+											
Paratettix sp. C			+											
Paratettix sp. D			+											
Paratettix sp. E			+											
Tettigoniidae														
Conocephalus longipennis					+									
Conocephalus maculatus						+								
Conocephalus sp.			+	+										
Phaneroptera sp.				+										
Ruspolia nitidulus						+								
Ruspolia vicinus				+										
Tridactylidae														
Tridactylus sp.				+										
THYSANOPTERA														
Phlaeothripidae														
Haplothrips avenae													+	
Haplothrips gowdeyi													+	
Haplothrips sp.									+					

continued on next page

Table 5 continued.

	Country[b]													
	Ben	BF	Cam	CI	Gam	Gha	Gui	GBi	Lib	Mal	Nga	SLe	Sen	Tog
Thripidae														
Chaliothrips impurus													+	
Chirothrips impurus													+	
Chirothrips meridionalis													+	
Exothrips monstruosus												+		
Sericothrips sp.													+	

[a]Agyen-Sampong (1977a), Alam (1992), Asanga (1992, 1995), Bleszynski (1970), Brenière (1969, 1976), J.C. Deeming (pers. commun.), Descamps (1956), Emosairue and Usua (1994), Etienne (1986, 1987), Etienne et al (1992), Heinrichs and Kassoum (1996), Imolehin and Ukwungwu (1992), Khan et al (1991), Kunjo et al (1995), Medler (1980), Meijerman and Ulenberg (1996), Owosu-Akyaw et al (1995), Scheibelreiter (1973), Shaw and Tambajang (1995), Stephen (1977), Trinh (1980), Twumassi et al (1992), Welty (1979), Wilson and Claridge (1991). [b]Ben = Benin, BF = Burkina Faso, Cam = Cameroon, CI = Côte d'Ivoire, Gam = Gambia, Gha = Ghana, Gui = Guinea, GBi = Guinea-Bissau, Lib = Liberia, Mal = Mali, Nga = Nigeria, SLe = Sierra Leone, Sen = Senegal, Tog = Togo. [c]It is not clear if *Chilo partellus* is present in West Africa. In Africa, it has been found in Kenya, Tanzania, Malawi, Sudan, and Uganda.

plant sap causes the leaves to turn yellow and the plants to be stunted. Root chewers include the termites, *Macrotermes*, *Microtermes*, and *Odontotermes* sp.; mole crickets, *Gryllotalpa africana* Palisot de Beauvois (Figs. 123–124); and larvae of the scarab beetles, *Adoretus* sp., *Anomala* sp., and *Schizonycha* sp.

Stem borers

Stem borer species as a group are generally considered to be the most important insect pests of rice in West Africa. All stem borer species are in the noctuid and pyralid families in the order Lepidoptera except for the *Diopsis* spp. and *Pachylophus* in the order Diptera. The most common stem borer species in rice in West Africa are *D. longicornis* Macquart (stalk-eyed fly; Fig. 98) and the lepidopterous species *S. calamistis* Hampson (Figs. 84–85), *C. zacconius* Bleszynski (Fig. 92), and *M. separatella* Ragonot (Fig. 88). Tunneling of stem borer larvae severs tillers thus reducing their number through the formation of "deadhearts" (pre-panicle formation stages) and "whiteheads" (panicle stage). Stem borers are difficult to control with insecticides because they feed within the stems where they are protected.

African rice gall midge

Dipteran gall midges prevent panicle formation by stimulating the leaf sheath to form a gall resembling an onion leaf. The African rice gall midge *O. oryzivora* Harris and Gagne (Figs. 95–97) is closely related to the Asian rice gall midge, *O. oryzae* (Wood-Mason). It is the only known gall-forming insect in West African rice. Although most abundant in irrigated fields, *O. oryzivora* is also present in hydromorphic and upland fields. "Hydromorphic" fields are those in which the water table is within the rooting zone of the rice crop during the crop growth period and is referred to as "hydro" in the figures depicting insect numbers at various toposequence sites. Upland fields are those that depend on rainfall and soil moisture for rice crop growth.

Leafhoppers and planthoppers

Leafhoppers (Cicadellidae) and planthoppers (Delphacidae) in the order Hemiptera remove xylem and phloem sap from the leaves and stems of rice. Excessive feeding causes plants to wilt. Both the leafhoppers and planthoppers act as vectors in transmitting rice viruses in Asia and the Americas but have not been shown to be vectors in West Africa. *Cofana* spp. (Figs. 366–368) and *Nephotettix* spp. (Figs. 374–375) are the most abundant leafhoppers in West Africa. The brown planthopper, *Nilaparvata lugens* (Stål), a delphacid, became a major rice pest in Southeast Asia soon after the adoption of high-yielding varieties and the accompanying cultural practices of the green revolution. Although *Nilaparvata maeander* Fennah (Figs. 348–350), closely related to the Asian species, occurs in West Africa, hopperburn has rarely been observed. Leafhopper and planthopper populations in Asia have increased with the increase in cropping intensity, fertilizer, and other inputs. With the development of more intensive rice production, these insects can potentially become severe pests in West African rice as well.

Foliage feeders

There are many insect species that feed on and within the leaves of rice in West Africa. In contrast to the leafhoppers, most of these insects have chewing mouthparts that enable them to remove portions or entire leaves. Extent of grain yield losses depends on the age of the rice plant at the time of defoliation (Oyediran and Heinrichs 2002). Leaf-feeding insects are found in the orders Coleoptera, Diptera, Hemiptera, Lepidoptera, and Orthoptera.

The coleopteran families Chrysomelidae, Coccinellidae, and Meloidae feed on rice leaves. Most common are the chrysomelids *Chaetocnema* spp. (Figs. 269–280) and *T. sericea* Guerin-Meneville (Figs. 281–282), and the coccinellid *C. similis* (Mulsant) (Fig. 261). In most cases, both the larvae and the adults are foliage feeders. Larvae of *T. sericea* tunnel as leafminers, leaving only a thin layer of epidermal tissue at the top and bottom of the leaves. The adults scrape the upper leaf surface tissue and leave white streaks of uneaten lower epidermis between the parallel leaf veins (Reissig et al 1986).

The genus *Hydrellia*, of the dipteran family Ephydridae, is called the rice whorl maggot. The adults are attracted to plants growing in standing water. Larvae feed within developed leaf whorls. They eat the tissue of unopened leaves and when the leaves grow out, the damage becomes visible.

The whitefly (family Aleyrodidae) *Aleurocybotus indicus* David and Subramaniam and the aphid (family Aphididae) *Hysteroneura setariae* (Thomas) feed on rice leaves. Both have sucking mouthparts and they remove leaf sap. Their excreta cause leaves to become sticky.

The order Lepidoptera contains a large number of species that defoliate. The larval stages (caterpillars) of the families Arctiidae, Hesperiidae, Lymantriidae, Satyridae, and some Noctuidae and Pyralidae are leaf feeders. The armyworms, *Mythimna* and *Spodoptera* spp., sometimes occur in outbreak numbers. The pyralids *Marasmia trapezalis* Walker (rice leaffolder; Fig. 89) and *Nymphula depunctalis* (Guenée) (caseworm, Fig. 86) may be important rice feeders in certain localized situations. The latter is aquatic in the larval form and only occurs in paddies with standing water.

Many grasshopper (order Orthoptera) species feed on rice. Most are the short-horned grasshoppers (short antennae) belonging to the family Acrididae (Figs. 129–131, 138–142). Long-horned grasshoppers belong to the family Tettigoniidae (Figs. 116–122). Grasshoppers are herbivorous, feeding on many plant hosts and often build up populations on these hosts before moving into rice fields to feed on the foliage. Migratory locusts generally are not a problem in most of the West African rice-growing regions.

Panicle feeders

The earwig, *Diaperasticus erythrocephalus* (Olivier) (Dermaptera: Forficulidae), has been reported to feed on panicles in Liberia (Stephen 1977). Although earwigs are primarily scavengers, the adults feed on pollen, stamens, and pistils of rice when the glumes open, causing abortion and sterility of the grain. Blister beetle adults feed on the floral parts of the rice plant. The panicle thrips *Haplothrips* spp. feed on the rice inflorescence, damaging the lemma and the palea.

Grain-sucking bugs

Several species of true bugs in the Heteroptera suborder attack developing rice grains. Both nymphs and adults feed on the grain by inserting their sucking mouthparts between the lemma and the palea. They prefer rice at the milk stage but will also feed on soft and hard dough rice grains. Removal of the liquid milky white endosperm results in small and unfilled grains. When the bugs feed on soft or hard dough endosperm, they inject enzymes to predigest the carbohydrate. In the process, they contaminate the grain with microorganisms that cause grain discoloration or "pecky" rice. Damage from feeding at this stage reduces grain quality rather than weight. Pecky rice grains are prone to break during milling.

Leptocorisa, *Riptortus*, and *Stenocoris* spp. in the Alydidae family and several species in the Pentatomidae family are common in rice in West Africa. Among the various pentatomids, *A. armigera* Fabricius (Fig. 396) is commonly seen and has been reported from several countries. The relative importance of grain-sucking bugs in West Africa is not well known.

Role in disease transmission

Insect-vectored diseases of rice currently appear to be of minor importance in West Africa compared with Asia and Central and South America. In those regions, numerous leafhopper- and planthopper-vectored viruses are of extreme importance and cause severe economic damage.

Rice yellow mottle virus

In West Africa, rice yellow mottle virus (RYMV) is the only rice virus disease currently known to be transmitted by insects. Hoja blanca virus, a disease that is common in Central and South America, has been reported from the University Farm at Suakoko, Liberia (Stephen 1977). The vector of hoja blanca virus in the Americas, *Sogatodes* (=*Tagosodes*) *cubanus* (Crawford) has been reported from Liberia in addition to Benin, Côte d'Ivoire, Nigeria, and Senegal (Table 5). However, the presence of this disease has not been properly confirmed and needs further investigation.

W. Bakker first isolated RYMV from the rice cultivar 'Sindano' collected from a field near Kisumu, Kenya, along the shores of Lake Victoria. His treatise (Bakker 1974), *Characterization and ecological aspects of rice yellow mottle virus in Kenya*, still stands as a classic. He proposed the name rice yellow mottle and named the causal agent rice yellow mottle virus, a virus in the genus *Sobemovirus*, which he showed to be mechanically transmitted (Bakker 1970).

Bakker (1974) described the characteristic symptoms of RYMV as a discoloration and stunting of the plants. Discoloration was observed about 2–3 wk after transplanting; but leaf color varied greatly by cultivar—yellowish (Sindano), mild green (Basmati 217), or orange (IR8). In Basmati 217, symptoms were not distinct but were more pronounced in fresh ratoons. John et al (1984) reported the symptoms of RYMV to be yellowing, mottling, necrosis, stunted growth, partial emergence of panicles, and spikelet sterility. Although diseased plants usually survive, they produce few tillers and are delayed in flowering. Panicles emerge only partially and the grains are unfilled and discolored (Bakker 1974). The effect of RYMV on rice grain yield depends on the time of infection and the rice cultivar (Bakker 1974). In a 1966 outbreak in Kisumu, Kenya, the yield reduction of variety Sindano was estimated to be 50%. Natural infection of IR65 in an associated mangrove swamp in Sierra Leone resulted in 17% stunting, 72% increase in spikelet sterility, 66% increase in grain discoloration, and 82% reduction in yield (Taylor et al 1990). In controlled experiments conducted in a screenhouse at WARDA, grain yields of artificially inoculated susceptible cultivars Bouaké 189 and BG90-2 were reduced 84 and 67%, respectively, while that of resistant Moroberekan was only reduced 4% (Sy and Alluri 1993).

RYMV occurs in many countries in East and West Africa. According to the literature, rice yellow mottle has been reported from Krasonodar Territory, Russia, but there is some question as to whether it is the same organism as RYMV in Africa. After RYMV was first reported from Kenya (Bakker 1970), it was soon reported from Sierra Leone (Raymundo and Buddenhagen 1976); Côte d'Ivoire (Fauquet and Thouvenel 1977); Nigeria (IITA 1978); Tanzania, Zanzibar, and Liberia (Rossel et al 1982); Burkina Faso and Mali (John et al 1984); Niger (Reckhaus and Adamou 1986); and Guinea (Fomba 1990). Severe epidemics have been reported from Niger where, in 1984, infection exceeded 25%. In Mali, severe infection was observed in the Office du Niger area and in the Projet Hydro-Agricole Aval in southwest Mali near Selingue (WARDA 1994). In the latter area, one farmer reported a 100% loss of his 1.5-ha crop.

RYMV is most commonly found in lowland irrigated rice but was also reported in mangrove and inland swamps in Guinea during 1982–86 (Fomba 1990) and in upland rice in Sierra Leone during 1987 and in Côte d'Ivoire in 1985 (Awoderu et al 1987). Screening for resistance to RYMV at IITA (1982) indicated that all *O. glaberrima* and most upland cultivars tested were tolerant, whereas most irrigated lowland cultivars were susceptible.

In Côte d'Ivoire, upland cultivars selected from tests in the African uplands did not show RYMV symptoms, whereas Philippine-bred Asian cultivars, UPLRi 5 and IR52, were infected with RYMV. Indeed, Asian cultivars appear to be especially susceptible as the most severe outbreaks of RYMV have occurred in lowland cultivars introduced from Asia while local cultivars have been less severely affected (Thresh 1991). Bouaké 189, a cultivar based on Asian germplasm but selected in Africa, is widely grown in Côte d'Ivoire and is highly susceptible to RYMV (Heinrichs 1997). In 1994, in Mali, the susceptible cultivar, BG90-2 from Sri Lanka, was grown over 90% of the Office du Niger area and was severely infected (WARDA 1994).

Increasing incidence of RYMV in Africa appears to be due to a change in cropping practices, especially a change from one crop to two crops per year. This was also observed for hoja blanca in Latin America where the introduction of daylength-insensitive cultivars allowed the growing of two crops per year (Thresh 1989). In Surinam, the impact of double-cropping was apparent in the hoja blanca vector, *Tagosodes orizicolus* (Muir), populations (van Hoof et al 1962). Loevinsohn et al (1988) documented increased incidence of virus vectors in the Philippines due to multi-rice cropping, which allowed the disease to multiply. Natural control was exerted by the long nonrice fallow in single rice systems. In contrast to the above studies, experiments conducted at WARDA indicated that there was no evidence that RYMV incidence increases in successive seasons under continuous cropping (Heinrichs et al 1997).

The area of the first recorded outbreak of RYMV in Africa was associated with a newly developed irrigation project that provided water for sequential plantings throughout the year (Thresh 1989). Similar conditions are suggested to be responsible for an outbreak in southeastern Nigeria in the early 1980s (Rossel et al 1982). In Niger, the irrigated rice area increased from 571 ha in 1974 to 4,803 ha in 1984 (Reckhaus and Adamou 1986). RYMV was not observed until 1982 but by 1985 it occurred throughout most of Niger's irrigated area. In 1993, severe infections of RYMV were observed in a 300-ha irrigated rice project in Sakassou, Côte d'Ivoire (30 km southwest of Bouaké), where farmers were planting two crops of Bouaké 189 annually (Heinrichs et al 1997). In the Office du Niger area, in Mali, the level of incidence was reported to have increased with a shift from direct seeding to transplanting and with planting of BG90-2 (WARDA 1994).

Bakker (1974) cited a number of plant species that proved to be systemic hosts of RYMV in laboratory tests. Among these were several species of wild *Oryza* spp. The grasses *Dinebra retroflexa* (Vahl) Panz., *Eleusine indica* (L.), *and Eragrostis tenuifolia* (A. Rich) Steud. were reported as potential alternate hosts of RYMV at the Ahero and West Kano Irrigation Scheme in Kenya (Okioma et al 1983). These grasses occur abundantly around the rice paddies and are believed to serve as reservoirs during the off-season. In valley bottoms in Sierra Leone, volunteer rice and ratoons from previously harvested crops favor survival of the virus during the off-season (Fomba 1988). Fomba successfully transmitted RYMV to *Eleusine indica* and *Echinochloa crus-galli* (L.) at Rokupr. RYMV symptoms have been observed on *Echinochloa colona* (L.) on roadways and along irrigation ditches bordering lowland paddies on the WARDA farm at M'bé. The disease was mechanically transmitted from *E. colona* to *O. sativa* and then recovered from the rice plants (D.E. Johnson, E.A. Heinrichs, and A.A. Sy, WARDA, 1995, unpubl. data). In areas of Mali, severely damaged by RYMV, *O. longistaminata*, a perennial species of rhizomatous wild rice with RYMV-like symptoms, was observed growing profusely in irrigation canals (WARDA 1994). In a study conducted by John et al (1984), plants of *O. longistaminata*, reacted positively to the RYMV antiserum and exhibited the typical symptoms of RYMV infection. They surmised that *O. longistaminata* may be the original wild host for RYMV.

Bakker's (1970, 1971, 1974) pioneering studies on RYMV transmission in Kenya continue to be the seminal work on the subject. Bakker tested nematodes, mites, and insects as potential vectors. Insects tested were leafhoppers, cercopids, aphids, and beetles. Only the chrysomelid beetles, genus near *Apophylia*, *Oulema dunbrodiensis* Jac. f. *nigripennnis* Hze., *Monolepta flaveola* Gerst., *M. irregularis* Rits., *Sesselia pusilla* Gerst., *Chaetocnema abyssinica* Jac., *C. pulla* Chapuis, *Dactylispa bayoni* Gestro, *Dicladispa paucispina* (Weise), *D. viridicyanea* (Kraatz), and *Trichispa sericea* Guerin-Meneville, and the long-horned grasshopper, *Conocephalus merumontanus* Sjöstedt were transmission agents. Short-horned grasshoppers, *Oxya* spp. were also reported to be vectors of RYMV (IRRI 1983). Of the species listed by Baker (1971, 1974) and IRRI (1983) only *C. pulla* (Figs. 273–274), *Dactylispa bayoni*, *Dicladispa viridicyanea* (Figs. 283–285), and *T. sericea* (Figs. 281–282) and *Oxya hyla* (Figs. 141–142), respectively, occur in West Africa. *Chaetocnema* sp. (Figs. 275–280) was reported to be present at all mangrove and inland swamp sites visited in Guinea where RYMV-infected plants were present (Fomba 1990). Severe RYMV infections in the rice cultivar Bouaké 189, at Sakassou, Côte d'Ivoire, were associated with high *T. sericea* populations (Heinrichs et al 1997).

Bakker (1974) studied the relationship between the virus, insect vectors, and plant host. The test insects were chrysomelid beetles, *S. pusilla*, *C. pulla*, and *T. sericea*, belonging, respectively, to the subfamilies Galerucinae, Halticinae, and Hispinae. Minimum acquisition and inoculation period was 15 min and maximum retention period was 8 d. *Chaetocnema pulla* was able to transmit the virus from the nonrice grass host, *Dinebra retroflexa*, to the rice cultivar Sindano. Studies at WARDA have identified eight new vectors and alternate host plants such as weeds, which could serve as sources of inoculum for the spread of the disease (Nwilene 1999; F.E. Nwilene, K.F. Nwanze, and A.K. Traore, WARDA, 2002, unpubl. data). Natural sources of RYMV were found in grasses belonging to the annual and perennial species at Gagnoa and Sakassou, Côte d'Ivoire. The role of perennial hosts with rhizomes could be important because they act as reservoirs for the spread of the disease.

A novel trapping net cage technique was developed at WARDA for monitoring and collecting live vector populations from rice and grasses (F.E. Nwilene, A.K. Traore, and A.N. Asidi, WARDA, 2002, unpubl. data). The technique is simple and inexpensive and reduces the time required for sorting, counting, and identifying potential vectors. It also facilitates direct release of such live vectors onto healthy rice plants for observation.

RYMV has been observed on the WARDA research farm at M'bé since lowland experiments were first conducted in 1992. In 1993, a study was initiated to determine the phenological and seasonal occurrence of insects and RYMV on the farm. There was no relationship between the population of the various species and incidence of RYMV (Heinrichs et al 1997).

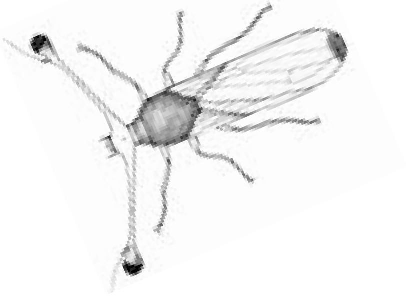
Pathogen transmission

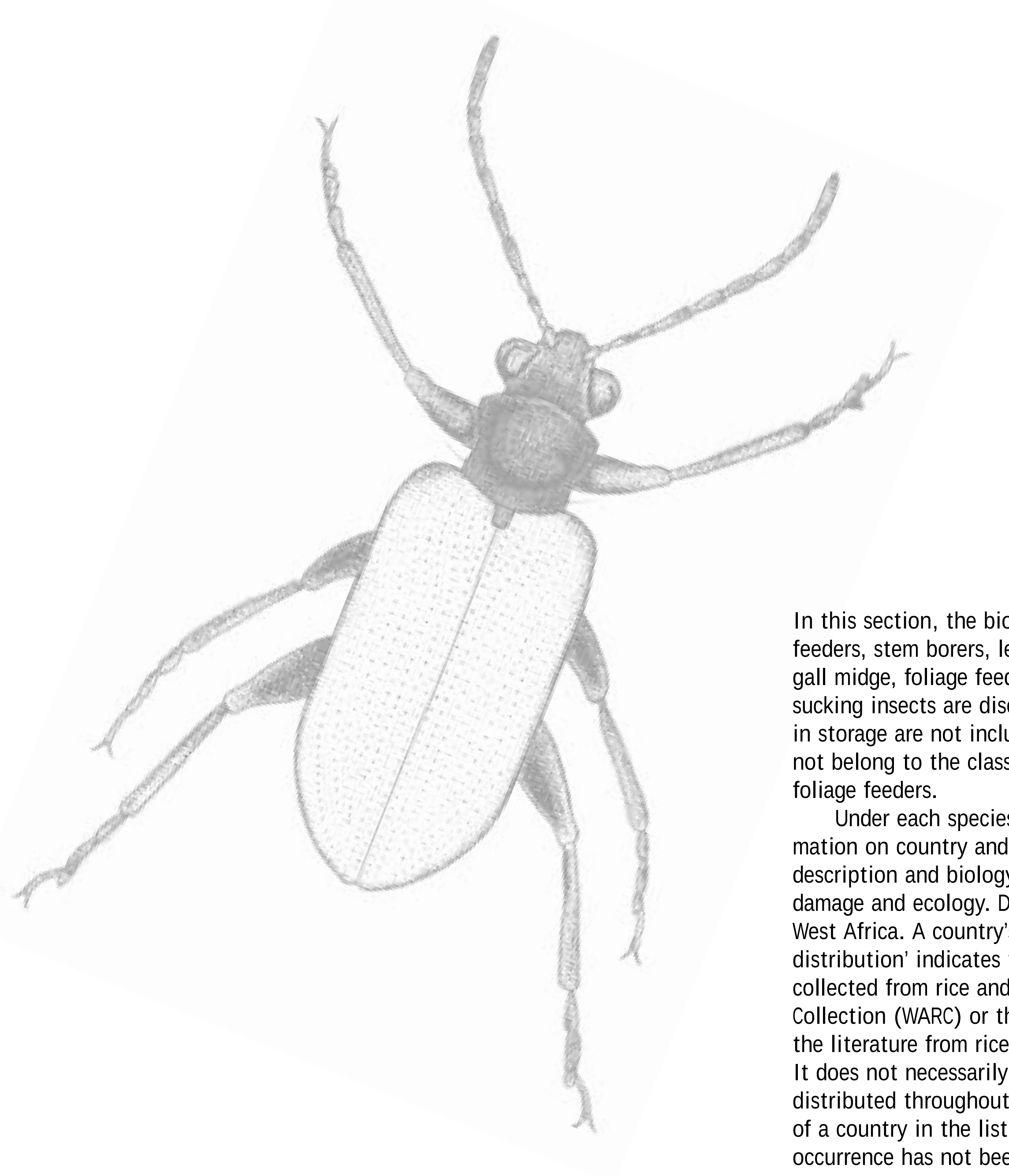
Additional studies on the role of insects in rice pathogen transmission are needed. Many additional insect species are potential transmission agents and should be evaluated for their activity to transmit RYMV. Banwo et al (2001a,b) reported *Dactylispa lenta* Weise and a new species of *Chaetocnema* to be vectors in Tanzania. Also, numerous other virus-like symptoms have been reported on rice in West Africa. More in-depth studies are needed to determine the extent to which insects play a role in their transmission.

In addition to transmitting diseases, chewing and sucking insects predispose rice plants to infection by pathogens. Studies conducted at IRRI have shown that sheath blight, *Rhizoctonia solani* Kühn, severity/incidence was higher in treatments where the brown planthopper was feeding (Lee et al 1985). A positive correlation between stem rot disease and stem borer populations was recorded in Asia (Thri Murty et al 1980). It has been speculated that mechanical injury by leaffolder may intensify disease infection in rice plants (Lee et al 1985).

Pollet (1978b) studied the relationship between feeding of the stem borer, *M. separatella* (Fig. 88), and incidence of blast (*Pyricularia oryzae* Cav.) infection in Côte d'Ivoire. Results indicated that fungus attack is most common in plants previously damaged by the stem borer larvae and that there was a synergistic interaction between the two pests resulting in total destruction of the plants.

Biology and Ecology of Rice-Feeding Insects





In this section, the biology and ecology of root feeders, stem borers, leafhoppers and planthoppers, gall midge, foliage feeders, panicle feeders, and grain-sucking insects are discussed. Insects feeding on rice in storage are not included. Mites, although they do not belong to the class Insecta, are discussed under foliage feeders.

Under each species, we provide available information on country and geographical distribution, description and biology, habitat preference, and plant damage and ecology. Distribution records are limited to West Africa. A country's name under 'country distribution' indicates that the species has been collected from rice and is in the WARDA Arthropod Collection (WARC) or the species has been reported in the literature from rice from some part of that country. It does not necessarily mean that the species is distributed throughout the country. Also, the absence of a country in the list means only that a record of its occurrence has not been found in the literature. In most cases, the distribution is expected to be broader than reported, as surveys in some countries have been limited. For cross comparisons, this information is also available in Table 5.

Under the 'description and biology' heading, we provide references where information is available, the major identifying characteristics of the various stages of the insect species, and information on biology and behavior as pertinent to the development of management strategies. More explicit details on the morphological characters of the species are provided in the identification section of this book. It should be noted, that for some pests, literature on the description and biology is limited and thus the coverage of the different species varies accordingly.

The relative abundance of the species in the various climatic zones of West Africa and their relative abundance in different ecosystems from uplands to lowlands are described under the heading of 'habitat preference'. The information presented is based on a review of the literature and on surveys conducted by the author and colleagues in farmers' fields in the forest and Guinea savanna zones of West Africa and studies conducted in the transition zone between the forest and Guinea savanna zones at the WARDA Research Station at Bouaké, Côte d'Ivoire.

Surveys of farmers' fields were conducted in Côte d'Ivoire in July, August, and October 1995 and in Guinea in September 1995. In the surveys, all fields observed along selected roads were sampled. The climatic zone, growth stage of the crop, and the ecosystem (upland or lowland) were recorded. Sampling consisted of taking 500 sweeps with a sweep net per field and observing 100 hills per field for stem borer and gall midge damage. Plant stems were dissected to determine the percentage of tillers infested with stem borer and gall midge larvae and to determine the relative abundance of the various stem borer species and the gall midge.

Studies conducted on the continuum toposequence at WARDA determined the relative abundance of rice insect pests in various ecosystems and as affected by the presence of weeds. The study was conducted during the 1992 wet season on a continuum toposequence site with ecosystems divided into Upland 1 (upper portion of the upland), Upland 2 (lower portion of the upland), Hydromorphic 1 (upper portion of the hydromorphic zone below Upland 2), Hydromorphic 2 (lower portion of the hydromorphic zone next to the lowland), and the lowland (continually flooded). The hydromorphic zone in this study refers to the zone where the water table is about 0.5 m below the soil surface from which the rice roots can draw water. The experimental design was a factorial with the ecosystem (toposequence site) as the main factor and varieties (four upland and four lowland) and weeding regime (weeded and nonweeded) as subfactors. Treatments were replicated three times. Sweep net samples and visual observations for insect damage were taken five times at 2-wk intervals from 4 to 12 wk after planting. Sweep net data presented in the figures represent a total of the five dates and eight varieties and are based on 2,000 sweeps (50 sweeps per plot × 5 dates × 8 varieties).

The 'plant damage and ecology' section contains information on the occurrence of insect species in relation to the crop growth stage (vegetative, booting, flowering-ripening) as based on data from farmers' field surveys. Data from a monthly planting experiment ('rice garden') conducted at WARDA provide information on the abundance of various species at different weeks after transplanting and in crops planted on different dates. In this experiment, the lowland rice variety Bouaké 189 was transplanted at monthly intervals from May 1994 to April 1995. Each transplanting date was replicated three times by planting three randomly arranged plots measuring 7 × 14 m. Fertilizer in the form of NPK (10-18-10) was incorporated into the soil at the rate of 150 kg ha^{-1} at transplanting. Urea at 75 kg ha^{-1} was broadcast at 30 and 60 d after transplanting and plots were hand-weeded. Sweep net samples and observations for insect damage were taken at biweekly intervals from 2 to 12 wk after transplanting. Fifty sweeps plot^{-1} were taken. Data representing insect populations at indicated weeks after transplanting (2–12) are based on 1,800 sweeps (12 crops [1 crop month^{-1}] × 3 plots × 50 sweeps plot^{-1}). Data representing insect populations as per month of transplanting are based on 900 sweeps (6 sample dates × 3 plots date^{-1} × 50 sweeps plot^{-1}).

Root feeders

There are numerous insect species that feed on rice plant roots in West Africa. Some are confined to the roots, while others feed on both the roots and the lower part of the stem at the soil level, causing wilted tillers. Wilted plants may completely disappear from the field by being blown in the wind or by being consumed by saprophytic organisms. Heavily infested fields have many missing hills. Because of their cryptic habit, little is known about the biology and ecology of many of the root-feeding species in West Africa. Root-feeding insects include the mole crickets (family Gryllotalpidae), root aphids (family Aphididae), termites (family Termitidae), black beetles (family Scarabaeidae), and the rice water weevil (family Curculionidae).

The subterranean environment in which root-feeding insects live limits mobility, especially in locating food. As a result, root feeders have adapted by 1) being long-lived either as individuals (beetles), as colonies of social insects (ants and termites), or as dependent on social insects (mealybugs and aphids) and 2) having a wide host range (all species) (Litsinger et al 1987).

Mole crickets, *Gryllotalpa africana* Palisot de Beauvois; Orthoptera: Gryllotalpidae; Figs. 123–124

Mole cricket adults and nymphs are nocturnal and feed on roots. This insect is readily identifiable by its large size and enlarged front legs that are adapted for digging in soil—hence the name 'mole' cricket.

Country distribution. Benin, Burkina Faso, Côte d'Ivoire, Ghana, Liberia, and Nigeria. *G. africana* has been reported from Africa, tropical Asia, Europe, and Japan.

Description and biology. Adult mole crickets are strong fliers and are phototropic, being attracted to lights at night. They are large insects, 25–35 mm in length, and are light brown in color. The front legs are enlarged and modified for burrowing in soil (Fig. 123). The first segment of the thorax is enlarged, which helps the mole cricket to push its way through the soil. At night, adults make branched burrows by their digging action in the soil or they search for food items such as other insects or seeds above ground. They remain underground during the day. Adults are sometimes seen swimming in flooded fields when the paddy is being puddled as flooding causes them to leave their burrows. Thus, mole cricket populations are low in flooded fields where they are mostly found in the levees.

Female mole crickets attract males by chirping. The burrow acts as a resonator of the sound. Each species has a unique calling signal. Males can be attracted by playing back a recording of the mating call.

Female crickets burrow in levees of irrigated fields and construct hardened cells below the soil surface in which the eggs are laid. During its life span of more than 6 mo, each female may lay several hundred eggs in batches of 30–50. Eggs are laid in cells beneath the soil surface and hatch in about 1 mo. Development of the light brown nymphs occurs in the soil and lasts 3–4 mo (Reissig et al 1986, Dale 1994). Adults are highly mobile and can leave a flooded field to locate more suitable habitat (Litsinger et al 1987).

Habitat preference. Although mole crickets occur in all rice environments, they are most prevalent in upland rice when fields are damp (Dale 1994). Irrigated fields are generally not attacked, except before flooding or when water supply is irregular or inadequate causing dry areas to occur (Brenière 1983). When they occur in lowlands, they inhabit rice field levees but evacuate them when water levels rise. Mole crickets prefer low-lying, moist upland soils with high organic matter (Akinsola 1984b). Sandy or light soils are preferred in India (Chatterjee 1973).

Plant damage and ecology. Although mole crickets have been reported as predacious on other insects (Chatterjee 1973) and are cannibalistic, they primarily feed on a number of plant species. In addition to rice, they have been reported as serious pests of other agricultural crops (Matsura et al 1985) and turf and pasture grasses (Nickle and Castner 1984). Mole crickets sometimes feed on germinating seedlings. Severe mole cricket attacks of rice in nursery beds have been reported from Asia (Kureha et al 1974). In rice fields, the feeding of mole crickets can easily kill seedlings with their small root systems. Older plants are more tolerant of injury because of their larger root systems. Mole cricket nymphs and adults dig tunnels and attack stems and roots below the soil level. Sometimes, only the base of one or two tillers of a plant is cut and the damage is only evident when tillers begin to die a few days later. When feeding is severe, the entire plant dies. Dried plants are evident as dead patches in the rice field. In irrigated fields, young and newly planted seedlings are most commonly attacked in the early part of the season before fields are flooded (COPR 1976). Feeding activity most commonly occurs at night. In contrast to field crickets, mole crickets do not carry cut tillers into their burrows (Tripathi and Ram 1968).

Root aphids, *Tetraneura nigriabdominalis* (Sasaki); Hemiptera (suborder Homoptera): Aphididae

Root aphids seldom are widespread, even within a field. Populations are highest in light-textured soils with high percolation rates.

Country distribution. Sierra Leone. *T. nigriabdominalis* is a widely distributed species of root aphid having also been reported from Cuba, Fiji, India, Japan, Malaysia, New Guinea, Taiwan, and Zambia.

Description and biology. The root aphids are soft-bodied insects that live in colonies composed of nymphs and adults (Reissig et al 1986). Eggs develop and remain inside the body of the viviparous females (gives birth to nymphs). A female produces 35–45 nymphs in a lifetime of 2–3 wk. Adult females are 3–5 mm in length, are more or less spherical in shape, and brown. The body of the aphid is usually covered with a thin film of white powder. The females are parthenogenic, producing offspring without mating. The root aphids are normally composed entirely of females. There are winged and wingless forms of adults. Winged adults fly into the rice field from their alternative plant hosts at the beginning of the rice season and rapidly produce young that become wingless adults. Several generations occur on rice. Winged adults are produced when the crop is near maturity and, at that time, the aphids leave rice to seek new plant hosts.

Habitat preference. Root aphids occur in well-drained soils in rainfed environments including upland and rainfed lowlands (Reissig et al 1986). In Japan, they feed on upland rice but not irrigated fields (Dale 1994). In upland fields in China, the aphids are most abundant at the base of hills (Ding 1985). Ants harbor the aphids in their nests over winter or during periods unfavorable for rice plant growth. Root aphids fly to rice plants at the beginning of the rice season and pass through several generations. Populations build up gradually and they become most abundant in the late vegetative and reproductive stages of the rice crop.

T. nigriabdominalis was observed feeding on rice in Sierra Leone during the early wet season (Akibo-Betts and Raymundo 1978). Adults emerge and infest the roots simultaneously with the peach aphid, *Hysteroneura setariae* (Thomas), which feeds on the leaves and grain in April and May. Most of the infestations observed in Sierra Leone seemed to coincide with the infestation of rice by termites, among which *Pericapritermes nigerianus* Silvestri (=*socialis*) was the most abundant species.

Plant damage and ecology. Graminaceous weeds such as *Eleusine indica* (L.), *Pennisetum subangustum* Stapf and Hubb., *Ischaemum rugosum* Salisb., and *Paspalum commersonii scrobiculatum* L. serve as alternate hosts for the root aphid in Sierra Leone (Akibo-Betts and Raymundo 1978). These grasses are most common in upland ecosystems and are the most important weed competitors of rice. Akibo-Betts and Raymundo (1978) suggested removing these weed hosts as a means of controlling the root aphid. The root aphid has many additional hosts throughout the world. In India, it is a pest of finger millet or ragi, *Eleusine coracana* (L.), where up to 200 nymphs and adults may feed on one plant (Gadiyappannavar and Channabasavanna 1973).

Both the adults and nymphs remove plant sap with their sucking mouthparts and, as a result, the rice leaves turn yellow and become stunted. In severe cases, which are rare in West Africa, plants wilt and die. Yield loss occurs mainly through reduced tillering (Litsinger et al 1987). Yield losses due to root aphids in West Africa have not been determined. In Japan, Tanaka (1961) reported that rice root aphids cause yield reductions of up to 50%.

In India, *T. nigriabdominalis* is one of a complex of aphid species that attacks the roots of rice seedlings in nursery beds during the rabi (winter) crop. Populations vary greatly among the various rice cultivars with Jaya having a higher infestation than IR8 (Dani and Majumdar 1978).

Although several aphid species have been reported to serve as vectors of tobacco vein-banding virus (TBMV) in China, *T. nigriabdominalis* did not transmit the virus in laboratory experiments (Fang et al 1985).

Termites, *Macrotermes*, *Microtermes*, and *Trinervitermes* spp.; Isoptera: Termitidae

Termites are known as white ants because of their color and they look like ants. Subterranean termites, of the family Termitidae (subfamilies Macrotermitinae and Nasutitermitinae), are common pests of upland rice in West Africa where they may cause serious damage during dry periods.

Country distribution. Various species are distributed throughout West Africa.

Description and biology. Termites are social insects living in colonies usually composed of a reproductive pair (king and queen) and many sterile workers whose activities include foraging, nest building and maintenance, care of eggs and young, and defense. All species maintain a symbiotic relationship with microorganisms, which are essential for digestion (Logan et al 1990).

The *Macrotermes* and *Microtermes* (Macrotermitinae) lack symbiotic protozoa to help digest plants. Instead, they are fungus-growing termites and depend on the breakdown of plant material in their food through a sophisticated form of symbiosis with a basidiomycete fungus, *Termitomyces*, which is cultivated within the nests on fungus combs constructed from fecal material (Cowie et al 1990).

The *Trinervitermes* (Nasutitermitinae) are characterized by a soldier head, which is extended anteriorly into a tube that emits an adhesive-like repellent for chemical defense.

Habitat preference. Even though rice fields are small and surrounded by perennial vegetation that can serve as a food host, African termites seem to prefer rice (Litsinger et al 1987). Termites are primarily upland feeders but can occur in light-textured soils in rainfed lowland areas. They cannot survive in flooded fields (Reissig et al 1986). In farmers' fields, surveyed in Côte d'Ivoire in the rainy season of 1995, slightly higher levels of termite damage occurred in the savanna zone as compared with the forest zone. Savannas harbor more alternate grass hosts than forest zones. Termite damage in upland rice in the forest region of Côte d'Ivoire is positively correlated (r = +0.61) to the length of the fallow period, prior to growing rice (E.A. Heinrichs, WARDA, 1994, unpubl. data). This may be related to less disturbance in long fallow fields, including burning and land preparation. In studies in the northern Guinea savanna in Ghana, Benzie (1986) reported an increase in termites as a function of the consecutive year's protection from fire. In Senegal, the greater abundance of *Trinervitermes* in habitats not subjected to fire was considered the result of the increased food supply in protected habitats (Roy-Noel 1978).

Logan et al (1990) mention several generalizations with respect to the severity of termite feeding as affected by ecological conditions. Feeding is generally more severe on exotic or introduced plant species or varieties than on indigenous ones, presumably because the latter have evolved some level of resistance. Feeding is more severe on plants that have been subjected to abiotic and biotic stresses such as drought, diseases, weeds, lack of fertilizer, and mechanical or fire damage. Crops planted at low altitudes are more likely to be attacked than those in highland areas because altitude often limits termite distribution. Also, with some notable exceptions, termites cause more severe damage in drier savanna than in wet forest agriculture.

Plant damage and ecology. Of the approximately 2,500 termite species in the world, about 300 are recorded as pests (Logan et al 1990). In Nigeria, 120 species have been identified, but only 20 damage crops and buildings (Logan 1992). Although most termite species feed on dead plant materials, a few attack living plants in the soil. Under adequate rainfall, termites cause little damage, but they can destroy drought-stricken rice plants. Harris (1969), IITA (1971), and Malaka (1973) have reported that *Macrotermes*, *Microtermes*, and *Trinervitermes* feed on upland rice in Nigeria. Nineteen species of termites have been associated with upland rice in Nigeria, of which *Macrotermes* is the most common and destructive genus (Obasola et al 1981).

Wood and Cowie (1988) considered termites to be the most significant soil pests of crops in Africa. They cited examples of damage to maize, sorghum, wheat, barley, teff, and upland rice by *Macrotermes* and *Microtermes*. They reported on yield losses caused to various crops but did not include rice.

Microtermes feed on the plant's root system, whereas *Macrotermes* cut seedlings at the base of the stem just below the soil surface or just above the soil surface. *Trinervitermes* are foragers that feed on green and dry leaves and inflorescences of grasses.

In Africa, both *Trinervitermes* and *Macrotermes* build mounds. *Macrotermes* build large epigeal nests (mounds), which house many thousands or even up to 2 million termites (Collins 1981), and construct shallow subterranean foraging galleries radiating from the nest for distances up to 50 m (Darlington 1982). The main galleries give rise to a network of smaller galleries from which foraging parties exploit potential food resources over extensive areas. Their usual food is dead wood, grass, and dung. They forage on the surface, often under the cover of earthen runways that protect them against desiccation and predators. Normally, crops are not affected, but under dry conditions and when alternative food is scarce, crops can be damaged (Kooyman and Onck 1987).

Macrotermes feed on plants at the seedling stage, attacking them at the base of the stem. Usually, the seedlings are completely severed, resulting in low plant populations (Wood and Cowie 1988). Farmers in areas where *Macrotermes* damage is prevalent use higher than recommended sowing rates to compensate for the expected loss of seedlings. *Macrotermes* occasionally cut the base of older, well-established plants, but this is insignificant compared with the seedling damage.

Microtermes, which are strictly subterranean, do not build mounds. Their nests consist of a diffuse network of galleries and chambers. The chambers, in which the fungus combs are located, have a subspheroidal shape and a diameter of 2–4 cm. Galleries have a circular cross-section of 800–1,200 cm. Both the chambers and galleries are plastered with clay and saliva and have a glossy appearance (Kooyman and Onck 1987).

Plant damage by *Microtermes* occurs late in the crop growth stage when they attack maturing plants. In contrast to the readily observable damage by *Macrotermes*, damage by *Microtermes* has no immediate observable effect on the plant. *Microtermes* enter and consume the large roots and continue their excavations into the stem, hollowing it out and frequently filling it with soil. Evidence of these subterranean attacks is when plants fall over due to weakened root systems or weakened stems. Yield losses due to lowered translocation of water and nutrients depend on the timing of the attack in relation to grain development. Lodged plants suffer further damage from ground-dwelling pests, including termites, ants, and rodents and from saprophytic fungi and bacteria. Excessive wind and rain increase lodging (Wood and Cowie 1988).

Trinervitermes build small mounds from which they forage on a wide range of grass species (Cowie et al 1990). The *Trinervitermes* genus in Nigeria is composed of two groups: those that store grass fragments in their mounds and those that do not (Sands 1961). The grass storers are *T. ebenerianus* Sjöstedt, *T. carbonarius* Sjöstedt, and *T. suspensus* Silvestri. The nonstorers are *T. oeconomus* (Trägårdh) and *T. auriaterrae* Sjöstedt. *T. ebenerianus* emerges from holes in the mound or from subterranean tunnels and forages at night in about a 10-m radius around the mound. Foraging in northern Nigeria ceases during the wettest months (July to September) and during the cold, dry months (November to February). High foraging activity occurs at the beginning and end of the rainy season, March to May and September to October, respectively. Little information is available regarding the extent of termite damage on rice and its overall economic effect in West Africa. Damage is extremely variable in space and time and is apparently dependent on the level of rainfall and subsequent drought stress. In a study on the relationship between length of fallow period and insect damage conducted in upland fields in the forest zone near Gagnoa, termite-damaged plants in upland fields ranged from 0 to 78% with an average of 14% for 20 farms (E.A. Heinrichs, WARDA, 1995, unpubl. data). Such levels are considered to be of significant economic importance.

Termites also have some positive attributes in enhancing soil fertility. However, there is little information on the overall value of termites to the small-scale farmer and on the extent that the beneficial value of termites outweighs the damage that they cause (Logan 1992). Termites process 8% of the annual litter production in the sahelian dry savannas of Senegal and 28% of the litter production in the humid savannas of Côte d'Ivoire. In studies conducted in the humid savanna zone in Côte d'Ivoire, the food habits result in the preservation of energy and nutrients from fire and thus, termite foraging activities are beneficial for the savanna ecosystem (Lepage et al 1993).

Termites have been referred to as "the earthworms of the tropics" for their role in soil aeration. Some farmers in Burkina Faso manage termites to improve the physical properties of soils (Logan 1992). Manure is put in shallow holes near newly planted millet seed to attract termites. The farmers believe that termite tunnels allow rainwater to accumulate in the holes and percolate into the soil. According to Wardell (1990), soil enrichment occurs around termite sites due to the biological wastes associated with the termites and the fact that they bring in nutrients from a wide surrounding area. However, there is conflicting information on the fertility of soils in termite mounds (Logan 1992).

In some cases, crop growth on mounds or in soil from mounds is enhanced; in others, growth is inhibited. The effect of termite mounds on soil fertility depends on the termite species, type of mound, soil type, depth of the water table, and crop grown. Azande farmers in the Congo have found that cowpea, white sorghum, and rice grow better on termite mounds, but groundnuts grow better on the surrounding soil (De Schlippe 1956). In Africa, termites are a popular human food that provides protein and energy when other foods are scarce. In some regions, termites are a delicacy eaten only by tribal chiefs (Logan 1992). Women and children in Nigeria collect winged reproductives and queens of *Macrotermes natalensis* Haviland for eating by all age groups (Fasoranti and Ajiboye 1993). In Bouaké, Côte d'Ivoire, the author has observed hordes of people frantically catching swarming termites under street lights after the first rains of the rainy season.

There is little known regarding the ecology of termites despite their importance as pests in tropical and subtropical habitats (Benzie 1986). Termite faunas have been reported to change with land use. When forests are cleared for agriculture, mound-building species (e.g., *Trinervitermes* spp.) and species dependent on wood and woody litter (e.g., *Macrotermes* spp.) decrease, while those with deep subterranean nests and the ability to live on crops and crop residues (e.g., *Microtermes* spp.) increase (Cowie et al 1990).

Black beetles, *Heteronychus mosambicus* Peringuey (= *H. oryzae* Britton); Coleoptera: Scarabaeidae: Dynastinae

The Scarabaeidae family is divided into two groups: the 'chafers' or 'white grubs' (subfamilies Melolonthinae and Rutellinae), in which adults feed on tree leaves and the larvae feed on roots of living plants; and the 'black beetles' (subfamily Dynastinae), in which the adults feed on roots of living rice plants and the larvae, or grubs, feed on organic matter in the soil but do not feed on living plants. The black beetle feeds on numerous crop species including upland rice.

Country distribution. Nigeria, Senegal, Sierra Leone, and Togo.

Other black beetle species from rice in Côte d'Ivoire in the WARDA Arthropod Reference Collection (Table 5) are *Onthophagus* spp., *Geotrupes auratus* Motschulsky, *G. leaviatriatus* Motschulsky, *Schizonycha* sp., and *Bupachytoma* sp. (Figs. 315–316). Litsinger et al (1987) list the following species as occurring in upland rice in Africa: *Heteronychus andersoni* Jack, *H. bituberculatus* Kolbe, *H. licas* (Klug), *H. mosambicus*, *H. arator* (Fabricius), *H. plebejus* (Klug), *H. pseudo-congoensis* Ferriere, *H. rugifrons* Fairmaire, and *H. rusticus niger* (Klug).

Description and biology. The larvae of the scarab (Scarabaeidae family) beetles can be distinguished from other soil-inhabiting larvae by the swollen end of their abdomens. The adult black beetle, *H. mosambicus*, is about 10 mm long and reddish-brown to black with reddish-brown legs. The beetle breeds in decomposing plant material such as rotting weeds. Eggs are deposited singly. The larvae are typical grubs with a brown head and a white body. The life cycle of this species is long, taking several months to pass through the egg, larval, and pupal stages before they become adults. The adult black beetle adults can live up to 1 yr (Reissig et al 1986).

Habitat preference. Larvae feed only on organic matter in dryland fields and do not feed on rice. Feeding by the adults is restricted to nonflooded environments. Adults are highly mobile and, although sensitive to flooding, invade rice fields soon after they drain (Litsinger et al 1987). An outbreak in Rokupr, Sierra Leone, occurred in direct-seeded rice near a mangrove swamp (Agyen-Sampong 1977a).

Plant damage and ecology. The beetle attacks newly sown rice up to the age of 6 wk (COPR 1976). At Rokupr, the adults began feeding on rice at the two-leaf stage. The adults feed on rice stems and roots a few centimeters below the ground level. The first sign of damage is wilting of the central leaves, followed by the progressive wilting of outer leaves. Finally, the entire plant withers, turns brown, and dies. The beetles move below the soil surface, leaving behind a raised track as they move from one seedling to another. Severely damaged fields have to be resown. Damage is most severe when the rice plants are exposed to drought when they are less able to replace the eaten roots. Another *Heteronychus* species, *H. arator*, causes similar damage to rice in South Africa (COPR 1976) and *H. lioderes* Redtenbacher feeds on rice in India (Kushwaha 1981). *H. lioderes* damages both the seedlings in the nursery and the transplanted crop in irrigated fields. In Bangladesh, feeding at the base of the rice stem by *H. lioderes* causes whitehead development (Shahjahan et al 1983). In Madagascar, *H. plebejus* damages rice growing in humid soil during the dry season and *H. mosambicus* feeds on rice roots in Malawi (Grist and Lever 1969).

Rice water weevils, *Afroryzophilus djibai* Lyal; Coleoptera: Curculionidae

In the late 1980s, S. Djiba of the Institut Sénégalais de recherches agricoles, Djibelor, Senegal, found that water weevil larvae were causing damage in flooded fields adjacent to mangrove swamps and the Casamance River (Djiba 1991). Using specimens collected in Djibelor, C.H.E. Lyal of the Natural History Museum, London, described *Afroryzophilus djibai* as a new species (Lyal 1990).

Country distribution. Distribution in West Africa, outside of Casamance, Senegal, has not yet been determined.

Description and biology. *Afroryzophilus djibai* was originally thought to be the rice water weevil, *Lissorhoptrus oryzophilus* Kuschel, one of the major pests of rice throughout the southern USA rice belt and in California. This native North American insect has, in the last few decades, become established in Japan and Korea and might therefore be expected to occur in other rice-growing areas of the world. However, the West African weevil has proved not to be *Lissorhoptrus* but, as described by Lyal (1990), is a previously unknown genus and species.

A long-nosed weevil in the phanerognathous subfamily Erirhininae, this species belongs to the same group as *Lissorhoptrus* and other Gramineae-feeding Erirhininae, including *Echinocnemus* and *Hydronomidius*. In India, these latter two rice water weevils cause damage similar to that of *L. oryzophilus* in North America (Pathak 1969). Allied *Lissorhoptrus* species are also pests of rice in South America.

The larvae of *A. djibai* are very similar in appearance to those of *Lissorhoptrus* species, differing only in having dorsomedial spiracles on abdominal segment I and conical dorsal projections on the terminal abdominal segment. Pupae are similar to those of *Lissorhoptrus*, differing only in their smaller size and elongate shape. Adult *Afroryzophilus* differ from all other Erirhininae in that their mandibles are toothed externally.

The biology of *A. djibai* is not well known; however, Lyal (1990) provides a brief description. In general, it is similar to that of *L. oryzophilus*, which has been studied extensively in the USA (Bowling 1967) and Japan (Okada 1982). The adults feed on the rice leaves and oviposit within the leaf sheath. Larvae, upon hatching, move down to the rice roots where they feed. The presence of the dorsal spiracular hooks indicates that the method of obtaining oxygen, when submerged in flooded paddies, is similar to that in *Lissorhoptrus*. Although not confirmed by research, it is most likely accomplished by the piercing of inflated cells of submerged rice roots.

As in *Lissorhoptrus* and other members of the group, the pupa develops in a case that is thinly covered with soil and is attached to the rice roots. Adult weevils have been collected from rice plants and in light traps. Further detailed studies on the distribution and biology of this insect are needed.

Habitat preference. *A. djibai* has been found in flooded rice fields adjacent to mangrove swamps and the Casamance River in Senegal (Djiba 1991). It is aquatic as a larva and the larva is only found in flooded fields.

Plant damage and ecology. The adults make longitudinal feeding scars on the leaves. However, major damage is caused by the larvae that feed on the roots. The reduced root volume affects plant growth and heavy infestations most likely delay maturity and reduce yield (S. Djiba, Institut Sénégalais de recherches agricoles, 1996, pers. commun.). Based on yild loss studies and the known economic importance of *L. oryzophilus* in the USA, Lyal (1990) suggests that *A. djibai* may have potential to cause serious damage to rice in West Africa. Thus, rice entomologists should be aware of its occurrence and should conduct research to determine its importance.

Stem borers

Stem borers are key pests of rice in West Africa as they are in other rice-growing regions throughout the world. Rice stem borers in West Africa belong to two orders, the Diptera (flies) and Lepidoptera (moths). The dipterous stem borers consist of the Diopsidae and Chloropidae families and the lepidopterous stem borer complex consists of the Noctuidae and the Pyralidae families (Table 5). Meijerman and Ulenberg (1996) developed a taxonomic key to the African noctuid and pyralid stem borer larvae and gave the geographical distribution of the various species.

Although there is a number of species that feed on rice in West Africa (Table 2), four are considered to be of major importance: the dipterous stalk-eyed fly (*Diopsis longicornis*) and the lepidopterous white stem borer (*Maliarpha separatella*; Fig. 88), striped stem borer (*Chilo zacconius*; Fig. 92), and pink stem borer (*Sesamia calamistis*; Figs. 84–85) (Akinsola 1975, 1979; Alam 1988; Alam et al 1985a). Although *Busseola fusca* (Fuller) and *Eldana saccharina* Walker (Noctuidae) occur in rice (Khan et al 1991) and have been observed in rice grown as an intercrop with maize in Côte d'Ivoire (Fig. 11), their populations in rice are generally low. They are more important as pests of maize, millet, sorghum, and sugarcane (Betbeder-Matibet 1981; Gasogo 1982; Kaufmann 1983; Sampson and Kumar 1983, 1985, 1986; Khan et al 1991; Conlong 1994).

Plant damage caused by the dipterous and lepidopterous stem borers differs. The dipterous borers occur early in the crop season and cut the internal portion of the stem in a slanting fashion about 10 cm

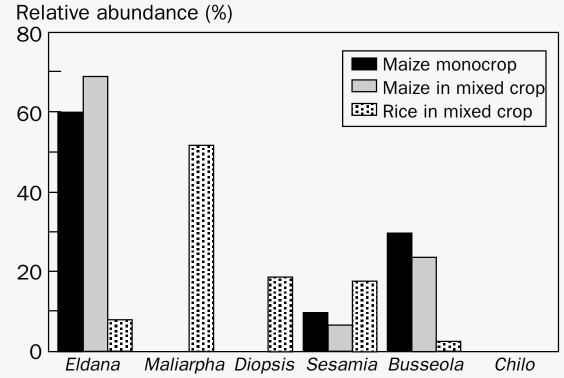


Fig. 11. Relative abundance of six genera of stem borers in maize in a maize monocrop; in maize in a maize/rice mixed crop; and rice in a rice/maize mixed crop. Farmers' fields, forest zone, Côte d'Ivoire, November 1994 (Heinrichs and Schulthess 1994).

above the ground level, which causes 'deadheart' symptoms (Brenière 1983). The lepidopterous borers feed on young plants at the tillering stage, which also causes deadhearts. However, at flowering, they feed a few centimeters below the panicles, resulting in white or dry panicles called 'whiteheads'. In addition, when mature larvae lodge in the lower parts of the stems, they may reduce or interrupt panicle growth. When this occurs during the milk stage, the drying of one or more spikelets occurs, reducing the number of harvestable grains. This damage, although much less visible than deadhearts or whiteheads, reduces grain weight. Stem borer feeding is most damaging when it occurs after tillering because plants cannot produce any more tillers.

The general biology of the lepidopterous species is similar. Nocturnal adults oviposit on rice leaves or between the leaf sheath and the stem. Newly hatched larvae move on the plant surface and to neighboring plants by means of a silk thread that they attach to leaf tips. Larvae feed at first on the leaf but shortly thereafter penetrate through the leaf sheaths into the interior of the rice stems. Pupation occurs in the stem or in the folds of leaf sheaths or, occasionally, in the soil. There are generally two generations on a given crop and five to seven generations annually in a given area, depending on the availability of suitable host plants (Brenière 1982).

Percentage species composition of stem borers varies among the climatic zones of West Africa. In a survey conducted in Guinea (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data), *Diopsis longicornis* adults were more abundant than *D. apicalis* Dalman adults. However, for each *Diopsis* species, there was no difference in the number of adults between the two climatic zones, the forest and Guinea savanna. In July, August, and October surveys conducted in Côte d'Ivoire in 1995, percentage species composition of stem borer larvae in the forest and Guinea savanna, as based on rice stem dissections, varied depending on the date. In July, *Diopsis* spp. and *Chilo* spp. were the predominant species in both zones (Fig. 12). In August, *Sesamia* was most abundant in the forest and *Diopsis* the most abundant in the savanna, while in October, *Sesamia* was again the most abundant in the forest and *Sesamia* and *Chilo* the most abundant in the savanna. *Scirpophaga* was the least abundant, being present slightly more in the savanna than in the forest.

The relative abundance of rice stem borers is influenced by micro-environmental conditions (Akinsola 1990) and plant growth stage. *Maliarpha separatella* has been reported to be abundant in both upland and lowland environments. *Sesamia* spp. predominate in upland rice. *Chilo* spp. are most abundant in lowland rice. However, surveys conducted in July, August, and October in Côte d'Ivoire indicated that the relative abundance of the different stem borers in upland and lowland rice varies, depending on the month and thus the plant age. All borers occurred in both the upland and lowland rice ecosystems. The abundance of *Diopsis* compared with that of other borers was highest in the uplands in July (Fig. 13), whereas *Sesamia* was the most abundant in the uplands in August and *Chilo* the most abundant in October. *Diopsis* was equal to

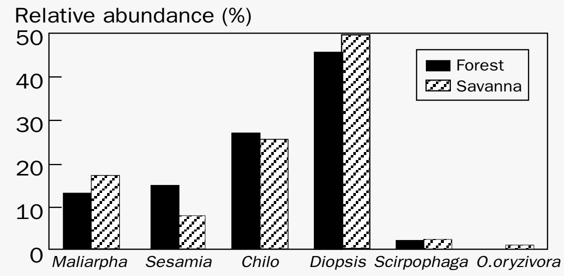


Fig. 12. Relative abundance of five stem borer genera and gall midge in the forest and savanna zones in Côte d'Ivoire, July 1995 (E.A. Heinrichs, WARDA, 1995, unpubl. data).

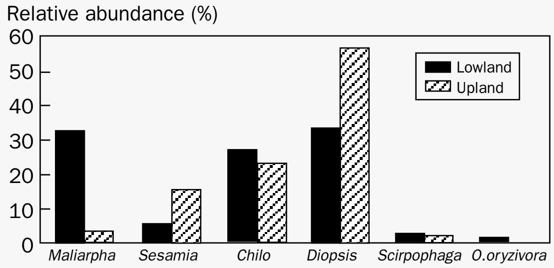


Fig. 13. Relative abundance of five stem borer genera and gall midge in upland and lowland environments in Côte d'Ivoire, July 1995. Data based on a composition of both forest and savanna zones and all crop growth stages (E.A. Heinrichs, WARDA, 1995, unpubl. data).

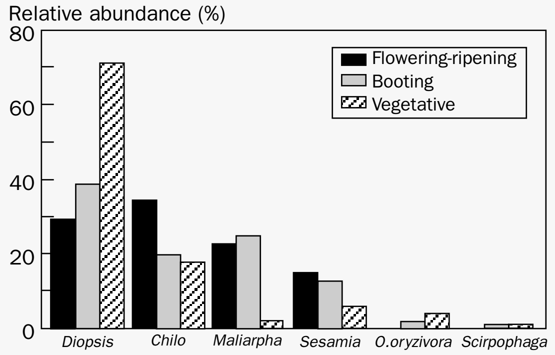


Fig. 14. Relative abundance of five stem borer genera and gall midge, *Orseolia oryzivora* Harris & Gagne in three crop growth stages in Côte d'Ivoire, July, 1995. Data based on a composition of both forest and savanna zones and lowland and upland environments (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Maliarpha in the lowland in July (Fig. 13) and the most abundant in August, while *Sesamia* was the most abundant in October.

These genera also differ in their preferred stage of plant growth. In general, lepidopterous stem borers are rare in nurseries and during the early vegetative stage of rice development, while feeding by the dipterous stem borers occurs early during plant development.

Results of studies on the relative abundance of stem borers and the African gall midge *O. oryzivora* in farmers' fields in Côte d'Ivoire in July (Fig. 14), August, and October 1995 indicated that *Diopsis* was the most abundant genus in the vegetative stage, but by the flowering-ripening stage, its abundance had severely decreased. In the July survey (Fig. 14), *Chilo* was most abundant in the flowering-ripening stage but in the August and October surveys, *Sesamia* was relatively the most abundant genus at the flowering-ripening stage.

At this point, the stalk-eyed flies warrant a special mention. Adult diopsid flies are easily recognized by their characteristic eyes and small antennae on the tip of stalks; hence their name. Several species of *Diopsis* have been reported as feeding on rice. Descamps (1956, 1957a) reported *D. longicornis*, *D. tenuipes* (Westwood), *D. collaris* Westwood, and *D. serveillei* Macquart as stem borers in rice in West Africa. In addition, we have also collected *D. lindneri* Feijen and *Diasemopsis meigenii* (Westwood) in rice in Côte d'Ivoire (Table 5). *Diopsis thoracica* Westwood and *D. macrophthalma* Dalman are synonyms of *D. longicornis* (Fig. 98) and *D. tenuipes* Westwood is a synonym of *D. apicalis* Dalman (Fig. 99; Feijen 1986).

Based on feeding behavior, larvae of *Diopsis* can be divided into two groups: those having obligatory phytophagy such as *D. longicornis* and those with optional phytophagy, such as *D. apicalis* (Scheibelreiter 1974). Feijen (1986) believes that a future systematic revision of the genus *Diopsis* will include additional species occurring on rice. Because *D. longicornis* and *D. apicalis* appear to be the most important species of the complex, and the most studied, they are the ones we emphasize.

Stalk-eyed fly, *Diopsis longicornis* Macquart; Diptera: Diopsidae; Fig. 98

Of the various *Diopsis* species that have been collected in rice, *D. longicornis* Macquart has been reported as being the most abundant and most important (Vercambre 1982, Cocherau 1978).

Country distribution. Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal, Sierra Leone, and Togo.

Description and biology. The adults (Fig. 98), which are the largest of the various *Diopsis* species observed in rice, have a distinct black thorax and reddish-orange abdomen. The flies are found in areas with water throughout the year and occur in swarms in shady areas near streams and canals and on weeds along levees in fallow lowlands during the dry season.

In studies at M'bé, Côte d'Ivoire, adults were observed in lowland fields throughout the year. Adult populations in a monthly planting study (Fig. 15) were highest in the plots planted in November and lowest in May. In the same study, flies appeared shortly after transplanting and reached a peak at 8 wk after transplanting (WAT; Fig. 16). By 12 WAT, there were few flies left in the field. Thus, based on the 8-WAT peak for flies, the highest population for the November planting occurred in December-January.

Alghali (1984b) described mating behavior, which occurs on the rice plant. The male flies toward the female that is on the rice plant. The male holds the female at the thoracic region with its tarsi. The female

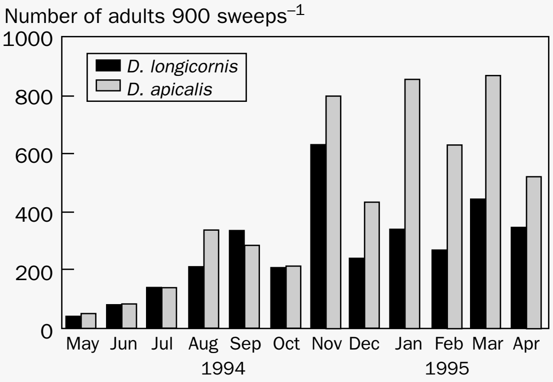


Fig. 15. Number of *Diopsis longicornis* Macquart and *D. apicalis* Dalman adults collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994 to April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

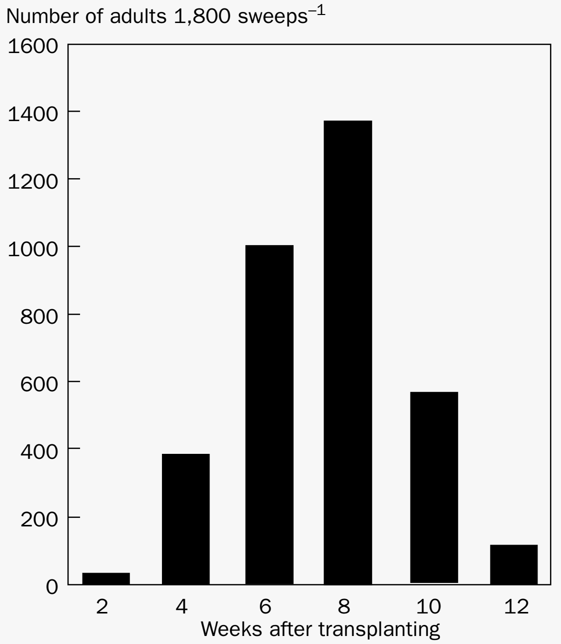


Fig. 16. Number of *Diopsis longicornis* Macquart adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994 to April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

stretches its middle and hind legs, spreads its wings and curves the abdominal tip so that copulation is possible. Mating takes about 5–8 min after which the male flies away. Occasionally, flies mate several times with the same partner or with a new partner after a few minutes.

Age of the rice plant affects both the number of eggs laid and the oviposition substrate (Alghali 1983). Gravid females lay eggs singly on the upper surface of young leaves, normally in the midrib groove of the subterminal leaf (Fig. 17). In older plants, the eggs are placed on the leaf sheath (Alghali and Osisanya 1981, Alghali 1983). Peak of oviposition on the leaf blades occurs about 30 d after transplanting (DT), while oviposition on leaf sheaths occurs about 10 d later. Boat-shaped, striated eggs, 1.7 ± 0.4 mm, with a characteristic anterior projection, are attached to the leaf with a glue-like substance that prevents them from being washed off in heavy rains (Hill 1975). Eggs are creamy white when laid but later turn to tan. Each female lays about 30 eggs over a 20-d period at the rate of a maximum of four eggs day^{-1} (Brenière 1983). Peak oviposition occurs at 30–40 DT and practically terminates by the end of the tillering stage (Alam 1988, Umeh et al 1992). Virtually no eggs are laid and no deadhearts develop on 60-d-old plants (Alghali and Osisanya 1981).

The eggs hatch 2–3 d after oviposition. About 60 d are required from hatching of the larvae through to the maturation and mating of the adults and egg-laying for the next generation. Two long extensions on the abdomen that end in black hooks pointed forward make the larvae easy to recognize. The larvae are yellowish maggots, about 18 mm long and 3 mm wide. Upon hatching, they move down inside the leaf sheath and feed above the meristem on the central spindle of young leaves, causing deadhearts. Larvae move readily from one tiller to another. One larva can destroy up to 10 neighboring tillers (Feijen 1979). Later generations feed on the developing flower head. The larval stage lasts for 25–33 d (Cocherau 1978). Prior to pupation, the larvae move to new tillers within the same rice hill or stay on the damaged tillers and move to the outer leaf sheaths.

Pupation normally occurs in the first three leaf sheaths (Alghali 1984c) of healthy tillers, generally one pupa per tiller. Pupa-bearing tillers remain healthy. The pupae, which are red with brown dorsal bands, are flat and almost triangular because of the compression inside the stem. During the later stages, the winged adult can be seen inside the pupal case. After a 10- to 12-d pupation period, adults emerge and mating occurs on the rice plant. Between 15 and 20 d of maturation are required after emergence before the females begin laying eggs. Two principal generations occur between June and October and a third less prominent generation during the off-season.

Habitat preference. *Diopsis longicornis* is equally present in the three climatic zones (humid tropical, Guinea savanna, and the Sudanian savanna) according to the literature (Table 2). Adult populations based on sweep net counts in the three surveys conducted in Côte d'Ivoire and in a survey conducted in Guinea in 1995 are illustrated in Figure 18. The date of the survey had an effect as *D. longicornis* adults were more abundant in the savanna in the July Côte d'Ivoire survey but more abundant in the forest in the August and October surveys (E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data). In a survey conducted in Guinea in September, *D. longicornis* adult populations were similar in the forest and the Guinea savanna (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data).

Percentage of the stem borer larval population consisting of *Diopsis* spp. in the 1995 Côte d'Ivoire survey was highest in both the savanna and the forest in July (Fig. 12) and highest in the savanna in the August survey. The percentage of tillers infested by *Diopsis* spp. larvae in the July and August surveys was slightly higher in the savanna.

Diopsis longicornis is reported as a major pest of rice in many parts of tropical Africa. Severe damage has

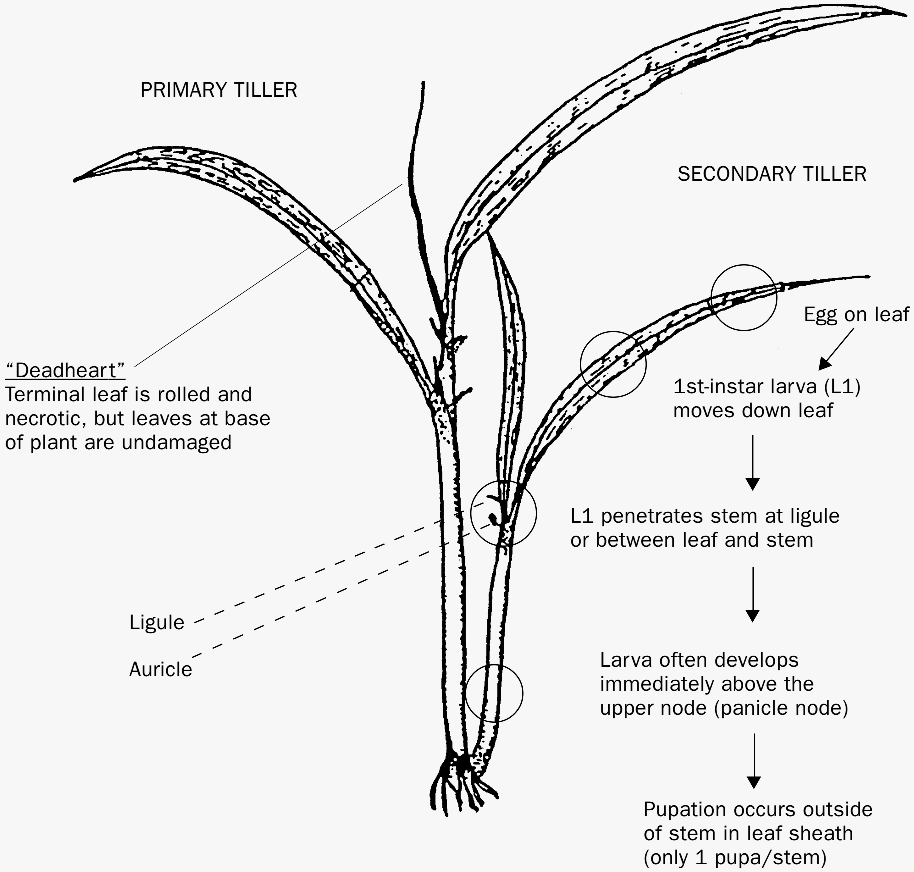


Fig. 17. Chronological development of stalk-eyed fly, *Diopsis longicornis* Macquart, attack on the rice plant from egg to pupa (modified from Pollet 1977).

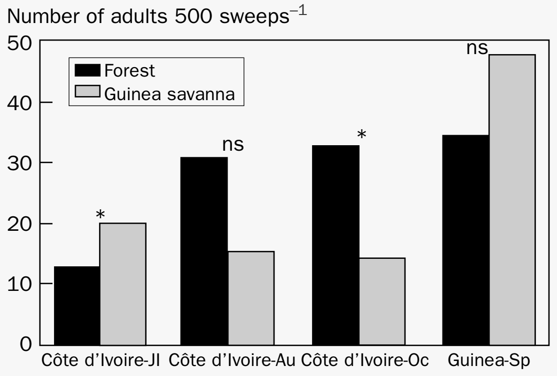


Fig. 18. Relative abundance of stalk-eyed fly adults collected with a sweep net in farmers' fields in the forest and Guinea savanna zones in Côte d'Ivoire in July (Jl), August (Au), and October (Oc) and in Guinea in September (Sp), 1995. Asterisks indicate statistical significance between the two zones at the 0.05 probability level (E.A. Heinrichs, WARDA, 1995, unpubl. data).

been reported in Sierra Leone and the Benue Valley of northern Cameroon. In Senegal, it only occurs in the south. In Burkina Faso and Mali, it is a sporadic pest in areas that have sufficient humidity during the dry season.

This stem borer occurs in all rice ecosystems in West Africa (Table 4). However, it is most abundant in rainfed lowland and irrigated ecosystems. It has been reported to infest irrigated rice fields in Benin and Côte d'Ivoire where it also occurs in rainfed fields (Brenière 1976). Studies conducted in Guinea indicated that transplanted rice was much more severely damaged than direct seeded rice in the dry season but no differences were observed in the wet season (Chiasson and Hill 1993).

Adult populations are responsive to both toposequence site and weed abundance (Fig. 19). In studies conducted at M'bé, Côte d'Ivoire (E.A. Heinrichs, WARDA, 1992, unpubl. data), adult numbers increased at lower toposequence sites—being most abundant in the lowlands and least abundant in the uplands. Adult populations were highest in the

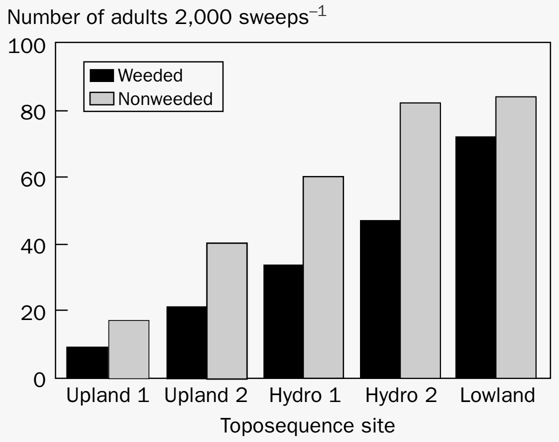


Fig. 19. Relative abundance of *Diopsis longicornis* Macquart adults collected by sweep net in weeded and nonweeded plots at five toposequence sites on the continuum. Data based on a total of five sampling dates and eight rice varieties (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

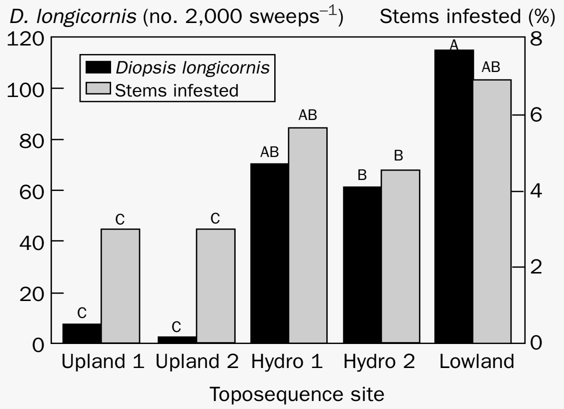


Fig. 20. Relative abundance of stalk-eyed fly adults collected by sweep net and percent of stems infested with stem borer larvae (including *D. longicornis* Macquart) at five toposequence sites on the continuum. Bars within a parameter (number or percent infested) with the same letter are not significantly different at the 0.05 probability level by Duncan's multiple range test (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

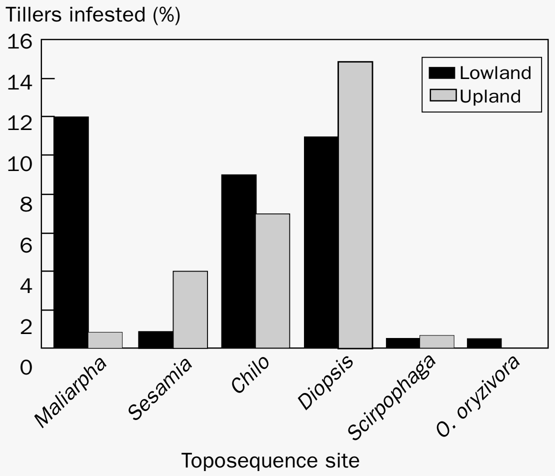


Fig. 21. Relative damage caused by five stem borer genera and gall midge in lowland and upland sites in farmers' fields in Côte d'Ivoire, July 1995. Data based on a composition of all crop growth stages and the forest and Guinea savanna zones (E.A. Heinrichs, WARDA, 1995, unpubl. data).

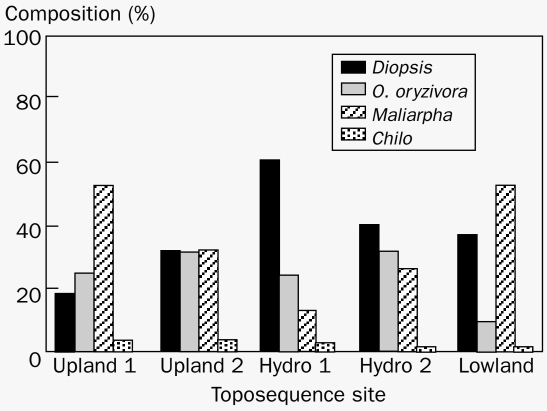


Fig. 22. Relative percentage genera composition of three rice stem borers and gall midge larvae at each of five toposequence sites on the continuum as based on tiller dissections (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

nonweeded plots. In another study conducted at M'bé (E.A. Heinrichs, WARDA, 1995, unpubl. data), adult populations were very low in the uplands but increased sharply in the hydromorphic zones and were highest in the lowlands. Percentage of stems infested with stem borer larvae (including *Diopsis* spp.) was also low in the upland sites and high in the hydromorphic and lowland sites (Fig. 20).

In a 1995 survey conducted in Côte d'Ivoire, based on percent species composition of stem borer larvae, *Diopsis* spp. larvae in rice stems were the most abundant of the various stem borer species in the uplands in July (Fig. 13). They were the most abundant species in the lowlands in the August survey. Percent of tillers infested by *Diopsis* spp. in the two surveys was similar for the lowlands and uplands. Percent of tillers infested with *Diopsis* spp. larvae was 11 and 15% in the lowlands and uplands, respectively, in the July survey (Fig. 21) and 13 and 12% in the August survey.

Figure 22 shows the percentage larval composition of stem borer species in rice stems on the continuum toposequence sites at M'bé. *Diopsis* spp., including *D. longicornis* and *D. apicalis*, are the predominant species in the hydromorphic sites.

In mangrove swamps in Gambia, *Diopsis* spp. make up 7% of the larval population in stems. The lepidopterous borers—*M. separatella*, *Chilo* spp., and *S. calamistis*—make up 82, 5, and 4%, respectively, and the dipterous gall midge, *O. oryzivora*, 2% (Jobe 1996).

Nitrogen level affects *D. longicornis* density. In tests conducted at M'bé, populations were lowest at 0 kg N ha^{-1} (0.4 sweep^{-1}) and reached a peak at 150 kg N ha^{-1} (1.2 sweep^{-1}). Populations then decreased at 200 kg N ha^{-1} (0.8 sweep^{-1}) and 250 kg N ha^{-1} (0.7 sweep^{-1}) (E.A. Heinrichs, WARDA, 1994, unpubl. data).

Plant damage and ecology. The survey conducted in Côte d'Ivoire in 1995 indicated that *Diopsis* spp. were the most abundant group in the stem borer complex, based on a total of collections in all climatic zones, ecosystems, and plant stages (Fig. 23). *Diopsis longicornis* has been reported to be primarily a rice feeder but may feed on crop plants other than rice such as wild rices and grasses. *Cyperus difformis*, a weed commonly found in rice fields, on which eggs, larvae, pupae, and adults have been found, may be a host plant during nonrice cropping seasons (Alghali 1979). In addition to the Cyperaceae, many of the grasses of the Poaceae family have been reported as hosts by Descamps (1957b), Zan et al (1981), and Alghali and Domingo (1982).

Although *Diopsis* larvae are present in stems throughout the crop growth period, they are most abundant in younger plants (Joshi et al 1992), possibly because of low silicon deposits. This pest attacks rice plants early in the crop growth stage (usually under 10 cm), shortly after emergence in direct-seeded fields or shortly after transplanting. Percent tiller infestation by *Diopsis* spp. in the July (Fig. 24) and August 1995 Côte d'Ivoire surveys was highest in the vegetative stage, intermediate in the booting stage, and low in the flowering-ripening stages.

In irrigated rice in Ibadan, Nigeria, adults appear before 20 DT and peak at 40 DT, at the beginning of panicle initiation (Alam 1988). Alghali (1983) reported oviposition in irrigated rice beginning at 10 DT and peaking at 30 DT. Deadhearts caused by *D. longicornis* appeared by 10 DT, peaking at 30 DT, and terminating by 60 DT. Oviposition on upland rice at M'bé continued from 3 to 10 wk after sowing (WAS) with a peak occurring 4 to 5 WAS (Dankers 1995). Deadhearts caused by *Diopsis* feeding were observed to occur by 6 WAS with a peak at 9 WAS. In mangrove rice in Gambia, *Diopsis* spp. were the most abundant of the five stem borers found in rice stems at the tillering stage, while *M. separatella* became the most abundant at flowering and maturity (Jobe 1996).

Descamps (1957a), Jordan (1966), Grist and Lever (1969), Brenière (1969, 1983), Pollet (1977), Feijen (1977, 1979), Cocherau (1978), Vercambre (1982), and Umeh et al (1992) have reported on damage in rice caused by *D. longicornis*. Generally, only one larva occupies a stem. The larva, feeding within the stem, makes a slanted cut, usually about 10 cm above the ground. Feeding of the larvae on the central shoot results in a deadheart. Most authors report that each infested tiller is destroyed. However, Feijen's studies indicated that larval feeding kills the last emerged leaf, but the stem is not killed and produces new leaves to compensate for the damage. The same larva feeds on the newly developed leaves and thus one larva can produce up to four deadhearts in succession on one plant.

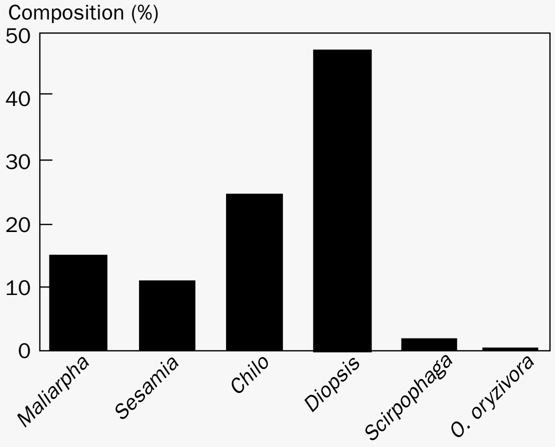


Fig. 23. Relative percentage composition of larvae of five stem borer genera and gall midge in farmers' fields in Côte d'Ivoire, July 1995. Data based on a composition of both forest and savanna zones, all crop growth stages, and lowland and upland environments (E.A. Heinrichs, WARDA, 1995, unpubl. data).

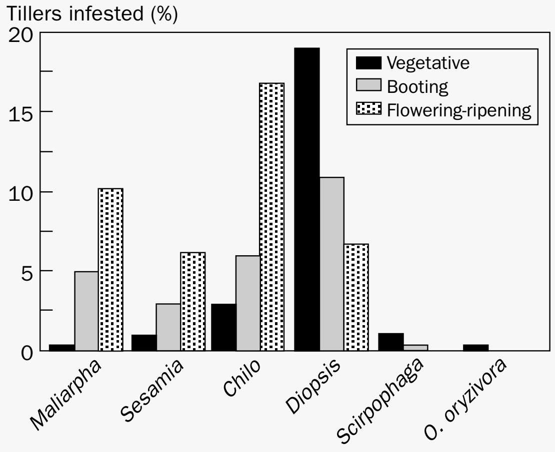


Fig. 24. Percent of rice tillers infested with five stem borer genera and gall midge at three rice growth stages in farmers' fields in Côte d'Ivoire, July 1995. Data based on a composition of both forest and Guinea savanna zones and lowland and upland environments (E.A. Heinrichs, WARDA, 1995, unpubl. data).

In studies conducted in Malawi, Feijen (1979) found that larvae remain in the same stem to pupation, except when small seedlings are attacked. Other authors have reported from 3 to 10 stems attacked by one larva. Pollet (1977) reported that larvae leave the stem at the first sign of necrosis and thus only 40% of the deadheart-damaged tillers examined were infested with a larva.

There is a great variation in the yield losses reported as caused by *D. longicornis*. Several estimates of infestation levels and yield loss have been reported from Ghana. Schröder (1970) reported 35–60% hills infested in a survey. In a wet-season survey, 66% of the tillers and 100% of the hills were infested (Scheibelreiter and Apaloo 1972). Abu (1972) reported that *D. longicornis* could cause 9% yield loss in the Volta Region, Ghana. Morgan and Abu (1973) reported on the importance of diopsid stem borers in rice production on the Accra Plains, Ghana. In a screenhouse test conducted in Badeggi, Nigeria, Akinsola (1980b) reported yield losses of 5–19% when plants were infested at the nursery stage. Morgan (1970) reported severe damage by *D. longicornis* of rice grown in reclaimed mangrove swamps in Sierra Leone.

Alghali and Osisanya (1984) conducted detailed studies on the effect of *D. longicornis* damage on rice yield components. The feeding of the larva significantly decreased the number of panicles produced (both total and mature), the percentage of tillers with panicles, grain weight, and the total yield of unprotected plants, and increased the number of immature panicles and time to 50% flowering. Compensation occurs through the production of new tillers, so yield reductions may not be directly related to percentage of damaged tillers. Production of new tillers, however, did not fully compensate for damaged tillers in most cultivars tested. Photoperiod-sensitive cultivars were better able to compensate for pest damage than photoperiod-insensitive cultivars. Compensation tillering may not contribute significantly to grain yield because of delayed and heterogeneous maturity within a field (Akinsola and Agyen-Sampong 1984).

According to Feijen (1979), *Diopsis* attack can have negative or positive effects on a rice plant (number of stems, height, maturation time, number of panicles, and yield), depending on level and time of attack and general growing conditions such as soil quality, fertilizer rates, hill spacing, and variety. He suggested that, under normal conditions, the influence of feeding larvae is positive or neutral and only becomes negative when poor growing conditions are combined with a late and heavy attack. Alghali and Osisanya (1982) studied the effects of rice varieties—with different levels of resistance—on the biology of *D. longicornis*. Varieties that prolonged the period between egg hatch and adult emergence were the most severely damaged.

Plant density has an effect on extent of *D. longicornis* damage. Ukwungwu (1987a) reported damage increasing with an increase in stand density: 14.6% deadhearts at 1 seedling hill^{-1} to 20% at 7 seedlings hill^{-1}. Alghali (1984a) reported that wider spacing resulted in more tillers per hill and subsequently more eggs per tiller and per hill. However, the number of eggs m^{-2} decreased slightly. The number of *D. longicornis* collected with a sweep net was highest at close spacing, ranging from 29 adults per 30 sweeps at a 10- × 10-cm spacing between hills to 12 adults at a 40- × 40-cm spacing (Fig. 25; E. A. Heinrichs, WARDA, 1994, unpubl. data). In the same study, the relative percentage of *Diopsis* spp. larvae in relation to *M. separatella* and *Scirpophaga* sp. larvae was highest at the closest spacings (10 × 10 and 20 × 20 cm) and lowest at the widest spacing between hills (30 × 30 and 40 × 40 cm).

Stalk-eyed fly, *Diopsis apicalis* Dalman; Diptera: Diopsidae; Fig. 99

Diopsis apicalis Dalman (= *Diopsis tenuipes* Westwood) only occurs in West Africa where it is the dominant species in the genus with apical wing spots. It commonly occurs in fields along with *D. longicornis*, but it is easily identified, as it is much smaller.

Country distribution. Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Nigeria, Senegal, Sierra Leone, Togo.

In East, Central, and Southern Africa, there is another closely related diopsid with apical wing spots that occurs on rice, maize, and other gramineous crops (Feijen 1985). Feijen states that, until the group is

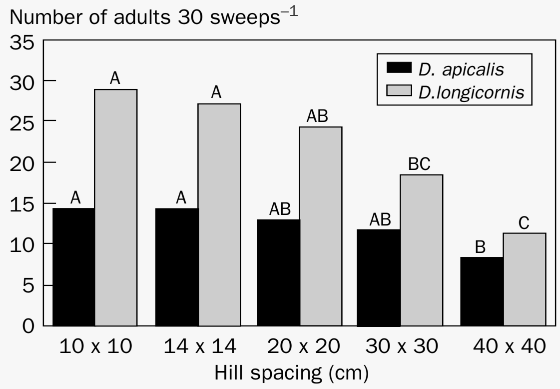


Fig. 25. Number of *Diopsis longicornis* Macquart and *D. apicalis* Dalman adults collected by sweep net in lowland rice plots transplanted at different spacings between hills. Bars within a species, with the same letter, are not significantly different at the 0.05 probability level by Duncan's multiple range test (E.A. Heinrichs, WARDA, M'bé, 1994, unpubl. data).

revised, it is best to refer to *Diopsis* flies with apical wing spots as species belonging to the *apicalis* complex.

Description and biology. Dalman in 1817 originally described and Feijen (1986) redescribed the species based on specimens from Burkina Faso and Nigeria. *Diopsis apicalis* is characterized by apical wing spots. However, there are about 10 *apicalis*-like *Diopsis* found in rice according to Feijen (1985). *Diopsis apicalis* is a polyphagous species that is often seen in rice fields. Adults, larvae, and eggs are similar in appearance to *D. longicornis*, but smaller. Adults have an apical, smoky spot at the tip of each wing (Fig. 99). This character is absent in *D. longicornis* (Fig. 98).

According to Abu (1972) and Scheibelreiter (1974), *D. apicalis* oviposits exclusively on stems infested with *D. longicornis*. In a similar fashion to *D. longicornis*, eggs are deposited on the last emerged leaf (Pollet 1977; Fig. 17). Scheibelreiter (1974) found that three-fourths of the eggs were attached to the withering terminal leaf or were laid in the basal groove of the mid-vein of the subterminal leaf. The remaining eggs were laid on the stem below.

The life cycle is similar to, but shorter than, that of *D. longicornis* (Cocherau 1978). In the tropics, days from egg to adult are 15–17 compared with 44 for *D. longicornis*. Egg, larval, and pupal stages are 36 h, 8–10 d, and 6 d, respectively, compared with 50 h, 25–33 d, and 10–12 d, respectively, for *D. longicornis*. In contrast to *D. longicornis*, the larvae complete their development within one stem (Morgan and Abu 1973).

Habitat preference. In the dry season, the flies are abundant in wet areas such as along rivers. In the rainy season, they move to rice fields (Feijen 1986). In three 1995 surveys conducted in Côte d'Ivoire, adults were more abundant in the Guinea savanna zone than in the forest zone in July, but were most abundant in the forest zone in August and October. There was no difference between zones in Guinea (Fig. 26; E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data.).

The distribution of adults on the continuum toposequence (Fig. 27) is similar to that of *D. longicornis* (Fig. 19), except that *D. apicalis* populations are higher in the upper slope. *Diopsis apicalis* adult populations are also higher in the nonweeded than in the weeded plots (Fig. 27; E.A. Heinrichs, WARDA, 1992, unpublished data).

Nitrogen levels affect the populations of adults in rice field plots. Sweep net collections in plots treated with rates of 0–250 kg N ha^{-1} indicated a peak population at 50 kg N ha^{-1}. This is in contrast to *D. longicornis*, which peaked at 150 kg N ha^{-1} (E.A. Heinrichs, WARDA, 1994**,** unpubl. data).

Plant damage and ecology. The larvae feed on healthy plants or on decomposed tissue that occurs after stem borer attack. According to Descamps (1957b), the larvae exist as phytophages on healthy plants, as saprophytes on damaged plants, or as predators of larvae of other species in rice stems. Deeming (1982) records eight alternative host plant species for *D. apicalis* in northern Nigeria. Scheibelreiter (1974) observed *D. apicalis* feeding on dead larvae of *D. longicornis*. So, *D. apicalis* may be considered at times to be a beneficial insect, although Brenière (1983) believes its role as a predator does not make up for the damage it causes to the rice crop.

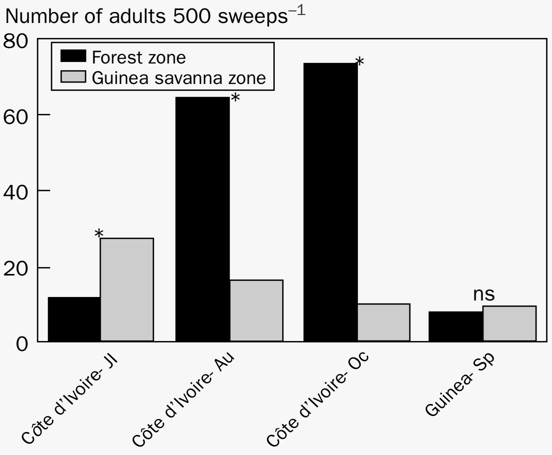


Fig. 26. Abundance of *Diopsis apicalis* Dalman adults as collected with a sweep net in farmers' fields in two climatic zones in Côte d'Ivoire, in July (Jl), August (Au), and October (Oc) and in Guinea in September (Sp) 1995. Asterisks indicate statistical significance between the two zones at the 0.05 probability level (E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data).

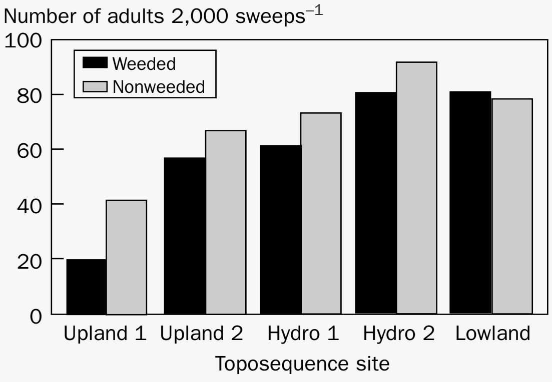


Fig. 27. Number of *Diopsis apicalis* Dalman adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

Chiasson and Hill (1993) studied the population density, development, and behavior of *D. longicornis* and *D. apicalis* in Guinea. At the beginning of the crop season, the adults of *D. apicalis* were as abundant as those of *D. longicornis*. Thereafter, they decreased until the end of the season when the *D. apicalis* numbers were half those of *D. longicornis*.

Similar to *D. longicornis*, adult populations, in a monthly planting study (Fig. 15), were high in the plots planted in November and lowest in the May planting. In contrast to *D. longicornis*, populations were much higher in the January to March plantings. In the same study, as based on an average of 12 planting dates (months), flies appeared shortly after transplanting and reached a peak at 6–8 WAT (Fig. 28). By 12 WAT, there were few flies left in the field. Thus, based on the 8-WAT peak for flies, the highest population for the November planting occurred in December-January, in the middle of the dry season and harmattan period. The “harmattan” is an annually occurring period of strong winds coming from the Sahara Desert and relatively low temperatures.

In Ghana, larvae were found to infest plants later than those of *D. longicornis* (Morgan and Abu 1973). Adults were found in the fields throughout the cropping period but peaked at about 8 WAT. Eggs and larvae were observed at about 40 DT, with eggs reaching a peak at about 60-70 DT and larvae reaching a peak about 2 wk later. In the seedling density experiment conducted at M’bé, adults were most numerous at 4 WAT. Cocherau (1978) reported similar results for lowland rice growing near Bouaké.

In studies in Guinea (Chiasson and Hill 1993), transplanted and direct-seeded rice had similar adult populations, but the number of larvae was 10 times greater in the direct-seeded fields as compared with the transplanted fields. Adult populations in studies at M’bé were dependent on the spacing of transplanted seedlings and the seeding rate of direct-seeded fields (E.A. Heinrichs, WARDA, 1994, unpubl. data). High plant populations, such as in the close spacing of transplanted seedlings (14 × 14 cm) and in the high seed rate (120 kg ha^{-1}) in direct seeding, had the highest *D. apicalis* populations.In a transplanting study where five spacings were compared, the number of *D. apicalis* collected with a sweep net was similar at both 10- × 10- to 30- × 30-cm spacings, decreasing only at the 40- × 40-cm spacing (Fig. 25; E.A. Heinrichs, WARDA, 1994, unpubl. data.).

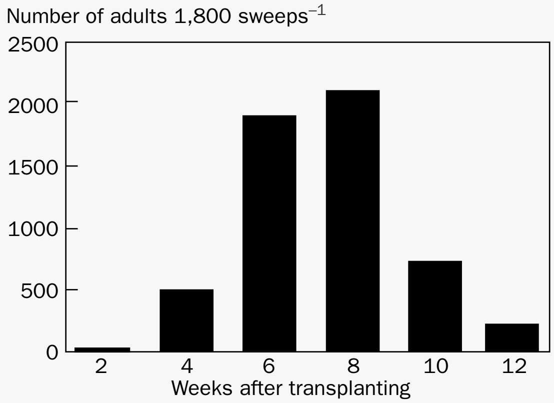


Fig. 28. Number of *Diopsis apicalis* Dalman adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994 to April 1995 (E.A. Heinrichs, WARDA, M’bé, 1995, unpubl. data).

Stem borer, *Pachylophus beckeri* Curran; Diptera: Chloropidae

Pachylophus beckeri Curran is a minor feeder of rice and among the least studied of the various rice stem borers. It is the only other reported dipteran stem borer besides the diopsids in West Africa.

Country distribution. Cameroon, Côte d’Ivoire, Gambia, Mali, Nigeria, Senegal, Sierra Leone. This insect was originally described from Zaire and has been reported from Zimbabwe as well (J. Deeming, National Museum of Wales, U.K., pers. commun.).

Description and biology. Deeming (1973) and Moyal (1982) have reported on the biology and ecology of *P. beckeri* Curran in Nigeria and Côte d’Ivoire, respectively, and have described the morphological features for the various stages. This insect is apparently ovoviviparous, i.e., bears live young, as eggs have never been seen. The larva is similar in appearance to that of the whorl maggot, *Hydrellia prosternalis*, and the stalk-eyed flies but differs in that it does not have two spinelike structures at the extremity of the abdomen. The third-instar larva is about 9 mm in length and 2 mm in width.

Habitat preference. *Pachylophus beckeri* occurs in both the humid tropical and the Guinea savanna zone in Côte d’Ivoire where it feeds in irrigated lowland fields (Moyal 1982).

Plant damage and ecology. *Pachylophus beckeri* attacks rice throughout the year, having been reported in Côte d’Ivoire from February to December. At Korhogo, in north Côte d’Ivoire, this insect is most abundant in the second cycle of rice (Moyal 1982). It occurs in rice throughout all crop growth stages. In Moyal’s study, it was the most abundant of the various stem borer species in the later growth stages of the second crop (October). Plant damage is similar to that caused by diopsids in that feeding causes deadhearts. The number of stems destroyed by one larva has not been determined (Moyal 1982). There are two generations within one rice crop. Peak populations of the larvae occur at 75–90 DT.

African striped rice borer, *Chilo zacconius* Bleszynski; Lepidoptera: Pyralidae; Fig. 92

Chilo zacconius Bleszynski (Fig. 92) is the predominant rice stem borer in West Africa. The larvae of 43 *Chilo* species have been reported as stem borers in various crops (Bleszynski 1970). *Chilo* constitutes one of the major lepidopteran genera of stem borers in Africa (Akinsola 1990). The existence of several similar species caused problems for earlier rice entomologists. Although Bleszynski's publication in 1970 resolved some of the taxonomic problems, there is still some confusion in the literature.

Chilo zacconius along with *C. diffusilineus* (J. de Joannis) (Figs. 93–94) and *C. aleniellus* (Strand) are reported as rice pests in West Africa (Tavakilian 1977, Moyal and Tran 1992). They are among the major rice stem borer species reported occurring in the humid forest and savanna zones according to Akinsola (1990). *Chilo zacconius*, *C. diffusilineus*, and *C. aleniellus* are similar in appearance and in the plant damage that they cause. Bordat and Pichot (1978) and Vercambre et al (1990) report that *C. zacconius* prefers irrigated rice, while *C. diffusilineus* prefers upland rice fields. *Chilo aleniellus* is widely distributed in Africa and has been reported from Cameroon, Ghana, Nigeria, Côte d'Ivoire, and Sierra Leone in West Africa and Congo, Ethiopia, Uganda, and Zaire (Bleszynski 1970, Bonzi 1982, Akinsola and Agyen-Sampong 1984). It is also a pest of maize in Côte d'Ivoire, but its distribution there is limited (Moyal and Tran 1992) between latitudes 6° and 8° N. Appreciable populations in maize are found only in the western part of the forest area, particularly in Man where *C. aleniellus* regularly represents 10–20% of the maize borers. Its distribution on rice in Côte d'Ivoire has not been established. Based on a survey conducted in Côte d'Ivoire in 1995, *Chilo* spp. were the second most abundant group based on all collections in all climatic zones, ecosystems, and plant stages (Fig. 23).

Chilo zacconius (Fig. 92) and *C. diffusilineus* (Figs. 93–94) are similar in appearance. Vercambre et al (1990) described the subtle morphological characteristics that distinguish the two species. They differ in the genitalia of the adults, crochets on the prolegs of the larvae, and spines on the cremaster of the pupae. Also, the eggs of *C. diffusilineus* are larger, being 0.76 mm in length and 0.60 mm in width, whereas eggs of *C. zacconius* are 0.60 × 0.48. *Chilo diffusilineus* is a pest of maize, millet, and sorghum in Burkina Faso. Other hosts in addition to rice are the wild rice species *Oryza longistaminata*, *Panicum* sp., and *Paspalum scrobiculatum* (Bonzi 1982).

Chilo partellus (Swinhoe) (Figs. 90–91) is the predominant rice stem borer in East Africa. *Chilo agamemnon* Bleszynski is predominant in North Africa (especially Egypt) according to Akinsola (1990). *Chilo* spp. are important rice pests because 1) they feed on plants at critical stages of plant development, 2) their feeding occurs within the stem, 3) a large number of plant species serve as hosts, 4) the biological plasticity between the two sympatric species (*C. zacconius* and *C. diffusilineus*) allows them to inhabit diverse environments (Vercambre et al 1990), and 5) they are difficult to control.

Country distribution. Benin, Cameroon, Côte d'Ivoire, Ghana, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone.

Description and biology. The adult has pale yellow fore wings with small, distinct, irregular black spots at the tip of the fore wings (Akinsola 1990; Fig. 92). Males are darker than females. The body length of adults ranges from 11 to 13 mm in the female and 9 to 11 mm in the male. Moths are nocturnal and hide from flying predators during the day. They begin oviposition about 24 h after emergence (Bordat and Pichot 1978). Under laboratory conditions, the females live from 4 to 7 d.

Oviposition occurs in the upper or middle leaves (Dale 1994). Pale yellow eggs are laid in two or three overlapping longitudinal rows (Brenière 1976). Eggs are oval, flat, and imbricate like fish scales. (See Brenière [1976] for illustrations and a key to eggs produced by rice insects in West Africa.) The number of eggs laid per female varies considerably (ISRA 1989, Akinsola 1990) but averaged 250 and 350 female^{-1} in two laboratory studies (Bordat and Pichot 1978, Coquard and Breniere 1979). The majority of the eggs are laid on the third day. At 3 d after oviposition, the eggs turn orange and the embryo becomes visible. On the fourth day, the black head capsule is visible through the chorion (Bordat and Pichot 1978). Eggs hatch in 4–6 d after oviposition.

Upon hatching, the larvae move actively on the plant, feed for a short time on the leaf, and then enter the stem by penetrating the leaf sheath. Feeding occurs at the upper internodes. The larvae can move from one stem to another when the stem decays and no longer provides nourishment. Pupation occurs inside the stem after the larva cuts an exit hole for its later emergence as an adult. Larval and pupal periods are about 28 and 6 d, respectively (Akinsola 1979).

Brenière (1976) has illustrated and described *C. zacconius* larvae and Meijerman and Ulenberg (1996) have developed a taxonomic key to separate the larvae from those of other African stem borers. The larva, which passes through five or six instars, has an ivory-colored body with seven longitudinal pink stripes. Stripes near the ventral part of the body are incomplete and less distinct. The head and prothoracic scutellum are dark brown. The pupa is dark brown and 11–12 mm long. The head bears two protrusions and the abdomen ends in a four-pointed crest.

From five to seven generations can occur within a year. The number of generations is limited by the length of the dry season and the availability of suitable host plants (Brenière 1982). Generally, two successive generations occur in a given rice crop.

Habitat preference. *Chilo zacconius* occurs in the humid tropical, Guinea savanna, and Sudanian savanna zones of West Africa but is most abundant in the latter two zones (Table 2). Considering all ecosystems and both the savanna and forest climatic zones, *Chilo* spp. were next to *Diopsis* spp. in abundance in the July 1995 survey in Côte d'Ivoire (Fig. 23). In three surveys conducted in Côte d'Ivoire in 1995, the *Chilo* (predominantly *C. zacconius*) portion of the larval stem borer population was similar in the savanna and forest in July (Fig. 12) and August but rose to about 50% of the stem borer population in the savanna zone in October. Percent of tillers infested by *Chilo* in the July survey was similar in the savanna and the forest while, in the August survey, tiller infestation was highest in the forest zone.

Chilo zacconius occurs in all ecosystems, but is generally most abundant in the uplands (Table 4). It occurs in the mangrove swamps, but it is of much less importance than *M. separatella*. Studies in Gambia indicated that *C. zacconius* made up only 5% of the stem borer composition in irrigated and mangrove swamps while *M. separatella* (82%) was the most abundant species (Jobe 1996). In the three surveys conducted in Côte d'Ivoire in 1995, the percentage of the stem borer population consisting of *C. zacconius* larvae in stems was similar in the lowlands and uplands in the July survey (Fig. 13), but was two and five times higher in the uplands in August and October, respectively. Percentage of stem borer-damaged tillers infested with *Chilo* (predominantly *C. zacconius*) larvae was slightly more in the lowlands than the uplands in the July survey (Fig. 21) but increased in the uplands in August.

Figure 29 shows the number of *Chilo* (predominantly *C. zacconius*) larvae compared with other stem borers on the continuum toposequence at M'bé in 1995. *Chilo* made up a small portion of the stem borers and was only observed in the uplands.

Plant damage and ecology. *Chilo zacconius* is a polyphagous pest of rice attacking both cultivated and wild gramineous plants. These plants serve as alternate hosts on which the larvae survive during the off-season when rice is not available and that serve as a reservoir from which they invade rice fields (Akinsola 1990). Other host plants include *O. barthii*, *Echinochloa crus-galli* (L.), *E. pyramidalis* (Lamarck) Hitchcock and Chase, *Pennisetum* spp., *Rottboellia cochinchinensis* (Loureiro) W.D. Clayton, *Saccharum officinarum* L., *Sorghum arundinaceum* (Desv.) Stapf., and *Zea mays* L. (Sampson and Kumar 1986, Akinsola 1990, Dale 1994).

Collections of adult *Chilo* spp. in light traps at M'bé indicate that there are two generations per year. Peak populations occurred from April to May and again in October (Fig. 30). Identification of a sex pheromone (Zagatti et al 1983) has facilitated studies on the seasonal occurrence of *C. zacconius*. In Niger, *C. zacconius* adults were collected in sex pheromone traps from February to June and again from September to December. Peak populations occurred in May and November (Abdou 1992). In Djibelor, Senegal, adults were collected from June to October with highest populations occurring in August (Djiba 1996).

The percent stem borer species composition of *C. zacconius, M. separatella*, and *S. calamistis* throughout 1 yr in upland and irrigated rice ecosystems was determined at Ibadan, Nigeria (Alam 1988). *Maliarpha separatella* predominated in both ecosystems. *Chilo zacconius* populations were higher in irrigated rice than in upland rice. *Chilo zacconius* larvae were present from February to December with the highest percentage occurring in June.

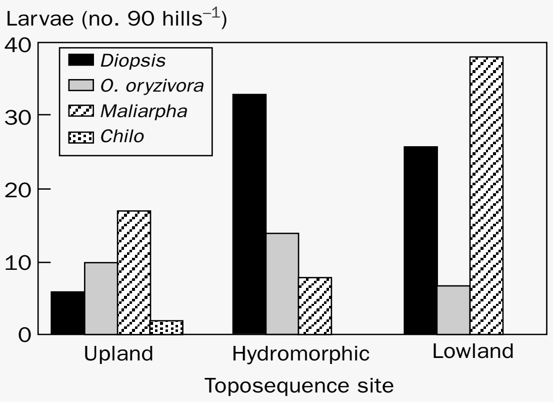


Fig. 29. Number of stem borer and gall midge (*Orseolia oryzivora* Harris & Gagne) larvae in 90 hills of rice at three continuum toposequence sites (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

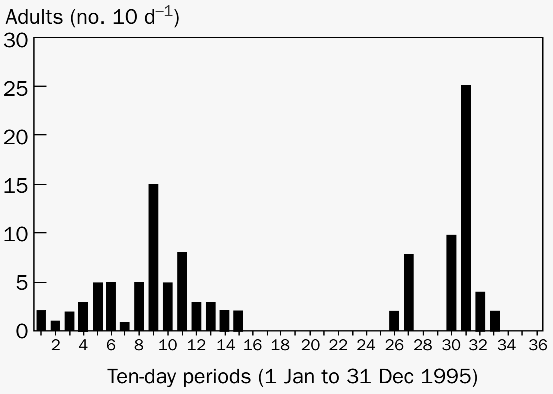


Fig. 30. Number of *Chilo* sp. adults collected in a kerosene light trap over 10-d periods from 1 Jan to 31 Dec 1995. The trap was located in a hydromorphic rice plot, about 100 m from lowland rice (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

In the irrigated Sahel region, *C. zacconius* is a major stem borer species (Akinsola 1990). Dry-season crops grown from December to April are almost free of borers, while the main-season crop, grown from July to November, is heavily attacked. Figure 31 illustrates the relationship between month of transplanting and larval populations in the Sahel. The crops planted in July had the highest larval population with the number of larvae peaking at 79 DT. Lowest populations were observed in March and November plantings.

Larval populations of *C. zacconius* in a monthly planting experiment of lowland rice at M'bé were generally the lowest of four stem borer species as based on percent genera composition (E.A. Heinrichs, WARDA, 1994, unpubl. data). As based on number of larvae per 90 hills, *C. zacconius* populations in rice stems were low throughout the year (Fig. 32). The highest population was observed in the May planting with lower populations in the August, October, and December plantings. No larvae were observed in the other months. Monthly plantings at Badeggi, Nigeria, indicated that crops planted from January to June had higher *C. zacconius* larval populations than those planted from July to December (Ukwungwu 1984).

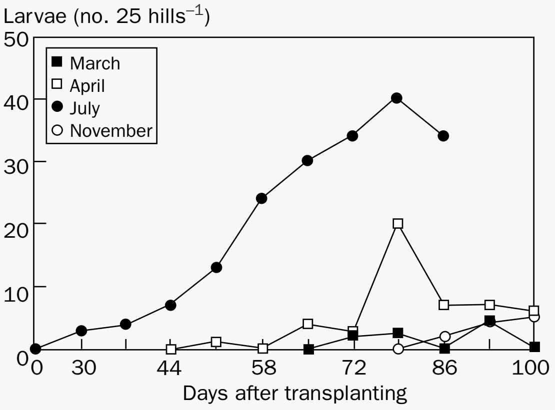


Fig. 31. Number of *Chilo zacconius* Bleszynski larvae in lowland irrigated rice stems at the indicated days after transplanting at Kogoni, Mali. Treatments consisted of four transplanting dates (March, April, July, and November) (Heinrichs and Hamadoun 1995).

Chilo zacconius larvae or pupae are present in rice stems throughout most of the crop period (Fig. 33). Oviposition by adults and feeding of larvae in rice stems in Mali begin in the tillering stage and continue to maturity of the rice crop (Toure 1989). Peak populations at Kogoni, Mali, occur at the end of tillering through panicle initiation to booting (Heinrichs and Hamadoun 1995). Genera composition studies on stem borer in irrigated rice in Casamance, Senegal, indicate that *Chilo* spp. are the only species present before 10 DT and are the predominant species until 50 DT when *M. separatella* predominates (Fig. 34) (Vercambre et al 1990). The second *Chilo* spp. generation peaks at 80 DT but is less abundant than *M. separatella*. In surveys conducted in Côte d'Ivoire in 1995, based on percentage genera composition, *Chilo* occurred in all stages of rice growth but was most abundant in the flowering-ripening stages (Fig. 14). Percentage of stem borer-damaged tillers infested with *Chilo* larvae in the Côte d'Ivoire surveys was highest in the flowering-ripening stages in both July (Fig. 24) and August.

Plant damage caused by *C. zacconius* is similar to that of other lepidopterous stem borers. Feeding inside the stem during the vegetative stage prevents the central leaf whorl from opening; instead, it turns brown and withers. Although the lower leaves remain green, the apical reproductive portion of the tiller is destroyed

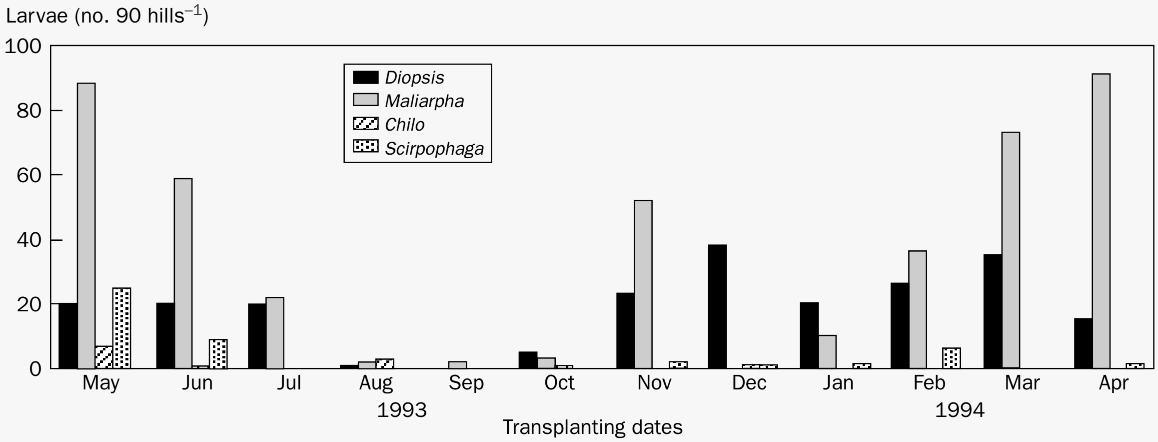


Fig. 32. Number of larvae of four stem borer genera in lowland rice (variety Bouaké 189) as affected by month of transplanting, May 1993 to April 1994 (E.A. Heinrichs, WARDA, M'bé, 1994, unpubl. data).

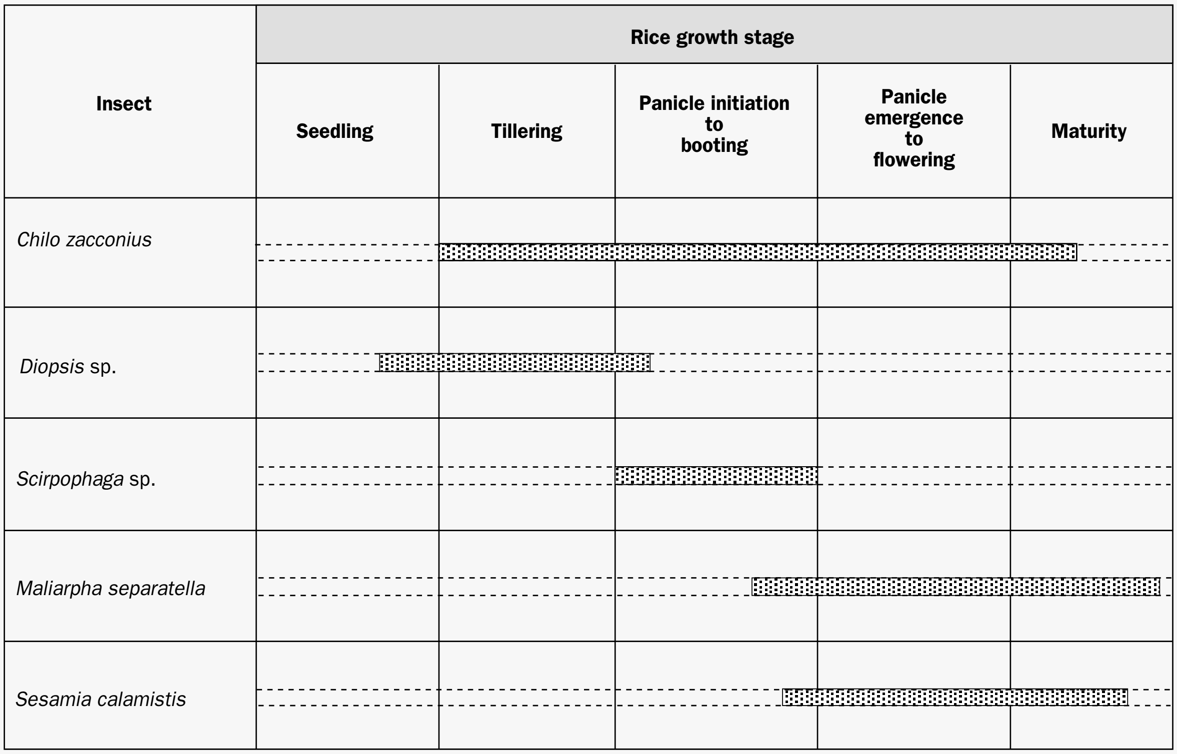


Fig. 33. Phenological occurrence of stem borer larvae in lowland irrigated rice at Kogoni, Mali, as related to five rice growth stages (modified from Toure 1989).

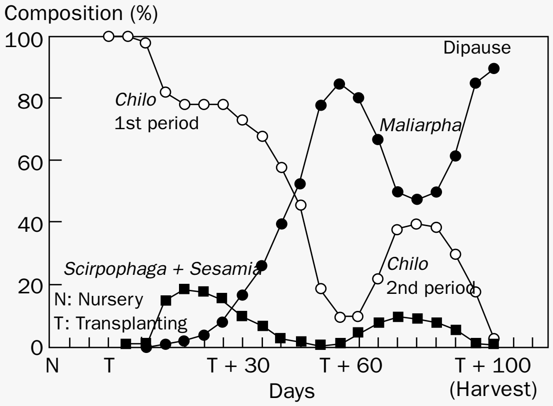


Fig. 34. Relative percentage of stem borer genera composition at different dates after transplanting of lowland irrigated rice in the Casamance, Senegal (modified from Vercambre et al 1990).

and the tiller fails to produce a panicle. Larval feeding at the panicle initiation stage or thereafter prevents the development of the panicle, resulting in a whitehead.

Although larvae, upon hatching, quickly establish themselves within the stem, the appearance of damage symptoms occurs gradually. Akinsola (1990) reported that when plants were artificially infested with larvae, the maximum number of deadhearts occurred 20 d after infestation (DAI). The particular internode in which feeding occurs is a factor in the rate at which damage symptoms appear—the higher the internode, the sooner the appearance of the deadhearts. The number of larvae per tiller also affects the percentage of tillers that show deadheart symptoms. Akinsola (1990) found that 4 larvae tiller^{-1} were required to attain 85% deadhearts. In nature, several larvae can be found in one tiller a few days after hatching. However, they disperse to other tillers after a few days and usually only one larva remains in a tiller to maturity.

The first generation causes mainly deadhearts, whereas damage by the second generation results in whiteheads. During the dry season, larvae may feed on weeds or in off-season rice fields. They can, however, live without food for several months (December to April in the Casamance, Senegal).

In a screenhouse experiment, Ukwungwu and Odebiyi (1984) studied the effect of *C. zacconius* larvae on rice plants. Larval infestation caused a reduction in plant height. Degree of plant height reduction appeared to be related to degree of susceptibility to borers. Larval infestation caused an increase in tiller production in most varieties studied, indicating a tendency to compensate for damage to primary tillers. The number of panicles produced per hill by infested and uninfested plants differed little. Damage tends to produce more secondary tillers that produce panicles but which may, or may not, mature, depending on time of harvesting of primary tillers. Infestation of susceptible varieties resulted in reductions in the number of filled grains per panicle. There was a positive correlation between percentage of deadhearts and reduction in filled grains per panicle and reduction in weight of grains. Thus, varieties that had more deadhearts sustained higher grain yield losses.

Rice varieties differ in their susceptibility to *C. zacconius* (Ukwungwu and Odebiyi 1985a,b) and the level of resistance affects the development of *C. zacconius*. Brenière (1971) observed strong differences in the susceptibility of upland varieties to *C. zacconius* in Senegal. Introduced varieties were the most susceptible. Also, in irrigated rice, the Asian varieties Taichung, Tainan, and IR8 were more susceptible than local varieties.

Larval survival and larval weight are affected by the level of silica in resistant varieties (Ukwungwu 1990). The hardening of the stem tissue through increased silica content appears to be an important factor of resistance to *C. zacconius* as larvae feeding on highly siliceous rice cultivars exhibit typical effects of antibiosis.

Sauphanor (1985) studied the factors involved in upland rice tolerance for stem borers. In artificial infestation tests, *C. zacconius* caused a high reduction in panicle weight on some cultivars but only a small reduction on others. On IRAT 13, a susceptible cultivar, larvae caused a 9% panicle weight reduction and a 23% yield loss. Sauphanor (1985) reported that the apparent higher tolerance of lowland irrigated varieties, as compared with upland varieties, was due to the higher tillering rate of irrigated varieties that allowed them to compensate for borer-damaged tillers. Another factor involved in tolerance for *C. zacconius* attack was the ability of infested stems to produce fertile panicles. Cultivars with thick stems, such as Moroberekan, possess this character but Moroberekan produces tillers poorly and thus does not compensate for damaged tillers.

Ukwungwu and Odebiyi (1984) used the insecticide check method to determine yield losses due to a mixture of *M. separatella* and *C. zacconius* in a field experiment at IITA in Ibadan, Nigeria. Yield losses ranged from 15% (694 kg ha^{-1}) in a resistant line, IR2035-120-3, to 55% (1467 kg ha^{-1}) in a susceptible variety, FARO 11. A detailed survey of rice fields in Casamance, Senegal, indicated that extent of damage due to insect pests was variable according to the level of cultural management (Etienne 1987). In intensive agriculture, yield losses reached 25% and were caused mainly by *Chilo* spp. Sauphanor (1985) predicted that if the uplands are intensively cultivated in Côte d'Ivoire, yield losses due to stem borers could amount to 10%, the level that was recorded on experiment station trials in Bouaké.

African white borer, *Maliarpha separatella* Ragonot; Lepidoptera: Pyralidae; Fig. 88

Maliarpha separatella Ragonot is one of the most common stem borers occurring in rice throughout West Africa and has been extensively studied. Its feeding damage is unique among the rice stem borers as it seldom causes deadhearts or whiteheads. The genus *Maliarpha* has been revised and what has been referred to in the literature as the African rice borer, *M. separatella*, is actually a complex of three closely related stem borer species (Cook 1997).

Geographical distribution. The African white borer is widely distributed in Africa. It has been reported from Asia (China, India, Myanmar), but it is not considered as a rice borer there. Bianchi et al (1993) believe that, based on the descriptions given for *M. separatella* ('green-striped borer') on sorghum in India by Sandhu and Chander (1975) and by Li (1985) on sugarcane in Papua New Guinea, they were reporting on another species. They believe that *M. separatella* is monophagous and its distribution may be restricted to sub-Saharan Africa. According to Lever (1975), although *M. separatella* was described in 1888, its first report as a pest appears to be when Hall (1955) found it feeding on irrigated rice in Swaziland. Dale (1994) and Delucchi et al (1996) have reported it to be a common pest of rice in Madagascar.

Description and biology. Reports on the biology and ecology of *M. separatella* have been published by Brenière (1969, 1982) and Pollet (1981) in Côte d'Ivoire, Akinsola (1975, 1979) and Akinsola and Agyen-Sampong (1984) in Nigeria, Diop (1979) in Mali, and Appert (1970) and Delucchi et al (1996) in Madagascar. Brenière (1976,1983) has described the eggs, larvae, and pupae.

The slender adult moth has fore wings that are yellowish or straw-colored with a prominent reddish brown line along the front edge (Fig. 88). The hind wings are pale yellow with a metallic sheen and fringed with long yellow hairs. The body is covered with yellowish scales. At rest, the V-shaped wings cover the body. Body length is 11–13 mm in the male and 13–15 mm in the female. The female produces a sex pheromone, which attracts the male for mating (Ho and Seshu Reddy 1983, Cork et al 1991). Ho and Seshu Reddy (1983) reported that moths fly at night and that peak flight activity in Kenya was between 2300 and 0300. In West Africa, 82% of the moths were caught between 1900 and 0100 and rainfall appeared to induce flight activity (WARDA 1979).

Eggs are laid during the night on preferably large, vertical leaves of tillering plants (Fig. 35). Sometimes eggs are deposited in the youngest unfolded leaf. Eggs are laid in parallel rows on the upper side of the leaf

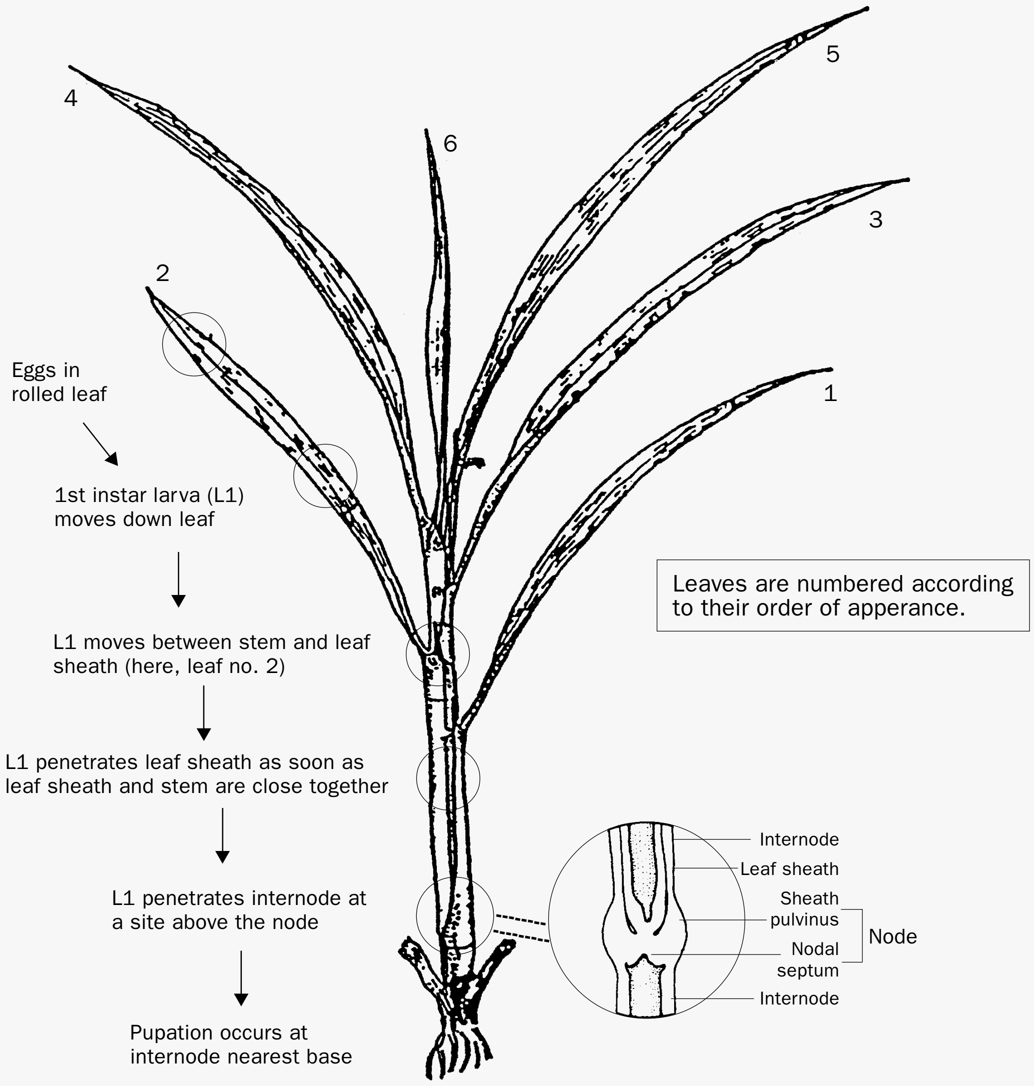


Fig. 35. Chronological development of attack of stem borer, *Maliarpha separatella* Ragonot, on rice (modified from Pollet 1977).

and are attached by a cement-like substance that, on drying, causes a characteristic pinching of the lamina, completely enclosing the eggs. Females deposit from one to six egg masses consisting of from 30 to 95 eggs. Total number of eggs laid can reach 300. On the second night after its emergence, the female lays the first egg mass and then may continue for two to three nights more. From two to three egg masses may be deposited each night.

After an incubation period of 7–10 d, larvae hatch at about 0700. Newly hatched larvae, which are white with dark brown heads that later turn yellow, are very active. Some move to the tip of a leaf blade where they suspend themselves from silken threads, which they produce. Suspended from the silken threads, the larvae drift in the wind and attach themselves to adjacent leaves of the same (or a neighboring) plant. First-instar (L1) larvae move down the leaf to the leaf sheath and the stem (Fig. 35).

After spending about 4–5 d in the leaf sheath, they have sufficiently large enough mandibles to penetrate the stem at the internode. It is believed that the larvae begin feeding in the stem about 4–5 d later. The larval stage lasts about 35–50 d during which it passes through five to seven instars. There is usually only 1 larva stem^{-1}.

Pupation occurs at the internode nearest the plant base (Fig. 35). Prior to pupation, the larva cuts an exit hole in the stem through which the adult will later emerge. A conical silky channel is prepared to connect the inner wall of the stem to the adult exit hole. The larva then pupates with its head just below the exit hole. The pupal period lasts from 32 to 65 d.

Diapause occurs during the sixth instar at the base of dried stubble. The larva resumes activity with the return of humid conditions and rapidly completes its life cycle. Larval diapause may last as long as 251 d (Akinsola and Agyen-Sampong 1984). In southern Nigeria, diapause starts in July and lasts until March of the next year. Diapause usually occurs before the rice plant starts drying and—in sub-Saharan Africa—is believed to be triggered by decreasing daylength and modulated by temperature (Delucchi et al 1996). Diapausing larvae are sluggish, milky white, and have a wrinkled body, while nondiapausing larvae are agile, yellowish white, and have a smooth body.

Habitat preference. *Maliarpha separatella* occurs in all climatic zones in West Africa but it is more abundant in the humid tropical and Guinea savanna than in the Sudanian savanna zone (Table 2). In the three 1995 Côte d'Ivoire surveys, percentage of total stem borer larval population composed of *M. separatella* was similar in both the forest (humid tropical) and Guinea savanna zones (Fig. 12). Percentage of stem borer-damaged tillers infested with *Maliarpha* larvae was slightly higher in the savanna in the July survey and higher in the forest zone in the August survey.

Maliarpha separatella is abundant in all rice ecosystems (Delucchi et al 1996). It is more abundant in the rainfed lowland and irrigated ecosystems than in the uplands and is the most abundant stem borer species in the mangrove swamps (Table 4). Surveys conducted in Côte d'Ivoire in 1995 indicated that about 35% of the stem borer larvae in the lowlands in the July (Fig. 13) and August surveys were *M. separatella*, whereas in the uplands only about 5 and 15%, respectively, were *M. separatella*. Populations were low in both ecosystems in the October survey when *Sesamia* spp. predominated in the lowlands and *Chilo* spp. in the uplands. Percentage of stem borer-damaged tillers infested by *Maliarpha* larvae was highest in the lowlands in both the July (Fig. 21) and August surveys.

Maliarpha separatella larvae are distributed throughout all toposequence sites in inland valley rice fields at M'bé (Fig. 22). It was the most abundant stem borer species in the drought-prone uplands and in the lowlands as based on percentage species composition. Based on number of larvae per 90 hills, it was the most abundant species in the uplands and in lowlands (Fig. 29).

Plant damage and ecology. In studies conducted by Brenière (1969) in Côte d'Ivoire, highest *M. separatella* populations occurred in Yamoussoukro where two crops of rice were grown annually. He reports that the same condition exists at the Richard Toll Station in Senegal where double cropping is practiced. He concludes that an increase in cropping intensity is expected to increase the level of damage caused by *M. separatella*.

Maliarpha separatella is mainly a rice pest and its alternate hosts are limited. Rice ratoons serve as a residual population between rice crops (Joshi and Ukwungwu 1993). Host plants reported in West Africa other than rice are *Andropogon tectorum* Schum. & Thonn. (WARDA 1977), *Sorghum bicolor* (L.) Moench., and the wild rices *O. barthii*, *O. longistaminata*, and *O. punctata* (Khan et al 1991). According to Delucchi et al (1996), reported hosts other than *Oryza* spp. in West Africa are doubtful.

Rice plants are usually attacked during the later stages of their growth cycle. Infestation generally begins in the panicle initiation to booting stages and continues to harvest (Fig. 33; Toure 1989). In studies in irrigated rice in Mali, very low larval populations were observed in the early tillering stage (Heinrichs and Hamadoun 1995). Populations peaked at the panicle initiation to booting stages and again near maturity. Low larval populations in Nigeria were observed by 30 DT and increased with crop age, reaching a peak at 90 DT (Ukwungwu 1987c). In Kenya, larval populations were highest in the ripening stage (Njokah and Kibuka 1982, Njokah et al 1982).

Figure 14 shows the percentage of total stem borers related to *M. separatella* larvae in the various plant growth stages in the July 1995 Côte d'Ivoire survey. In the July and August surveys, the population consisted of about 30% *M. separatella* larvae in both the booting and flowering-ripening stages, while in the vegetative stage it made up less than 5% of the stem borer population. In the October survey, the species composition in the vegetative stage consisted of primarily *Diopsis* and *Maliarpha*. Percentage of stem borer-damaged tillers, infested with *Maliarpha* in the July (Fig. 24) and August surveys, was highest in the flowering to ripening stages.

In studies by Vercambre et al (1990) in the Casamance, Senegal (Fig. 34), *M. separatella* was only about 1% of the species present at 15 DT. However, by 60 DT, it consisted of 80% of the larvae collected and by harvest about 94%, whereas the combined *Chilo*, *Sesamia*, and *Scirpophaga* populations were about 6%.

Data from a light trap located near lowland fields at the WARDA research station at M'bé indicated that *M. separatella* adults are present through most of the year with three possible peaks occurring in March, June, and November (Fig. 36). In monthly transplanting date studies at M'bé, *M. separatella* larvae, based on percent stem borer composition, were the most abundant of the stem borer species from February to July, and in the September and November plantings. Total number of larvae in studies at WARDA followed a similar pattern (Fig. 32), being least abundant at the peak of the wet season, August to October. In a monthly planting study in Nigeria, larvae were found in rice stems throughout the year but were

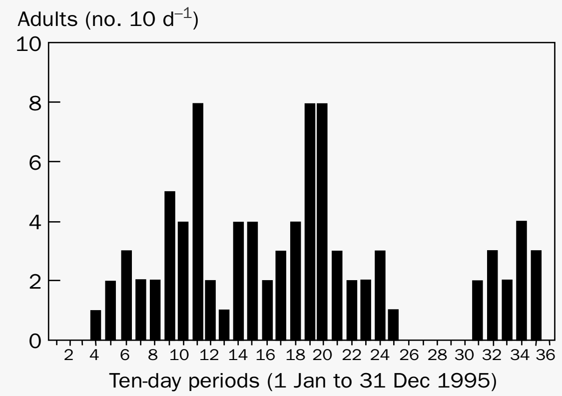


Fig. 36. Number of *Maliarpha separatella* Ragonot adults collected in a kerosene light trap over 10-d periods from 1 Jan. to 31 Dec. 1995. The trap was located in a hydromorphic rice plot, about 100 m from lowland rice (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

most abundant in the February to April plantings (Ukwungwu 1987c). In irrigated rice at the Office du Niger Project in Kogoni, Mali, where the winter season is very dry, *M. separatella* light trap catches indicated adults were flying throughout the summer season, May to November (Heinrichs and Hamadoun 1995). Peak populations occurred in October in 1991 and in November in 1993.

Maliarpha separatella damage to the rice plant is unique among the various rice stem borer species. Most authors report that it seldom causes the development of deadhearts or whiteheads because of its habit of dwelling at the lower internodes. This is a similar situation to that of *Rupella albinella* (Cramer) in Latin America. However, there may be varietal differences that affect whitehead development. Malinga (1985) reported that, in tests in Kenya, there was a positive correlation, especially in the lowland Asian cultivars BG 34-8 and BG 90-2, between number of egg masses and whiteheads. This was a field experiment, however, and the whiteheads could have been caused by another borer species. Bianchi et al (1993) reported only a slight effect on the number of whiteheads at infestation levels up to 68%. Based on the literature, it is apparent that *M. separatella* rarely causes whiteheads.

Akinsola and Agyen-Sampong (1984) reported that at the vegetative stage of rice growth, early-, middle-, and late-instar larvae are found in the first basal internode. During later crop growth stages, some larvae migrate up to the second or third internode, depending on the height of the plant. No larvae were found at the topmost internode. The larvae complete their development in one or two internodes and do not migrate from one tiller to another once they have lodged themselves within the stem.

In upland rice, the larvae are located toward the base of the plant while in flooded and swampy fields, the larvae tend to be located in the upper portion of the plant. Once they bore into the first or second internode, larvae feed on the inner stem tissues at a site above the node (Fig. 35). Feeding activity of the larvae results in small circular cavities in the stem, which is not pierced. The larvae pass from one internode to another by penetrating the node and, once established, they spend the entire larval stage in one stem and do not migrate from one tiller to another. They are not voracious feeders and throughout the larval stage, they limit their feeding to one or two internodes. The larvae generally cannot survive on young plants without elongated internodes.

In deep water rice, initial infestations are believed to occur before flooding. In Mopti, Mali, it was observed that tillers infested with *M. separatella* were detached at their base (Akinsola 1980a). Plants in deep water have a whitish, fragile portion at the base. Thus, stem borer feeding, plus the water pressure at a 3-m depth, leads to the detachment of the damaged portion of the plant. As a result, *M. separatella*-infested stems were observed floating on the water surface in the very deep zones (3 m) and 60% of the hills were missing due to *M. separatella* damage.

In addition to the direct damage caused by feeding of the larvae, Pollet (1978a,b) has reported a synergistic relationship between *M. separatella* and the rice blast fungus, *Pyricularia oryzae*. After *M. separatella* adults have emerged and left the stems, the fungus attacks the neck of the panicles and affects grain development. This insect-fungus combination can cause a complete grain yield loss.

There is a critical period of the rice plant's development—about 42–65 DT, depending on variety (Delucchi et al 1996)—when *M. separatella* infestation causes yield loss. Before this period, larval mortality is too high to cause serious damage and the plant compensates for the damage. After this period, the severity of injury caused by the larvae decreases until it becomes negligible.

Feeding by *M. separatella* at the tillering stage causes a reduction in plant height and number of filled grains (Akinsola 1984a). When infested at the booting stage, plant height is not affected but total number of grains per panicle, number of filled grains per panicle, and grain weight are significantly reduced. In studies of Ho et al (1983), plants were infested with *M. separatella* moths at 45 DT and feeding damage by the larvae only caused a reduction in 1000-grain weight and an increase in percentage of empty grains. Harvest index, number of panicles m^{-2}, grains $panicle^{-1}$, and percent of reproductive tillers were not significantly affected by the feeding of *M. separatella*.

Pollet (1979) reported that, in studies in central Côte d'Ivoire, *M. separatella* only reduced the number of grains $panicle^{-1}$. Based on a comparison of the panicle development of infested and uninfested stems of lowland Asian cultivar IR5, estimated grain yield losses were 19 kg ha^{-1} at Kotiessou and 48 kg ha^{-1} at Yamoussoukro.

Bianchi et al (1993) reported that in Madagascar tiller infestations up to 68% did not have any influence on the number of panicles produced or on the number of empty grains panicle^{-1}. However, they did observe an increasing number of immature panicles and a decrease in the 1000-grain weight. They concluded that, because of competition among larvae when they enter the internodes of the rice plant (causing high mortality), high population densities in stems do not occur, even at high infestation levels. Because of this and the fact that the larvae complete their life cycle inside the lower internodes without destroying the conducting vessels, the economic importance of *M. separatella* is minimized.

The economic threshold for *M. separatella* as developed in Madagascar (Appert 1970) is based on number of egg masses. Bianchi et al (1989, 1993) developed a sampling procedure for egg masses. Egg masses are distributed at random. They found that sequential binomial sampling is cost-efficient and decision making with respect to the action threshold is possible with 12 quadrats. According to the action threshold developed by Appert (1970), insecticide application is economical when the number of egg masses per sampling unit of 1 m × 1 m, computed every 10 d from 20 DT, is higher than 3.5. Studies by Delucchi et al (1996) in Madagascar in the 1980s indicated that the economic threshold for a 2-t ha^{-1} rice yield should be 8.6 egg masses 100 tillers^{-1}. This is equivalent to an infestation of 59% at the end of the critical period and corresponds to a yield loss of 22%. As the yield increases, the threshold decreases; for a yield of 4 t ha^{-1}, the threshold is 6.6 egg masses 100 tillers^{-1}.

Scirpophaga spp.; Lepidoptera: Pyralidae; Fig. 87

Scirpophaga spp. are among the minor rice stem borers in West Africa. There are 33 species in this genus throughout the world. Three species have been reported from rice in West Africa (Table 5).

Country distribution. *S. melanoclista* Meyrick: Cameroon, Côte d'Ivoire, Mali, Nigeria, Senegal; *S. occidentalla* (Walker): Côte d'Ivoire, Nigeria, Sierra Leone, Senegal; *S. subumbrosa* Meyrick: Ghana, Guinea, Mali, Togo.

The distribution and the taxonomic nomenclature of this genus are in need of revision (Brenière 1983) and thus much of the discussion in this section refers only to the genus *Scirpophaga* and not to species.

Description and biology. Pollet (1977), Ly (1978), and Brenière (1976, 1982, 1983) report on the description and biology of *Scirpophaga* spp. The adult has satin-like white wings that are folded roof-like when at rest. The female has a wing span of 30–35 mm, a long slender body, and a black thorax covered with white scales and white legs (Fig. 87).

Adults oviposit on young rice plants primarily during the tillering and booting stages. Brenière (1976) describes the eggs and larvae in detail. Eggs are laid in a group of two or three layers and are covered with a hairy mass composed of brownish scales from the abdomen of the female. The egg masses, which are 8–10 mm long and 4 mm wide, are stuck to the upper or lower surfaces of the leaves. A female lays 100–180 eggs. Eggs hatch in about 8 d.

The first-instar larvae (L1), upon hatching, move down the leaf on the leaf surface (Fig. 37). The L1 larvae penetrate the leaf sheath near the ligule and bore into the central vein of the leaf sheath. They later penetrate the stem above node 5 (panicle node) and bore spiral-like galleries. Fine brown hairs cover the larvae. The larval period lasts from 28 to 44 d.

Pupation occurs in the internode nearest the plant base (internode 1). The pupae are transparent pearly white and about 20–22 mm in length. They are located at the base of the stem in the median cavity constituted by the lower internodes. Only one pupa is found per stem. The pupal period is from 12 to 14 d.

Habitat preference. In surveys conducted in Côte d'Ivoire in 1995 covering all ecosystems, climatic zones, and rice growth stages (E.A. Heinrichs, WARDA, 1995, unpubl. data), *Scirpophaga* was the least abundant (2%) of the five lepidopterous stem borer genera found in rice stems (Fig. 23). Although *Scirpophaga* populations were low in the Côte d'Ivoire surveys, based on percentage composition of the stem borer genera, they were slightly more abundant in the savanna of Côte d'Ivoire than in the forest zone (Fig. 12). Similar results were obtained when stem borer-damaged tillers were examined for stem borer larvae.

Populations of *Scirpophaga* vary according to ecosystem. According to Agyen-Sampong (1982), *Scirpophaga* is most abundant in the rainfed and irrigated lowland ecosystems and less abundant under upland conditions and in the mangrove swamp (Table 4). In the Côte d'Ivoire surveys (E.A. Heinrichs, WARDA, 1995, unpubl. data), low populations were found in both the upland and lowland ecosystems. In the July survey, populations in the two ecosystems were about equal (Fig. 13), while in the August and October surveys, *Scirpophaga* was only collected in the lowlands.

Plant damage and ecology. Studies in irrigated rice at Kogoni, Mali, showed that *Scirpophaga* fed on rice primarily during the panicle initiation to booting stages (Toure 1989). In the 1995 Côte d'Ivoire survey (E. A. Heinrichs, WARDA, 1995, unpubl. data), based on percentage stem borer species composition, populations were only observed in the vegetative and booting stages (none in the flowering-ripening stage) in July (Fig. 14) and August. In the October survey, larvae

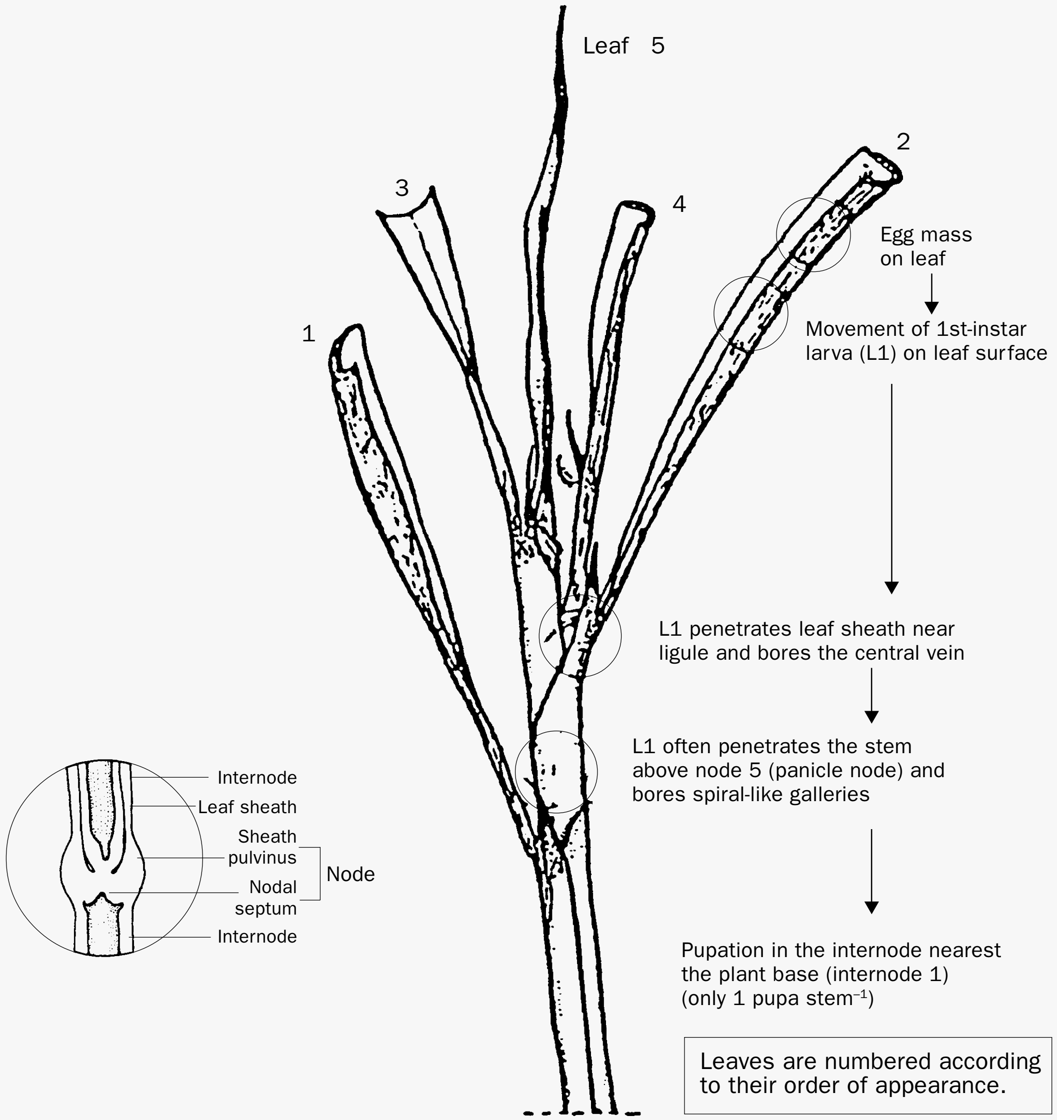


Fig. 37. Chronological development of attack of stem borer, *Scirpophaga* spp., on rice (modified from Pollet 1977).

were only found in plants in the vegetative stage. Calculations based on percentage of *Scirpophaga* in stem borer-damaged tillers at various plant growth stages indicated low populations in the vegetative and booting stages in July and August and no larvae in the flowering-ripening stage (Fig. 24).

Low populations of *Scirpophaga* have been observed in the monthly planting experiment (based on stem dissections made at 30, 50, and 70 DT) on the WARDA M'bé farm. Of the four major borers found in rice stems, from May 1993 to April 1994, *Scirpophaga* and *Chilo* populations were the lowest on most transplanting dates (Fig. 32). *Scirpophaga* larvae were only observed in crops planted in May, June, November to February, and April. The population was the highest in the crop transplanted in May (plants dissected in June and July) with 25 larvae 90 hills^{-1} observed. Percentage of the stem borer complex consisting of *Scirpophaga* was second highest in May (18% compared with 63, 14, and 5% for *Maliarpha*, *Diopsis*, and *Chilo*, respectively), but lower thereafter.

Even when adult *Scirpophaga* populations are high, rice plant damage by this genus appears to be minimal. In Mali, *Scirpophaga* composed 78% of the stem borer adults collected in light traps, while in the rice field, *Scirpophaga* only made up 3% of the larval population with 91% being *M. separatella* (Akinsola and Agyen-Sampong 1984).

The first-instar larvae bore through the leaf sheath and then into the stem. According to Brenière (1982), the larvae pass from one internode to another and some times cut the stem in two places to form a 4-cm-long section of stem in which they lodge. Protected by this stem section, they float on the water surface and may pass from one tiller to another tiller that they then penetrate. The larvae are semiaquatic and, in the case of floating or deep water rice, they can reach a stem below the water level from the piece of stem in which they live. Brenière (1982) reports that one larva can destroy up to four stems but most destroy only one stem. Kumar and Sampson (1982) assert that *S. subumbrosa* larvae do not appear to be as serious as *Chilo* spp. because the *S. subumbrosa* larvae feed inside only one tiller. Feeding damage by *Scirpophaga* spp. causes deadhearts and whiteheads.

Plant density has a minor effect on the relative percentage of *Scirpophaga* larvae in the stem borer population at M'bé. The percentage of *Scirpophaga* in a transplanting experiment increased at the wider hill spacings of 30 × 30 and 40 × 40 cm.

African pink borers, *Sesamia calamistis* Hampson (Figs. 84–85) and *S. nonagrioides botanephaga* Tams and Bowden; Lepidoptera: Noctuidae

Sesamia spp. are the most polyphagous among the rice stem borers. Five *Sesamia* species have been reported to feed on rice in West Africa; *S. calamistis* Hampson, *S. nonagrioides botanephaga* Tams and Bowden, *S. nonagrioides penniseti* Tams and Bowden, *S. eretica* Led., and *S. poephaga* Tams and Bowden. *Sesamia calamistis* is the most common species and occurs throughout West Africa, East Africa, Madagascar, and South Africa (Brenière 1982) and Reunion, Maurice, and Comores Islands in the Indian Ocean (Appert and Ranaivosoa 1970). *Sesamia nonagrioides botanephaga* is probably the next most common *Sesamia* species in rice and is limited to the tropical and equatorial areas of Africa. Sauphanor (1985) considers *S. calamistis* to be the main stem borer of upland rice in Côte d'Ivoire.

Country distribution. *Sesamia calamistis*: Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Ghana, Mali, Niger, Nigeria, Senegal, Togo; *S. nonagrioides botanephaga*: Côte d'Ivoire, Ghana, Liberia, Nigeria, Senegal, Togo.

Description and biology. Brenière (1976, 1983), Akinsola and Agyen-Sampong (1984), and Dale (1994) have described the various stages and the life cycle of *S. calamistis*. Appert and Ranaivosoa (1970) have described the morphology of the various stages and Meijerman and Ulenberg (1996) have described the larval morphology, host plants, and distribution. The adult moth is light brown with brown stripes. The margin of the fore wings is wide, whitish, and partly smoky. The rest of the fore wings are speckled with dark patches (Fig. 84). The hind wings are pearly white with a yellowish margin. The pronotum is covered with long hairs (Fig. 85). The moths are nocturnal and are capable of flying long distances. Mating of adults takes place as early as the first night after emergence and oviposition begins the same night.

The female lays up to 300 eggs. Eggs are laid loosely between the leaf sheath and the stem surrounding the upper internodes. Eggs are subspherical, flat at the poles, and have numerous longitudinal striations. Eggs are yellow and are laid side by side, without any specific alignment. Eggs hatch in 7–10 d after oviposition.

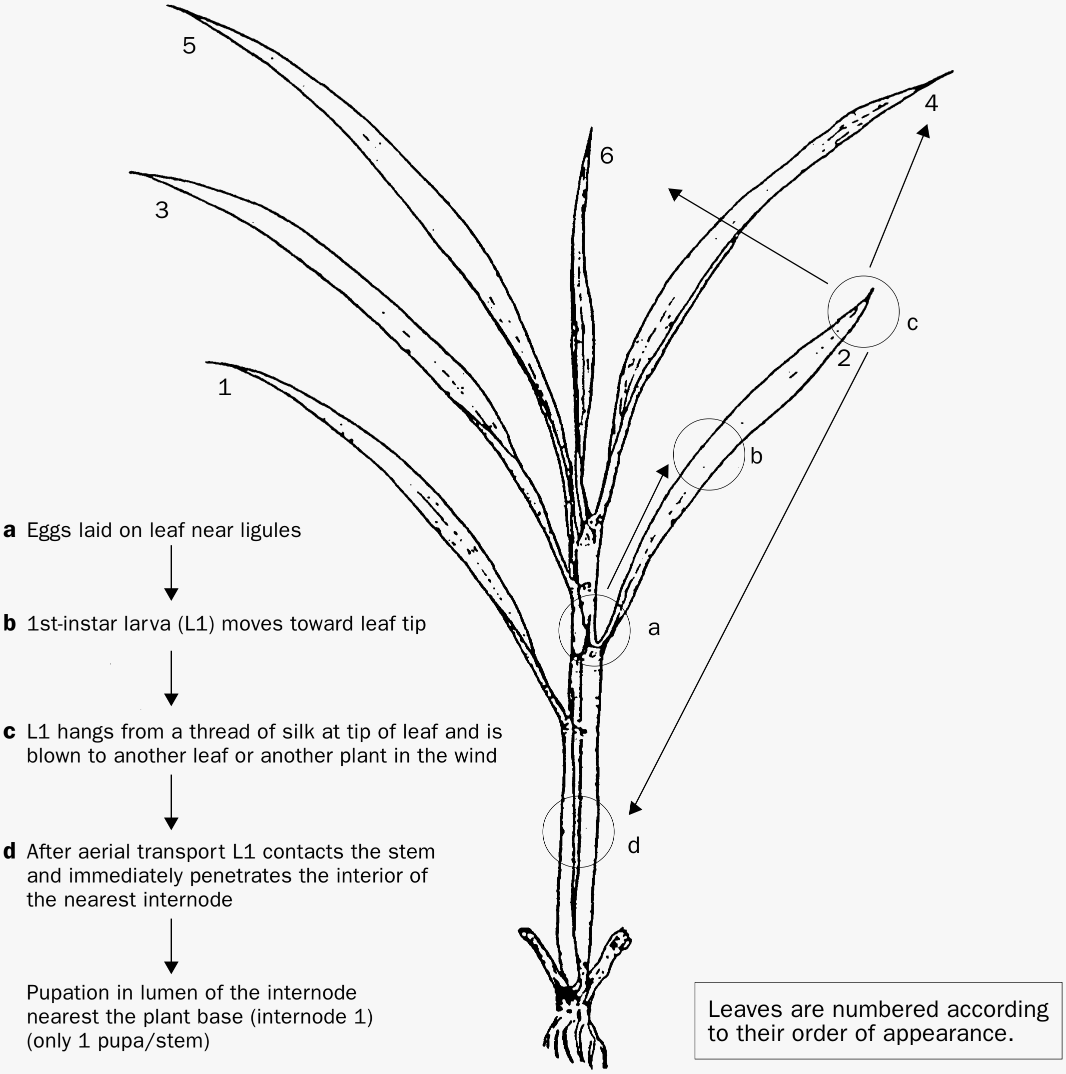
Sesamia calamistis larvae are smooth, uniformly yellowish-pink on the dorsum, with grayish lateral and dorsal stripes, and a dark brown head. First-instar larvae (L1) on hatching are gregarious. Larvae first feed within the tissues of the leaf sheath, causing a brownish yellow discoloration, and then enter the stem through a horizontal cavity and move downward, sometimes through several internodes. The frass, which fills the vertical galleries, is partly pushed out through openings in the leaf sheath. The duration of the larval period is from 28 to 35 d.

The larvae pupate within the base of the stem or in folds of withered leaf sheaths. The pupation period is 10–14 d. The reddish brown pupae are about 17 mm long. The tip of the abdomen bears two dorsal horns (cremaster).

In wet, tropical regions, the life cycle is practically continuous throughout the year. Drought or cold temperatures may slow development. Mature larvae become inactive from the start of the dry season and remain so until the rains begin. On crops that are irrigated out of season, development continues uninterrupted. Where rice is grown throughout the year, there may be at least six generations annually.

Akinsola and Agyen-Sampong (1984) and Pollet (1977) described the life history of *S. nonagrioides botanephaga*. Eggs are laid on the leaf near ligules (Fig. 38). The incubation period is 5–7 d. The L1 moves toward the leaf tip upon hatching and hangs from a silken thread. It is then blown to another leaf of the same plant or to another plant. After aerial transport, the L1 moves onto the stem and penetrates the nearest internode and feeds within the stem. There are six larval instars and the larval period lasts from 40 to 50 d. Pupation occurs within the lumen of the internode nearest the plant base. There is only one pupa per stem. The pupal period is from 10 to 12 d.

Habitat preference. *Sesamia calamistis* and *S. nonagrioides botanephaga* occur in the humid tropical and the Guinea savanna zones in West Africa (Table 2). Of the two species, *S. nonagrioides botanephaga* is most abundant in the forest zone where the dry season is short, while *S. calamistis* is most abundant in the savanna where the dry season is long (Appert and Ranaivosoa 1970, Akinsola and Agyen-Sampong 1984). Neither *Sesamia* species was found on irrigated rice in the Sudanian savanna in the Sahel at Fannaye, Senegal (Akinsola 19087). In surveys conducted in Côte d'Ivoire (E.A. Heinrichs, WARDA, 1995, unpubl. data), of the stem borer larvae collected, *Sesamia* spp. were the



a Eggs laid on leaf near ligules

b 1st-instar larva (L1) moves toward leaf tip

c L1 hangs from a thread of silk at tip of leaf and is blown to another leaf or another plant in the wind

d After aerial transport L1 contacts the stem and immediately penetrates the interior of the nearest internode

Pupation in lumen of the internode nearest the plant base (internode 1) (only 1 pupa/stem)

Leaves are numbered according to their order of appearance.

Fig. 38. Chronological development of stem borer, *Sesamia nonagrioides botanephaga* Tams & Bowden, attack on rice (modified from Pollet 1977).

third most abundant group in the forest in July (Fig. 12) but the most abundant in the August and October surveys and the most abundant in the Guinea savanna in October. Of the five lepidopterous borer genera, *Sesamia* was fourth most abundant in the complex when considering all climatic zones, ecosystems, and plant growth stages (Fig. 23).

Sesamia spp. occur in all ecosystems (Table 4). Populations are highest in the uplands with low populations occurring in the rainfed lowland, mangrove swamp, and irrigated ecosystems. Populations are especially high in upland rice fields near maize, which is actually the preferred host plant (Ho et al 1983). In mangrove rice at Rokupr, Sierra Leone, 18% of the larvae in rice stems were *Sesamia* spp., while 68% were *Maliarpha*, 8% *Chilo*, and 6% *Diopsis* (Akinsola 1987). In a monthly planting experiment at the International Institute of Tropical Agriculture, Ibadan, Nigeria, *S. calamistis* was the most abundant species of the stem borer complex in the uplands, during February, August, and September (Alam 1988). In irrigated fields, *S. calamistis* larval populations were low and were only observed in 7 of 12 mo, during which they composed less than 5% of the stem borer species complex consisting of *S. calamistis*, *M. separatella*, and *C. zacconius*. In Côte d'Ivoire, *Sesamia* spp. were relatively the most abundant of the various stem borer species in the uplands in the August 1995 survey. However, they were relatively less abundant in the uplands in July (Fig. 13) and October, when *Diopsis* and *Chilo*, respectively, predominated. Percent of stem borer-damaged tillers infested with *Sesamia* was distinctly greater in the uplands than in the lowlands in both the July (Fig. 21) and August surveys.

Plant damage and ecology. *Sesamia calamistis* has many plant hosts in addition to rice. These include species in the genera *Andropogon*, *Cenchrus*, *Chrysopogon*, *Coix*, *Cyperus*, *Echinochloa*, *Eleusine*, *Lepturus*, *Lolium*, *Hyparrhenia*, *Kyllingia*, *Panicum*, *Paspalum*, *Pennisetum*, *Phalaris*, *Rottboellia*, *Saccharum*, *Setaria*, *Sorghum*, *Tripsacum*, *Triticum*, *Vetiveria*, *Vossia*, and *Zea*. *Sesamia calamistis* is an important pest of rice, maize, millet, and sorghum in Africa and Madagascar (Appert and Ranaivosoa 1970, Khan et al 1991, Schulthess et al 1991, Hamadoun 1992, Dale 1994). In Ghana, *Echinochloa pyramidalis* (Lamarck) Hitchcock and Chase provides a potential source for the *S. calamistis* infestation on sugarcane (Sampson and Kumar 1986).

Sesamia nonagrioides botanephaga is also an important maize pest in West Africa (Shanower et al 1993). In Ghana, it causes such extensive losses in second-season maize (August-November) in the rainforest zone that farmers are reluctant to plant maize during that season (Tams and Bowden 1953). In a survey conducted in the rainforest region of Côte d'Ivoire in 1994 (Heinrichs and Schulthess 1994), *Sesamia* larvae were present in maize as a monocrop and as a mixed crop with rice and in rice when grown as a mixed crop with maize (Fig. 11).

Infestation of the rice crop by *S. calamistis* is highest at the latter part of the crop growth stage occurring from the end of the booting stage to maturity (Fig. 33). In irrigated rice in the Sahel at Kogoni, Mali, *S. calamistis* larval numbers in rice stems were first observed in the booting stage. Larval populations in both 1986 and 1987 peaked twice, at the end of the panicle initiation stage and again at maturity (Hamadoun 1992). The surveys in Côte d'Ivoire (E.A. Heinrichs, WARDA, 1995, unpubl. data) indicated that *Sesamia* spp. larvae were present in rice stems in the vegetative, booting, and flowering-ripening stages (Fig. 14). Their portion of the total stem borer complex in the flowering-ripening stage was highest in the August and October surveys. In the vegetative stage, *Diopsis* predominated in the three survey dates. Percentage of stem borer-damaged tillers infested with *Sesamia* larvae increased with crop age, reaching a peak in the flowering-ripening stage in both the July (Fig. 24) and August surveys.

Both light and pheromone traps have been used to study the seasonal occurrence of *S. calamistis* moths in irrigated rice at Kogoni, Mali (Hamadoun 1992). Rains in this part of the Sahel begin in June after a long, harsh, dry season and continue to December. In 1987, there were three major flights. Moths began flying in early August, reaching a peak in mid-August, and again peaking in mid-September and mid-October and terminating in early November.

Because the rice plants are generally attacked at the later growth stages (Fig. 33) by *Sesamia* spp., whiteheads are the primary result. Young larvae occupy the stalk at the base of the panicle causing whitehead development, but they feed lower in the stem as they become older.

The effect of feeding damage by *S. nonagrioides botanephaga* on rice development has been described in detail by Akinsola (1984a). Infestation by larvae in the tillering stage of crop growth resulted in the development of deadhearts. Feeding damage caused a significant increase in number of tillers. However, at harvest, uninfested plants had higher numbers of productive tillers. This indicated that the initial increase in tiller numbers in infested plants did not result in a corresponding increase in productive tillers at harvest. Thus, it appeared that the compensatory tillers produced contributed little to ultimate yield because they do not produce mature panicles at harvest. Feeding of the larvae also caused a significant reduction in the number of filled grains.

Larval infestation of plants at the booting stage caused yield loss by reducing the number of productive tillers through the formation of whiteheads. Infestation at this stage also caused the growth of compensatory tillers but these were too young to produce panicles before harvest.

Rice plant density and fertilizer level effects on rice plant damage caused by *S. calamistis* were studied under lowland rice conditions in Kenya (Ho and Kibuka 1983). Plant damage was similar at plant spacings of 10 × 20 and 20 × 20 cm, but there were significantly more empty grains that resulted from *S. calamistis* at 120 kg N than at 0 or 60 kg N ha^{-1}.

African rice gall midge

Orseolia oryzivora Harris and Gagne; Diptera: Cecidomyiidae; Figs. 95–97

The African rice gall midge, *Orseolia oryzivora* Harris and Gagne, was until recently misidentified and referred to as *O. oryzae* (Wood-Mason), which is the Asian rice gall midge. Harris and Gagne (1982) reported that the two species are morphologically distinct in the larval, pupal, and adult stages. They can be separated most easily in the pupal stage by the antennal horns, which are simple and terminate in a point in *O. oryzivora* but are bifid and terminate in two strong spines in *O. oryzae*.

The occurrence of distinct species of *Orseolia* on rice in Africa and Asia may be linked to the separate development of African and Asian cultivated rice. The Asian rice species, *O. sativa*, probably arose along the foothills of the Himalayas and associated mountain ranges in Southeast Asia and southwestern China and has been cultivated for about 9,000 yr. The African rice species, *O. glaberrima*, probably originated in the swampy basin of the upper Niger River about 3,500 yr ago (Chang 1976b).

Country distribution. Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo.

Orseolia oryzivora was first observed as a pest of rice in Nigeria in the early 1950s, but at that time was thought to be the Asian species, *O. oryzae* (Harris 1960). As a result of the clarification of the taxonomy, Harris (1990) stated that the African rice gall midge had first been reported in Sudan in 1947, in Malawi in 1973, and in Senegal and Burkina Faso in 1980. He goes on to state that this simply reflects the level of entomological interest and not the spread of the species, which must have been present on rice in Africa for thousands of years. It seems likely that the species originated on *O. glaberrima* in West Africa and it is therefore endemic to that area.

Orseolia oryzivora is widely distributed in West Africa and has also been reported from Zambia (Alam et al 1985b), Sudan (Harris 1987), and Malawi (Feijen and Schulten 1983). It also occurs in Tanzania where severe outbreaks were reported in the Kapunga Irrigated Rice Project, shortly after rice was first grown in the early 1990s (E.A. Heinrichs and A.R. Masawe, WARDA, 1995, unpubl. data).

Description and biology. The African rice gall midge is similar in appearance, behavior, and biology and in the plant damage caused to that of the Asian gall midge. The Asian gall midge is a severe pest of rice especially in India, Sri Lanka, Thailand, and Indonesia. It is well known for population variability as indicated by biotypic reactions to differential varieties (Heinrichs and Pathak 1981).

The description and biology of the African rice gall midge are published in Bouchard et al (1992), Brenière (1983), Umeh and Joshi (1993), and Dale (1994). The adult midge is similar in appearance to a mosquito (Fig. 95). It is 4.8 mm in length and has a bright red abdomen; dark antennae, pronotum, and thorax; and black eyes. The adult is attracted to artificial lights and they can be used to increase the level of midge populations in field evaluations of rice germplasm for gall midge resistance.

Mating of the adults takes place soon after emergence and oviposition begins within a few hours. The adults live about 2–4 d during which the female lays 100–200 eggs, either isolated, or in groups of three to five at the base of stems, on the ligule, near the base of rice leaves, or on leaf sheaths.

Eggs are elongated (cigar-shaped) and shiny white. With development, they turn yellow and then amber with red spots that appear just before hatching. Eggs require extremely high humidity for hatching, which may be a reason that they are pests during the rainy season and are most serious on rainfed lowland and irrigated rice. The incubation period is 3–4 d. Newly hatched larvae are green-white and stout with a pointed posterior end. Larvae have two pairs of distinct spines, which disappear at the third larval instar, when the larvae become milky-white with brown spiracles and distinct mouth hooks. The larvae, upon hatching, wiggle down the leaf blade in a film of dew and move between the leaf sheath and the stem until they reach the opening point of the apical or side bud at a node. Oviposition, egg development, and penetration into the stem take about 5 d. The larvae feed within the developing bud, which is a zone of differentiation for new tillers.

A hollow chamber called a 'gall' forms around each larva. Galls form from 16 to 18 d after hatching. There is only one larva per gall and the entire larval stage is spent within the gall. As the larva feeds, the gall enlarges at the base and elongates, having the tubular appearance of an onion leaf. The gall consists primarily of leaf sheath tissue with a small leaf at the tip. Because the leaf sheath tissue is light green, the gall is sometimes considered to be 'silvery,' hence the name 'silver shoot.' There are three larval instars and the larval period is from 15 to 20 d.

Pupation occurs within the gall. When galls are observed, the insect is already in the pupal stage. The pupa has several rows of abdominal spines that enable it to move up to the tip of the gall before adult emergence. The pupa makes a hole at the gall tip. The pupal period varies from 2 to 8 d. The adult, upon emergence, exits the gall through the hole, leaving the pupal skin sticking out of the hole. Emergence of the adult takes place at night or in the early morning. The entire life cycle from egg to adult is 25–38 d. There may be several generations within a crop season.

Parasitism is extremely important in the natural control of the African rice gall midge (Nacro et al 1995). Dakouo et al (1988) reported larval parasitism up to 77% in Burkina Faso. However, parasitism was mainly due to the microhymenopterans, *Platygaster oryzae* Cameron (Synonym: *Platygaster diplosisae* Risbec) and *Aprostocetus procerae* (Risbec) (synonyms: *Tetrastichus pachydiplosisae* Risbec and *Aprostocetus pachydiplosisae* Risbec), both of which are established late in the crop cycle. Ukwungwu and Joshi (1992) reported *P. diplosisae*, *A. pachydiplosisae*, and *Aphanogmus* spp. as parasitoids of the gall midge in Nigeria, with *P. diplosisae* being the dominant species. According to Harris (1987), further research should be conducted on the biology and ecology of the African rice gall midge with special emphasis on the parasite and predator complexes, which could possibly lead to an effective classical biological control program (Harris 1987).

Habitat preference. *Orseolia oryzivora* is reported to occur in the humid tropical and Guinea and Sudanian savanna zones of West Africa, but is more abundant in the savanna (Table 2). In Nigeria, where the African rice gall midge occurs in both the savanna and forest zones, it is most common in the southern portion of the Guinea savanna region of the country (Ukwungwu and Joshi 1992). Stem dissections in three surveys conducted in Côte d'Ivoire in 1995 indicated that gall midge infestation was low, but populations were higher in the Guinea savanna than in the humid forest region (Fig. 12). In surveys conducted in Côte d'Ivoire and Guinea (Heinrichs et al 1995), tiller infestation was 0.9 and 0.6% in the savanna and forest, respectively, in Côte d'Ivoire and 1.3 and 0.0% in the savanna and forest zones, respectively, in Guinea.

Williams et al (1994) studied seasonal changes in African rice gall midge populations at four contrasting sites in Nigeria (Fig. 39). They found gall midge larvae in *O. longistaminata* or *O. sativa* from May to December in the Guinea savanna zone, August to December in the forest/savanna transition zone, and February to December in the single- and double-cropped forest zone sites. The host plant species observed varied with locality and cropping pattern. In the forest zone, the gall midge survived on *O. sativa* ratoons, but in the savanna zone, wild perennial rice *O. longistaminata* was the key dry-season host, with *O. sativa* ratoons and volunteers providing bridges between it and the rice crop. In a wet-season study in Nigeria, gall midge damage on ratoons was higher than on the main crop (Joshi et al 1990).

According to Agyen-Sampong (1982), the African rice gall midge is most abundant in the irrigated and rainfed lowland ecosystems (Table 4) and does not occur in the uplands. However, upland infestations are not uncommon (E.A. Heinrichs, WARDA, 1994, personal observation). In Burkina Faso, the African gall midge was reported to feed on upland, lowland rainfed, and

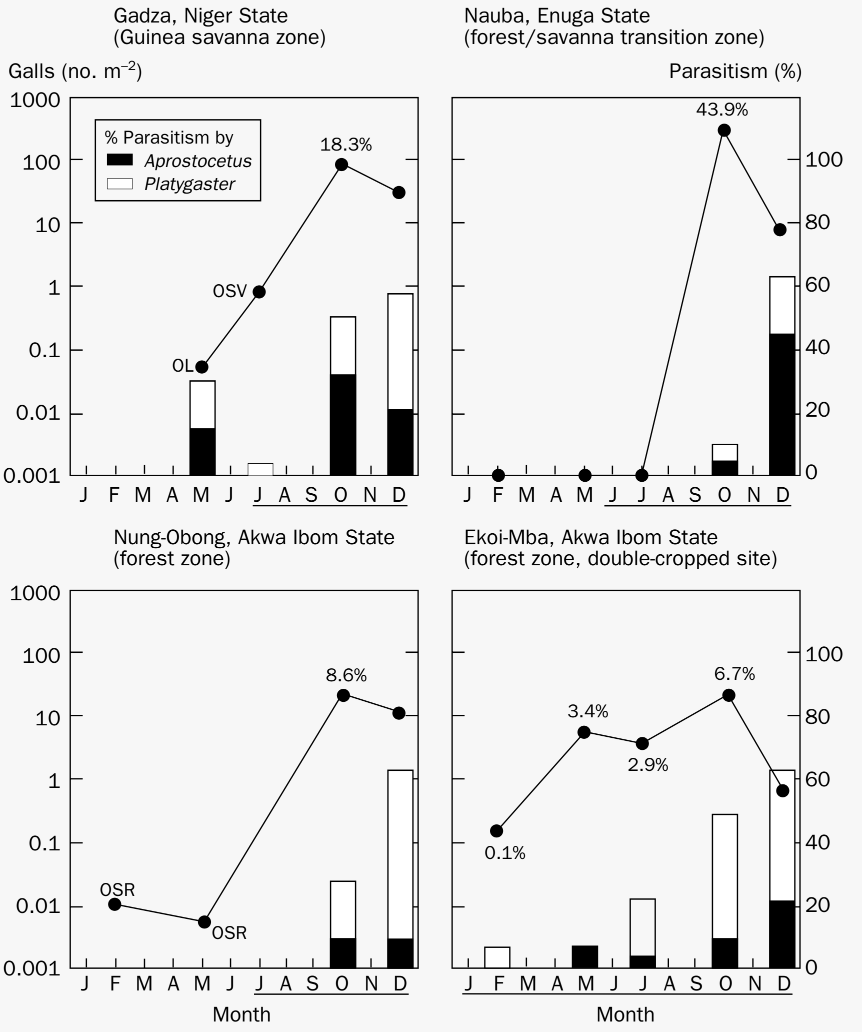


Fig. 39. Seasonal changes in population densities of African rice gall midge, *Orseolia oryzivora* Harris and Gagne, and parasitism by *Aprostocetus procerae* (Risbec) and *Platygaster diplosisae* Risbec at four contrasting Nigerian sites. Gall densities are site averages, including all main habitats. Lines under months indicate when rice crops were available. Percentages show average tiller infestation levels for sampled rice crops. Host plants other than rice, on which galls were found, are indicated: OL = *Oryza longistaminata* A. Chev. et Roehr, OSR = *O. sativa* L. ratoons, OSV = *O. sativa* volunteers (Williams et al 1995).

lowland irrigated rice (Dakouo et al 1988). In the forest region of Côte d'Ivoire, severe feeding was observed in rice, growing in hydromorphic environments, that was planted late in the 1991 rainy season (E.A. Heinrichs, WARDA, 1992, personal observation). Upland and hydromorphic rice fields were attacked at M'bé in 1992, during the peak of the rainy season, when misty rains occurred almost daily. In surveys conducted in Côte d'Ivoire in 1995, populations were low and were only found in the lowland in the July (Fig. 13) and October surveys, but larvae were present in both the upland and lowland in August. However, as in Asia, the rice gall midge appears to be of most serious economic importance as a pest of lowland rice in Africa.

Taylor et al (1995) first reported the rice gall midge in Sierra Leone in 1994. They observed rice plants damaged by gall midge in upland nurseries, hydromorphic areas, and in transplanted lowland fields at the Rice Research Station, Rokupr. Typical onion leaf-like symptoms were also observed on wild rices *O. longistaminata* and *O. barthii*.

Plant damage and ecology. *Orseolia oryzivora* shows more extreme variations in abundance, both spatially and temporally, than other rice insect pests in West Africa. It is the only rice insect pest in West Africa for which there is evidence of a long-term trend of increasing abundance over the last few decades. Gall midge attack can result in heavy yield loss under rainfed lowland conditions even at moderate infestation levels (Williams 1997).

Orseolia oryzivora has risen to the status of a major rice pest in certain regions of Nigeria (Ukwungwu et al 1989). Since it was first observed as a pest of rice in Nigeria in the early 1950s (Harris 1960), it has continued to increase in importance (Umeh et al 1992). Recent surveys have given an indication that gall midge infestations in other West African countries appear to be less than in Nigeria. In 1995, when the gall midge was first observed in Sierra Leone, infestations in farmers' fields reached 27% of hills attacked (Taylor et al 1995). A 1995 wet-season survey conducted by Hamadoun (1996) at six sites in the central and southern portion of Mali indicated percent tiller infestation levels ranging from 0.5% at Klela to 17 and 24% at Longorola and Baguineda, respectively. In a survey conducted in lowland fields of Côte d'Ivoire, Guinea, and Guinea Bissau during the 1995 wet season (Heinrichs et al 1995), tiller infestation was 1.6, 0.9, and 2.0%, respectively. In the July, 1995 Côte d'Ivoire survey, *O. oryzivora* was the least abundant of the larvae feeding in rice stems (Fig. 23).

The African gall midge has been reported on the weeds *Paspalum polystachion* (L.) and *P. scrobiculatum* L. and the wild rice *O. longistaminata* in Burkina Faso (Bonzi 1980). However, Harris and Gagne (1982) examined the larvae and pupae collected on *Paspalum* from Vallée du Kou in Burkina Faso and reported that the specimens represented an undescribed species of *Orseolia* and not *O. oryzivora*. Thus, it is likely that *O. oryzivora* hosts are restricted to the *Oryza* genus (Harris and Gagne 1982), and that *O. longistaminata* is an important host during the dry season. In studies conducted in Nigeria (Williams et al 1994), host plant species important for the dry-season survival of the gall midge varied according to locality and cropping pattern. In the forest zone, the insect survived on rice, *O. sativa* ratoons, but in the savanna zone, wild perennial rice *O. longistaminata* was the dry-season host, with *O. sativa* ratoons providing bridges between it and the rice crop.

The Asian gall midge occurs in weeds such as *Cynodon*, *Echinochloa*, *Leersia*, *Panicum*, *Paspalum,* and wild rice *O. barthii* during the dry season (Dale 1994). With the onset of the monsoon rains, the midge becomes active and completes one or two generations in grasses before it moves to the rice crop (Reddy 1967). Early planting of the rice crops before the midge emerges from the weeds is a cultural means of control in Asia.

Rice gall midge attack occurs from the nursery or seedling stage to the end of the tillering stage of crop growth. Young larvae cannot survive in the plants past the vegetative stage, as there are no actively growing apical buds for them to infest. In the 1995 Côte d'Ivoire surveys, larvae or pupae were found in rice stems only in the vegetative and booting stages of rice growth (Fig. 14).

In studies conducted in Burkina Faso (Dakouo et al 1988), galls in field plantings were first observed at 30 DT and became most abundant at 70–90 DT of a 135-d (seeding to maturity) variety. In a later study conducted at the irrigated rice project in Karfiguela, Burkina Faso (Nacro et al 1995), galls were first observed at 42 days after sowing (DS) of the nursery (27 DT) during the wet season and at 70 DS (55 DT) during the dry season.

Rice gall midge damage occurs primarily during the rainy season. At IITA, Ibadan, Nigeria, the rainy season occurs during the months of June to November and peak damage occurs in July (Fig. 40). However, gall midge damage at IITA was observed during the dry season, November 1993 to January 1994. According to Williams et al (1995), the gall midge was probably able to reproduce through the dry period because low night temperatures, typical of the 'harmattan,' produced dew on the leaves, allowing some eggs and newly hatched larvae to survive.

Date of transplanting of irrigated rice at Edozhigi, Nigeria, had a distinct effect on gall midge infestation of the rainy season crop (June to October) (Ukwungwu 1987b). Gall midge attack increased from about 10% infested tillers when transplanted 25 Aug to about 30% when transplanted 25 Oct.

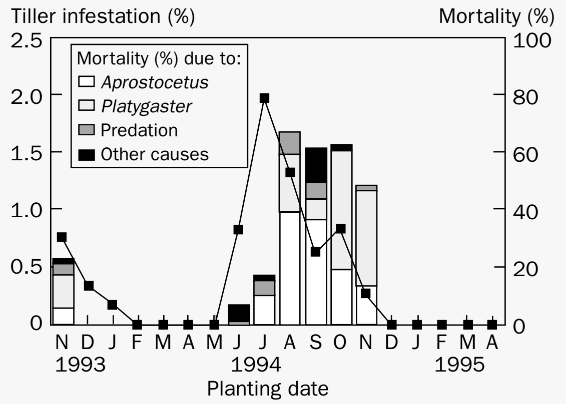


Fig. 40. Relationships between transplanting date, African rice gall midge, *Orseolia oryzivora* Harris and Gagne, infestation (line) and parasitism and predation levels within galls at 60 DT, as indicated by percent mortality (bars). Parasitism and predation were only determined if galls exceeded 7 per 100 hills. Parasitism due to *Platygaster diplosisae* Risbec and *Aprostocetus procerae* (Risbec) was separated. IITA, Ibadan, Nigeria (Williams et al 1995).

The rice gall midge produces a distinctly characteristic plant damage symptom—a gall resembling an onion leaf. Size of the gall varies, depending on the host plant, but is usually about 3 mm wide and 10–30 cm long. In studies in Nigeria, gall length was reported to be from 26 to 41 mm. Abnormal galls (spiral and twisted) were also observed (Ukwungwu and Joshi 1992).

Larval feeding suppresses leaf primordial differentiation at the growing tip and induces the development of radial ridges from the innermost leaf primordium followed by an elongation of the leaf sheath (Perera and Fernando 1968). Galls appear within a week after the larvae reach the growing point. Feeding on seedlings leads to profuse tillering and stunting of plants. A late infestation of the plants at the reproductive shoot apex causes a malformation of the leaves and panicles. Each gall represents a tiller that will not produce a panicle. After adult emergence, the gall turns yellow and then dries. The plant responds by producing new tillers that may in turn be attacked by the gall midge. If they are not attacked, they may produce a panicle but maturity will be severely delayed.

In West Africa, Nigeria is reported to be the 'hot spot' for gall midge infestation. Severe gall midge incidence in Nigeria was reported in the states of Plateau and Niger (Ukwungwu et al 1984). In 1988, there was a severe outbreak in the Guinea savanna zone (Ukwungwu et al 1989). Most severe damage was in Abakaliki in Anambra State where up to 80% tiller infestation was observed. About 50,000 ha of rice were damaged and total grain losses were recorded in severely infested fields. Outbreaks also reached catastrophic proportions in the forest zone in Cross River State in 1989 and in Akwa Ibom State. These outbreaks attracted national attention because they came at a time when rice importation had been prohibited. Suggested reasons for the outbreaks were 1) favorable weather with high rainfall, extensive cloud cover, and high humidity; 2) staggered planting of highly susceptible varieties that provide a continuity of favorable host plants; 3) the sale and exchange of gall midge-infested rice seedlings; and 4) the use of insecticides that have adverse effects on natural enemies (Ukwungwu et al 1989).

Few experiments to determine gall midge-caused grain yield losses have been reported in Africa. Studies over a 5-yr period using the insecticidal check method were conducted in the irrigated rice area in Karfiguela, southwestern Burkina Faso (Nacro and Dakouo 1990). Yield losses in 1982, 1983, 1984, 1986, and 1987 were, respectively, 19, 17, 11, 11, and 3%.

Williams (1997) in Nigeria conducted on-station and on-farm gall midge yield loss trials. In on-station trials, he observed a yield loss of 0.5% for every 1% increase in infested tillers at 84 DT. Results suggested that under the fertile conditions of experiment station fields, plants compensated well for gall midge attack and this compensation continued even after the time at which uninfested tillers would have passed the panicle initiation stage. In on-farm trials, yield losses were 2.3 (favorable site) and 3.1% (unfavorable site) per 1% increase in tillers with galls at 63 DT. This was considerably higher than in the on-station trial. Thus, one gall per five tillers at 49–63 DT caused 40 and 60% yield losses, respectively.

Nacro et al (1996) studied the relationship between gall midge adult populations and yield losses in 1-m^2 plots of caged rice seedlings. Yield losses ranged from 22% at one midge pair to 65% with 25 pairs m^{-2}. The infestation by the insects on the plants resulted in compensatory tillers that developed in response to the damage. However, the compensation was not sufficient to make up for the loss of yield due to the damaged tillers. One percent of tillers damaged resulted in 2% grain yield loss. In Asia, Israel et al (1959) reported that a 1% increase in infested tillers caused a 0.5% loss in grain yield. Israel et al (1959) also report that infestations are most severe when the first rains are early and are followed by a relatively long drought, which delays rice planting. The first generation occurs on grasses and, when rice becomes available, it is attacked. The extent of damage is related to the availability of host plants, the amount of rain (especially at the beginning of the season), and the cropping pattern in a locality. Wide varietal differences exist in the effect of gall midge infestations on yield losses.

Certain cultural practices affect population levels of the Asian gall midge. Incidence decreases with high levels of phosphate in combination with nitrogen and increases with high levels of potash (Israel et al 1963). Close spacing of transplanted rice resulted in a greater number of tillers and more leaves per unit area, an increase in the relative humidity within the canopy and a subsequent increase in gall midge incidence (Prakasa Rao 1975). In Nigeria, nitrogen and close plant spacing increased the number of gall midge-infested tillers (Ukwungwu 1987d).

Leafhoppers and planthoppers

Rice leafhoppers (Cicadellidae) and planthoppers (Delphacidae) have become important pests in Asia where, in recent decades, infestations have assumed epidemic proportions coterminous with the Green Revolution. The genera occurring in Asia are also present in West Africa but the species are different. The West African species are similar in appearance to Asian species but they are of only minor importance. In Asia, their importance has escalated with the intensification of rice production, especially the use of insecticides. Asian species not only cause direct plant damage, by removing the sap from leaves and stems, but several are also efficient vectors of rice viruses. No West African species has been shown to be a rice virus vector.

Leafhoppers attack all aerial parts of the plant but planthoppers occur primarily on the basal portion of the plant (Dale 1994). Oman (1949) classified the types of damage caused by leafhoppers and planthoppers into four categories: 1) removal of plant sap from the xylem or phloem, 2) damage to plant tissue and deformation of leaves and stems through oviposition, 3) transmission of pathogens, and 4) predisposition of the plants to pathogens that penetrate the oviposition and feeding punctures left by the hoppers in plant tissue. In Asia, leafhoppers are a threat to production mainly because of their efficiency in vectoring rice viruses, but generally do not cause direct damage by the removal of plant sap. The brown planthopper, *Nilaparvata lugens* (Stål), however, is a serious pest because it causes direct damage through the removal of large amounts of plant sap, and as a vector of several serious rice viruses (Heinrichs 1979).

In Asia, the sudden increase in the importance of these pests in the 1970s was attributed to the changes in cultural practices accompanying the intensification of rice production during the Green Revolution. It appears that high levels of nitrogen fertilizer, monocultures, continuous cropping, and mainly the application of insecticides that cause hopper resurgence are some of the intensification practices contributing to leafhopper and planthopper outbreaks (Heinrichs and Mochida 1984). In West Africa, where these insects are not known to carry viruses and where rice production intensification has been limited, the hoppers are still considered as only potential pests, which should be closely monitored as production practices are intensified.

Intensive surveys of the leafhoppers and planthoppers inhabiting West African rice environments are lacking. Also, their role as vectors of rice viruses in West Africa has not been determined. Based on the examination of museum specimens, Wilson and Claridge (1991) described the rice leafhoppers and planthoppers occurring on rice in the region south of the Sahara and have developed taxonomic keys for the identification of adults.

Wilson and Claridge (1991) list three planthopper species of the Delphacidae family that occur on rice in West Africa, *Nilaparvata maeander* Fennah (Fig. 348), *Tagosodes cubanus* (Crawford), and *Sogatella kolophon* (Kirkaldy) (Fig. 351). The literature and the WARDA Arthropod Reference Collection add *Delphacoides aglauros* and *Sogatella nigeriensis* to the delphacid species list in West Africa (Table 5). Closely related species attacking rice in Asia are the brown planthopper, *N. lugens* (Stål) and the whitebacked planthopper, *Sogatella furcifera* (Horvath). *Sogatella kolophon* is widely distributed in the world, occurring in West Africa, Australia, the Orient, the Atlantic Islands, the Pacific, the Ethiopian region, the New World, and the eastern Palearctic. It is most commonly found in the tropics. *Tagosodes cubanus* also occurs in South and Central America where it is a vector of the hoja blanca virus of rice, which can cause up to 50% yield loss (King and Saunders 1984).

Nisia nervosa (Motschulsky) is the only member of the Meenoplidae family attacking rice. The preferred host plant appears to be sedge species (Cyperaceae), but rice is frequently used as a host (Wilson and Claridge 1991). Grist and Lever (1969) mention it as a minor pest of rice and Huang and Qi (1981) have recorded it on rice and sugarcane in China.

Locris spp. (Cercopidae) are confined to Africa. They are easily recognized by their large size and red, orange, or brown coloration and patterning of the fore wings and head. Little is known about the biology of *Locris* spp. Akingbohungbe (1983) records *Locris rubens* Erichson, *L. maculata maculata* F., and *L. rubra* F. as minor pests of cereals in Nigeria. The most common *Locris* spp. occurring on rice are *L. erythromela* (Walker), *L. maculata maculata*, *L. rubra*, and *L. rubens* (E.A. Akinsola, WARDA, 1992, pers. commun.). They prefer irrigated and lowland rice to upland rice. Severe plant damage caused by *Locris* spp. is not common but leaf bronzing and wilting can occur.

Wilson and Claridge (1991) list five species of cicadellids in West Africa. Fourteen Cicadellidae species have been reported in the literature (Table 5). *Nephotettix* spp. are severe pests of rice in Asia where *N. virescens* (Distant), *N. cincticeps* (Uhler), and *N. nigropictus* (Stål) are vectors of the virus diseases tungro, rice transitory yellowing, rice dwarf virus, rice gall dwarf, and yellow dwarf. In West Africa, *N. modulatus* Melichar and *N. afer* Ghauri are, so far, of only minor importance, as they are not known to be virus vectors and populations seldom reach levels where feeding injury causes economic damage to rice.

Two other cicadellid species, *Cofana spectra* (Distant) and *C. unimaculata* (Signoret) occur on rice in West Africa. Both are widely distributed in the Old World tropics from Africa to Australia. *Cofana* spp. are not known to be virus vectors in any region of the world. There are several cicadellid species of the genus *Recilia* that are found on rice throughout the world. Of these, the zigzagged leafhopper, *R. dorsalis* (Motschulsky), is an important rice pest in Asia where it transmits tungro, rice dwarf virus, rice gall dwarf viruses, and orange leaf (Wilson and Claridge 1991). *Recilia mica* Kramer (Fig. 376) has only been recorded from West Africa (Kramer 1962) where it has been reported on rice (Zakra et al 1986), but evidence of crop damage has not been reported.

Little is known about the biology and ecology of planthoppers and leafhoppers that occur on rice in West Africa. However, the known literature and research conducted at WARDA on *Nephotettix*, *Cofana*, *Nilaparvata*, *Nisia*, and *Locris* spp. are reported below.

Green leafhoppers, *Nephotettix afer* Ghauri (Fig. 374) and *Nephotettix modulatus* Melichar (Fig. 375); Hemiptera: Cicadellidae

The *Nephotettix* genus in West Africa is represented by two species, *N. afer* and *N. modulatus* (Ghauri 1968). *Nephotettix modulatus* has also been recognized as *N. africanus* Emeljanov (Wilson and Claridge 1991).

Country distribution. *N. afer:* Côte d'Ivoire, Guinea, Guinea-Bissau, Nigeria; *N. modulatus:* Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Senegal, Togo.

Nephotettix modulatus is believed to be widely distributed in sub-Saharan Africa, extending southward to Tanzania and Angola, and in North Africa and the Middle East (Ghauri 1971). *Nephotettix afer* may be more widely distributed in West Africa than in the four countries listed in Table 5. It has a more southerly distribution than *N. modulatus*, having been found in South Africa. In contrast to *N. modulatus*, *N. afer* is not found in North Africa or the Middle East (Ghauri 1971). Like *N. modulatus*, it has been reported in Angola, Ethiopia, Kenya, Madagascar, Sudan, Tanzania, Uganda, and Zambia (Dale 1994). In countries where both *N. modulatus* and *N. afer* occur, they may be found together in the same rice fields.

Description and biology. Information regarding the biology of *Nephotettix* spp. in West Africa is scanty. More research is needed to determine the distribution, biology, and ecology of these species and their possible role as virus vectors in West Africa.

Nephotettix modulatus (Fig. 375), being green with black markings on the wings and head, is similar in appearance to *N. nigropictus*, an Asian species, with which it is often confused. *Nephotettix afer* (Fig. 374) differs from *N. modulatus* in that it has a distinct, complete submarginal black band on the vertex of the head, while in *N. modulatus*, the black band is separated or reduced in the middle (Wilson and Claridge 1991). Also, *N. modulatus* is lighter in color than *N. afer*, slightly larger, and differs in that the ovipositor is longer, and the dorsal setae of male pygofers are longer (Dale 1994). The color pattern of *N. afer* is even more similar to that of *N. nigropictus* than is *N. modulatus*. Three transverse marginal and submarginal black bands on the vertex are well developed.

Both the nymphs and the adults of *Nephotettix* spp. suck sap from the leaves and leaf sheaths. Eggs are deposited in groups of 10–25 in slits made by the ovipositor in leaf sheaths of growing rice plants. The incubation period is 4–10 d. Nymphs, upon hatching, suck the sap from leaves. High mortality occurs in the nymphal stage due to the predatory activity of spiders (E.A. Akinsola, WARDA, 1992, pers. commun.).

Habitat preference. In the three surveys conducted in Côte d'Ivoire in 1995, *Nephotettix* spp. populations were similar in the forest and savanna climatic zones in the July and October surveys. However, they were significantly higher in the forest zone in the August survey being 11.4 per 500 sweeps compared with 5.8 per 500 sweeps in the savanna (E.A. Heinrichs, WARDA, 1995, unpubl. data). In the 1995 survey in Guinea, *Nephotettix* populations were not significantly different in the two climatic zones, being 12.0 per 500 sweeps in the forest zone and 16.9 in the savanna (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data).

Nephotettix leafhoppers are distributed throughout the toposequence from the uplands to the lowlands. However, populations are generally higher in the lowlands. Agyen-Sampong (1982) reported higher populations in rainfed lowland, mangrove swamp, and irrigated ecologies than in upland rice (Table 4). In the 1995 surveys in Côte d'Ivoire, sweep net counts were 3.5 and 8.0 per 500 sweeps in the uplands and lowlands, respectively, in July, and 7.1 and 11.4, respectively, in August. In studies conducted on the WARDA M'bé Farm, the highest *Nephotettix* populations were found at the lower portion of the toposequence; the lower hydromorphic zone and the lowland (Oyediran et al 1999a) (Fig. 41). Also, nonweeded plots had higher populations than weeded plots in WARDA studies (Afun et al 1995).

Plant damage and ecology. Host plants of *N. modulatus*, other than rice, are *Rottboellia cochinchinensis* (Loureiro) Clayton, L., *Ischaemum rugosum* Salisb., and *Paspalum vaginatum* Swartz. Alghali and Domingo (1982) reported that *N. modulatus*

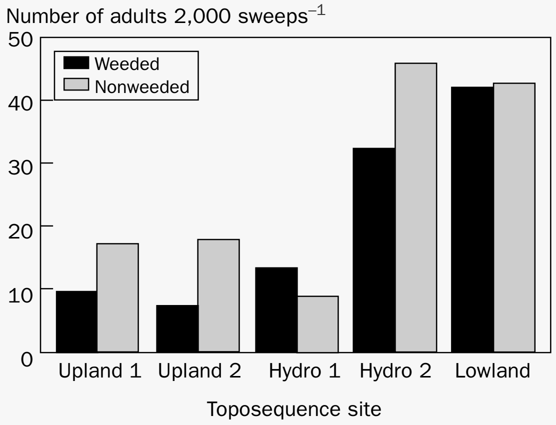


Fig. 41. Number of *Nephotettix* spp. adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

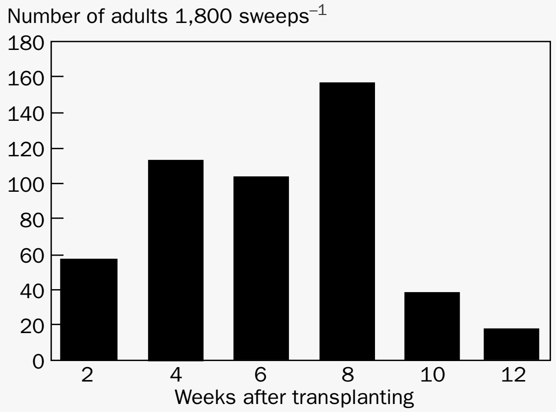


Fig. 42. Number of *Nephotettix* spp. adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

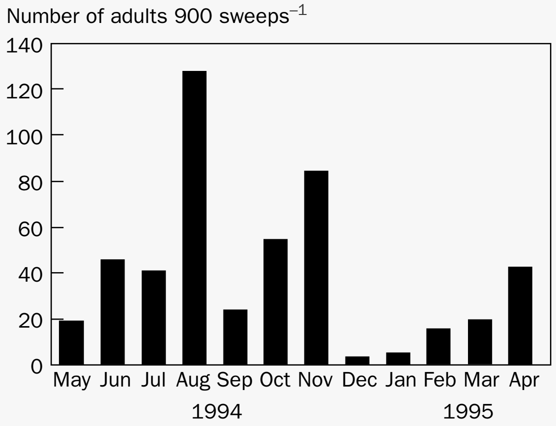


Fig. 43. Number of *Nephotettix* spp. adults collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent the total number of adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

nymphs were found on *R. cochinchinensis* and *I. rugosum* in the mangrove swamps of Mawir, Sierra Leone, when rice was at the heading stage and on *P. vaginatum* in mangrove swamps at Rokupr, Sierra Leone, when rice was at the vegetative stage.

Nephotettix leafhoppers in irrigated rice on the WARDA M'bé Farm are present from shortly after transplanting to near harvest. Peak populations occur from 4 to 8 WAT (Fig. 42).

Nephotettix spp. are present in irrigated rice at WARDA throughout the year (Oyediran and Heinrichs 1999). Populations in monthly plantings were lowest in plots transplanted during the dry season and harmattan period, December to January. Highest populations occurred during the rainy season when about 0.14 hoppers sweep^{-1} were collected in the August transplanting (Fig. 43).

Feeding on rice is mostly confined to the leaf and leaf sheath. Low infestation levels may reduce vigor of the plant and the number of productive tillers. Heavy infestation levels, which are not common, cause withering and complete drying of the crop.

Length of the fallow period, prior to the sowing of upland rice, has an effect on leafhopper populations. Studies conducted in the forest region of Côte d'Ivoire indicated that leafhopper populations in rice, planted after a fallow period, increase as the length of the fallow increases (Heinrichs et al 1993a).

White rice leafhoppers, *Cofana spectra* (Distant) (Fig. 367) and *C. unimaculata* (Signoret) (Fig. 366); Hemiptera: Cicadellidae

Two species of the *Cofana* genus are common in West African rice fields. Wilson and Claridge (1991) regard *Cofana spectra* (Distant) to be a pest.

Country distribution. *C. spectra*: Benin, Burkina Faso, Côte d'Ivoire, Guinea, Guinea-Bissau, Mali, Nigeria, Togo; *Cofana unimaculata*: Benin, Burkina Faso, Côte d'Ivoire, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Togo.

Cofana spectra and *C. unimaculata* probably occur throughout West Africa (Descamps 1956, Brenière 1969) and have a wide distribution in the Old World tropics from Africa to Australia (Wilson and Claridge 1991).

Description and biology. *Cofana spectra* (Fig. 367) and *C. unimaculata* (Fig. 366) are the largest of the leafhoppers occurring on rice in West Africa. They are easily distinguished. *Cofana spectra* is characterized by its larger size; the presence of a large, central, black spot on the vertex of the head toward the posterior margin (Fig. 367); and the brown lines on the fore wing.

Adults of *C. spectra* are found on the lower surface of the leaves or at the base of the plant. Adults are attracted to light at night. Females oviposit by making a cut parallel to the long axis of the leaf with their saw-like ovipositors. The eggs are laid in rows of 10–15 across the slit at the base of the plant above the water level. The number of eggs laid per female is about 50 and they hatch in 5–12 d.

Both *Cofana* species are parasitized by the strepsipteran parasite, *Halictophagus* sp. In a survey conducted in farmers' fields throughout Côte d'Ivoire, parasitism of *C. spectra* averaged 21%, while that of *C. unimaculata* averaged 12% (Heinrichs 1994). In a survey conducted in Guinea, strepsipteran parasitism of *Cofana* spp. averaged about 18% (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data). In lowland rice, on the WARDA Mbè Farm, *C. spectra* parasitism by *Halictophagus australensis* Perkins reached 100% at 65 DT, while *C. unimaculata* peaked at 45% at 75 DT (Oyediran et al 2000a).

Habitat preference. *Cofana* spp. are more abundant than the *Nephotettix* spp., particularly in upland rice. Populations of *C. unimaculata* in Côte d'Ivoire are generally two to three times those of *C. spectra* in the various climatic zones and ecologies. Both species are abundant in the forest and savanna zones. In the three 1995 surveys conducted in Côte d'Ivoire, *C. unimaculata* populations were about two times greater in the forest than in the savanna zone. Populations of *C. spectra* were similar in both zones in the July survey but were higher in the forest zone in the August and October surveys. In the 1995 survey in Guinea, in contrast to Côte d'Ivoire, *C. spectra* populations were twice those of *C. unimaculata*. Populations of each species were similar for the forest and savanna zones, being 11.3 and 10.9 per 500 sweeps, respectively, for *C. unimaculata* and 23.5 and 25.7, respectively, for *C. spectra*.

The 1995 Côte d'Ivoire surveys also indicated that populations of both *Cofana* species were higher in lowland than in upland fields. In the July and August surveys, *C. unimaculata* populations were 26.5 and 23.2 per 500 sweeps in lowland fields and 7.1 and 7.0 in upland fields, respectively. Studies on the continuum toposequence on the WARDA M'bé Farm indicate similar populations at all toposequence sites for both *Cofana* species with slightly higher populations in the lower portion of the hydromorphic zone (Oyediran et al 1999a). Generally, both species were more abundant in nonweeded plots than in weeded plots (Afun et al 1995) (Figs. 44–45). *Cofana spectra* was reported among the most prevalent insect species in upland rice in southeastern Nigeria (Emosairue and Usua 1996).

Plant damage and ecology. *Cofana spectra* and *C. unimaculata* are minor rice feeders in West Africa and are not known to transmit a viral disease. Adults and nymphs suck sap from the leaves. As a result, leaf tips first dry and then later the leaves turn orange and curl. The pest causes plant stunting and, in Asia, severe infestations can cause plant death (Sam and Chelliah 1984). In Africa, *Cofana* spp. rarely cause observable damage. No economic threshold for white leafhoppers has been established for rice in West Africa. In Asia, Reissig et al (1986) report a threshold of 30 *C. spectra* hill^{-1} from tillering to flowering.

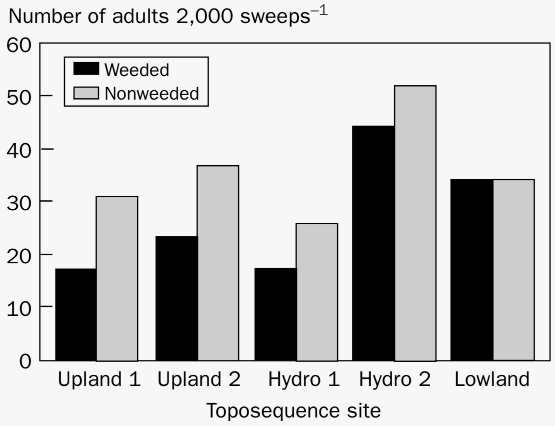


Fig. 44. Number of *Cofana spectra* (Distant) adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

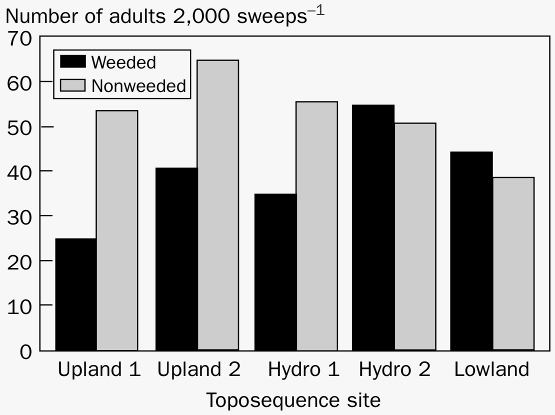


Fig. 45. Number of *Cofana unimaculata* (Signoret) adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

In addition to feeding on rice, *Cofana* spp. are also found on grass species at a distance from rice fields. Dale (1994) has reported *C. spectra* in South and Southeast Asia and has listed a number of host plants other than rice. These include *C. rotundus* L., *E. colona* (L.), *F. miliacea* (L.), *Saccharum officinarum* L., *Scirpus articulatus* L., *Sorghum bicolor* (L.), and *Zea mays* L.

On lowland rice at the WARDA M'bé Farm, both species are present throughout most of the crop period (Figs. 46–47). Peak populations occur at 6 WAT (late tillering phase of crop growth) and by 12 WAT (flowering phase of crop growth), populations are very low (Oyediran and Heinrichs 1999). Studies conducted in Sierra Leone (Taylor and Kamara 1974) showed that,

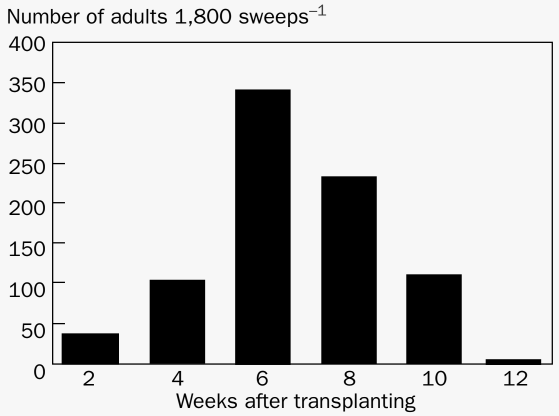


Fig. 46. **Number of *Cofana spectra* (Distant) adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).**

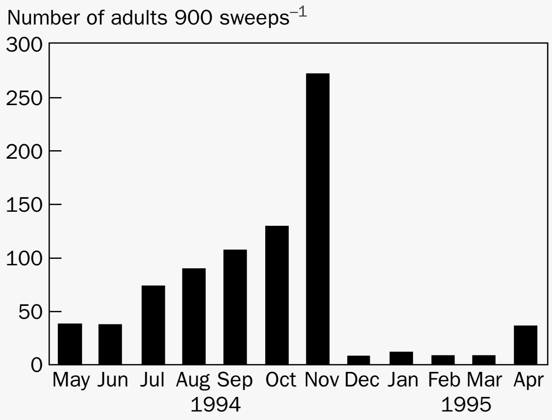


Fig. 48. **Number of *Cofana spectra* (Distant) adults collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).**

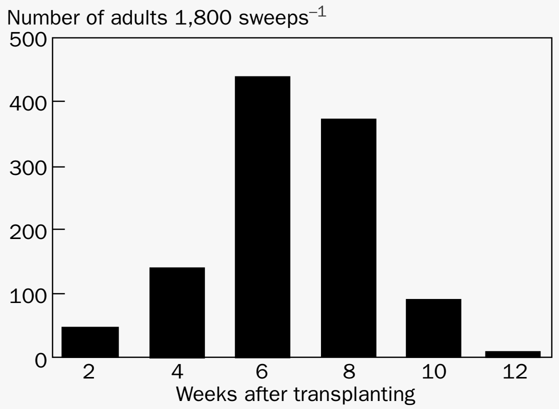


Fig. 47. **Number of *Cofana unimaculata* (Signoret) adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, 1995, unpubl. data).**

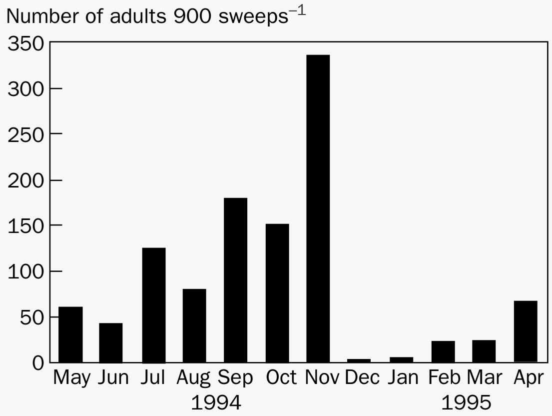


Fig. 49. **Number of *Cofana unimaculata* (Signoret) adults collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994 to April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).**

in a 120-d-duration variety (Tainan No. 5), *C. spectra* occurs throughout the entire crop growth period. However, highest populations occur from the seedling stage to tillering with the peak occurring at the same time as that of *L. maculata maculata* F., about 6 WAT during the wet season and 8 WAT during the dry season. After the tillering phase, populations drop rapidly. Seasonal occurrence of the two *Cofana* species, as based on a monthly planting experiment on the WARDA M'bé Farm, is similar (Figs. 48–49). Populations increase from the beginning of the rainy season in April and reach a peak in the crop transplanted in November. There is a severe drop in the population of the insects in the December-transplanted crop and the low populations continue through the March transplanting (dry season). In Sierra Leone (Taylor and Kamara 1974), *C. spectra* occurs in both the wet-season and the dry-season crops. However, the wet-season population is about two times that of the dry season.

In studies conducted on the WARDA M'bé Farm, *C. spectra* and *C. unimaculata* in lowland irrigated rice were not affected by planting method, i.e., direct seeding vs transplanting (Oyediran and Heinrichs 2001).

Plant spacing has an effect on *C. spectra* populations. Studies conducted on the WARDA M'bé Farm indicated that a close spacing of 10 x 10 cm between hills had higher populations than spacings of 14 × 14 cm or wider (Oyediran et al 1999b).

Both *Cofana* species responded to high rates of N fertilizer in WARDA tests (E.A. Heinrichs, WARDA, 1995, unpubl. data). *Cofana spectra* and *C. unimaculata* populations in lowland rice at 250 kg N ha^{-1} were three times those of plots treated with 100 kg N ha^{-1}.

The effect on *Cofana* populations of the length of the fallow period, prior to planting upland rice, was studied in the forest region of Côte d'Ivoire in 1994. Populations of both *C. spectra* and *C. unimaculata* were negatively correlated with length of fallow periods ranging from 2 to 35 yr (E.A. Heinrichs, WARDA, 1994, unpubl. data).

White-winged planthopper, *Nisia nervosa* (Motschulsky); Hemiptera: Meenoplidae

Meenoplidae is a small family of planthoppers that consists of about 100 described species within the superfamily Fulgoroidea. The most widely distributed and well-known meenoplid species in rice is *Nisia nervosa* (Motschulsky) (Wilson 1981). *Nisia nervosa* is the only common fulgorid in rice that does not belong to the Delphacidae. *Nisia nervosa* was described as *Livilla nervosa* Motschulsky and has been commonly known as *N. atrovenosa* (Lethiery). Catindig et al (1995) referred to *N. nervosa* as *N. atrovenosa carolinensis* Fennah.

Country distribution. Cameroon, Côte d'Ivoire, Gambia, Ghana, Nigeria. Its distribution includes southern Europe and extends through all of Africa, the Middle East, India, the Far East, and the Pacific region to northern Australia. Its distribution in West Africa likely includes more countries than currently indicated.

Description and biology. *Nisia nervosa* is a small species. Being a meenoplid, it differs from the cicadellid leafhoppers in lacking the mobile setae on the hind tibia and differs from the delphacid planthoppers in lacking the post-tibial spur. It is easily distinguished from other hopper species by the nerve-like, granulate vein on the fore wing (Reissig et al 1986).

Information regarding the biology and ecology of *N. nervosa* on rice in Africa is limited. Catindig et al (1995) studied the biology of *N. carolinensis* in the Philippines. On the sedge, *C. rotundus* L., 44 eggs were laid per female and the egg incubation period was 5 d. Eggs were laid in masses on the stem and leaf surfaces of grasses and rice and an egg mass was covered by a cotton-like mass of white hairs. There were five nymphal instars, each taking about 3 d with an egg-nymph development period of 22 d. Adult longevity was 9 d for males and 12 d for females. In temperate East Asia, there are four generations per year and overwintering occurs in the egg stage (Cheng 1956 as cited in Catindig et al 1995).

Habitat preference. Information is lacking on the distribution of *Nisia* spp. in climatic zones and its abundance on the continuum toposequence. It has been reported to occur in lowland rice in India (Reddy et al 1983).

Plant damage and ecology. *Nisia nervosa* is common in rice field habitats and is reported as a minor rice feeder. Based on laboratory oviposition and feeding studies with *N. carolinensis* (Catindig et al 1995), oviposition occurred on 16 plant species from six families. However, the only hosts that provided high egg and nymph survival and development to the adult stage were the sedges *C. rotundus* and *C. difformis*. Catindig et al (1995) were not able to confirm that rice is a host. In the Philippines, Cruz (1986) earlier obtained similar results where he reported *N. atrovenosa* on weedy levees of irrigated transplanted rice.

Similar to other leafhoppers, *N. nervosa* has piercing-sucking mouthparts that remove plant sap. Goel et al (1983) reported that *N. nervosa* sucks sap from leaves. In the studies of Catindig et al (1995), *N. carolinensis* feeding caused wilt and hopperburn on *Cyperus* spp. In India (Reddy et al 1983), *N. nervosa* populations increased during the tillering phase of lowland rice growth and decreased to low levels thereafter. Peak populations coincided with those of *Nephotettix* spp. but were about one-third those of *Nephotettix* spp. Misra and Reddy (1985) reported *N. nervosa* appearing in rice at 44 DT. According to Goel et al (1983), *N. nervosa* populations in West Bengal, India, increased rapidly in response to a change in agricultural practices. Primary host plants were rice and several grass species. Light trap catches of *N. nervosa* corresponded to the abundance of their host plants in the field, with peaks in January (when no rice crop was present), May (during the *boro* or winter rice crop), and October (during the *kharif* or rainy season rice crop).

Low *N. nervosa* numbers occur in light traps placed near lowland fields on the WARDA Farm at M'bé. Peak trap collections occurred in the middle of April 1995 (Fig. 50). A few were collected in early July and early October.

Brown planthopper, *Nilaparvata maeander* Fennah; Hemiptera: Delphacidae; Figs. 348–350

Nilaparvata maeander Fennah is the only *Nilaparvata* sp. found on rice in West Africa. Although it is a minor feeder, it is considered to be a potential threat as based on the rapid rise in importance of *N. lugens* (Stål) during the Asian Green Revolution. Soto and Siddiqi (1978) and Alam et al (1983) reported it on rice in West Africa.

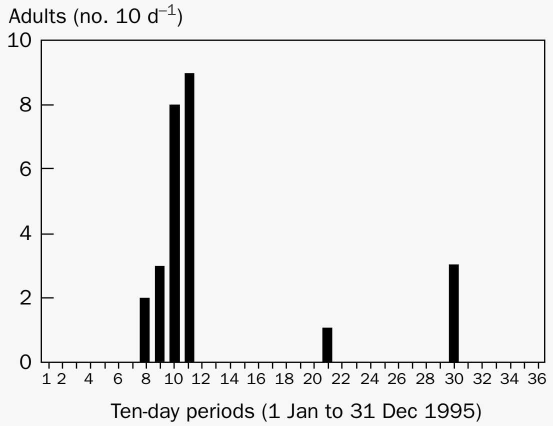


Fig. 50. Number of *Nisia nervosa* (Motschulsky) adults collected in a kerosene light trap over 10-d periods from 1 Jan. to 31 Dec. 1995. The trap was located in a hydromorphic rice plot, about 100 m from lowland rice (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

Country distribution. Benin, Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Senegal.

Although its presence has only been reported in seven West African countries, *N. maeander* likely occurs throughout most, if not all, of West Africa. Alam (1984) reported the first incidence of *N. maeander* killed plants due to its feeding in two rice fields in Ibadan, Nigeria, in March 1983. In September 1983, *N. maeander* was observed at the National Cereals Research Institute Rice Station at Badeggi, Nigeria. According to Alam (1984), Fennah first reported this insect in Sudan and French Guinea in 1958. Later, Critchley observed the insect in Ibadan in 1977. Courtship signal studies reported by Claridge et al (1987) confirmed the species status of *N. maeander*.

Description and biology. Wilson and Claridge (1991) have described the adults of *N. maeander*. The adult has a distinct tibial spur (Figs. 348–349). Little is known about its biology and ecology, but it is likely to be similar to that of *N. lugens*. Eggs are injected into the leaf sheath or the leaf. Nymphs feed on the plant and pass through five instars before becoming adults.

Habitat preference. The ecological distribution of *N. maeander* has not been determined. In a July 1995 survey in Côte d'Ivoire, populations of this species were very low. In the sampling of rice with a sweep net, *N. maeander* adults were found in the forest zone and in the uplands, while none were collected in either the savanna zone or in lowland fields (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Plant damage and ecology. Little is known about the range of host plants upon which it feeds (Wilson and Claridge 1991). It has only been reported on rice in West Africa.

Nilaparvata maeander has piercing-sucking mouthparts and damages the plant by removing plant sap. The removal of plant sap and the blockage of vascular vessels by the feeding sheaths cause the plant to wilt and die, a condition known as 'hopperburn.' The excreted 'honeydew' provides a medium for the growth of sooty mold fungi.

It is important to note from the report by Alam (1984) that *N. maeander* is a potential pest in West Africa. *Nilaparvata lugens* was practically an unknown rice pest in Asia until the 1960s and was not even mentioned in the proceedings of a 1966 rice insect symposium held at IRRI (Pathak 1967). However, in 1979, *N. lugens* was the subject of an entire symposium held at IRRI (IRRI 1979). The spread of *N. lugens* illustrates how intensification of rice production can increase the pest status of an insect. Crop intensification and misuse of insecticides in West Africa could also possibly cause an increase in the importance of *N. maeander*.

Rice delphacid, *Tagosodes cubanus* (Crawford); Hemiptera: Delphacidae; Fig. 354

The genus *Tagosodes* was recently described to accommodate the majority of the species in the *Sogatodes* genus (Asche and Wilson 1990, Wilson and Claridge 1991). The species *T. cubanus* (Crawford), *T. orizicolus* (Muir), and *T. pusanus* (Distant) are frequently found on rice but only *T. cubanus* occurs in West Africa.

Country distribution. Benin, Côte d'Ivoire, Liberia, Nigeria, Sierra Leone. *Tagosodes cubanus* is widely distributed in South America and the Caribbean where it is an important rice pest.

Description and biology. *Tagosodes cubanus* is smaller than *T. orizicolus*, being about 2 mm long. It is generally brown. When the wings are folded, a dark spot on the wings forms a saddle-shaped stigmata. It is a sedentary species and its spread is assisted by strong winds and flowing water.

The biology has been briefly described in COPR (1976). Females lay 30–350 eggs in batches of seven on the midribs of rice leaves. Eggs are 0.1 mm long, cylindrical, slightly curved, and white when first laid. As the eggs develop, the color darkens. Diapause can occur during the egg stage, but nymphs usually hatch in 4–8 d.

Habitat preference. There is no information available regarding the distribution of *T. cubanus* according to climatic zones and the continuum toposequence in West Africa.

Plant damage and ecology. Little is known about the plant damage, if any, caused by *T. cubanus* in West Africa. However, based on the damage caused by the insect in South and Central America, it can be considered at the least a potential pest in West Africa. *Tagosodes cubanus* feeds on rice and grassy weeds

(*Echinochloa* spp. and other Gramineae). Nymphs and adults of *T. cubanus* suck sap from rice leaves and stems. This pest excretes honeydew, which forms a substrate for the growth of sooty mold on the plant. *Both T. cubanus* and *T. orizicolus* are important vectors of hoja blanca virus in South and Central America (Everett 1969). Stephen (1977) reported high populations of *T. cubanus* in lowland rice at Suakoko, Liberia, during the middle of the wet season. Rice plants with virus-like symptoms were observed but no tests were conducted to verify the presence of hoja blanca or any other rice virus. Intercropping experiments conducted in Côte d'Ivoire indicated that upland rice was not a suitable crop for cultivation under or near coconut because of frequent infestations by the delphacids *T. cubanus* and *S. kolophon* and the cicadellid *R. mica*, which transmit dry bud rot and blast to coconut (Zakra et al 1986).

Spittlebugs, *Locris maculata maculata* Fabricius (Fig. 365) and *L. rubra* Fabricius (Fig. 363); Hemiptera: Cercopidae

Few cercopids have been reported to occur on rice throughout the world, but *Locris* spp. have been noted as minor rice feeders in Africa (Wilson and Claridge 1991).

Country distribution. *L. maculata maculata* F.: Burkina Faso, Côte d'Ivoire, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Togo; *L. rubra* F.: Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Gambia, Guinea, Guinea-Bissau, Mali, Nigeria, Senegal, Togo.

Locris species are the only cercopids recorded on rice in West Africa (Wilson and Claridge 1991) and they are confined to Africa (Akingbohungbe 1983). *Locris maculata maculata* and *L. rubra* are the most abundant of the species collected in rice in West Africa. Additional species are *L. atra* Lallemand, *L. erythromela* (Walker), and *L. rubens* Erichson. Adenuga (1971) developed a key to the *Locris* genus in Nigeria. He indicated that there are many color forms that are intermediate between generally accepted species and that some species may thus be morphs of a single species. For example, *L. rubens* appears to be the same species as *L. rubra*.

Description and biology. *Locris* spp. are distinct from other rice insects by the boat-shaped form of the body, their large size, and reddish coloration with characteristic spots (Figs. 363–365). Little is known about the biology and ecology of spittlebugs in rice in Africa. Cercopids generally lay eggs in the stems or leaf sheaths of grasses. The nymphs that hatch feed on the stems of grasses and surround themselves with a frothy, spittle-like mass. After the last molt, the adult leaves the spittle and moves about freely. The spittle is derived from fluid excreted from the anus and from a mucilaginous substance excreted by the epidermal glands on the abdomen. Air bubbles are injected into the spittle by means of caudal appendages on the insect. Spittlebugs generally rest head downward on the plant and, as the spittle forms, it flows down and covers the insect. The spittle provides the nymph with a moist habitat and may provide some protection from natural enemies. The adults do not produce spittle (Borror et al 1981).

In Brazil, the spittlebug, *Deois flavopicta* (Stål), which feeds on rice, has six nymphal instars (Pacheco et al 1984). In the laboratory, the durations of stages one through six were 6.4, 3.4, 2.9, 6.5, 8.3, and 10.6 d, respectively. The sex ratio was 1:1.

Habitat preference. Surveys conducted in Côte d'Ivoire (E.A. Heinrichs, WARDA, 1995, unpubl. data) and Guinea (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data) indicate that both *L. maculata maculata* and *L. rubra* were more abundant in the savanna climatic zone than in the forest zone. In the two 1995 surveys in Côte d'Ivoire, *L. rubra* populations were 0.0 and 4.5 per 500 sweeps in the forest and savanna zones, respectively, in July, and 0.0 and 0.4 per 500 sweeps, respectively, in August. In Guinea, *L. rubra* populations were 0.1 and 7.5 per 500 sweeps in the forest and savanna zones, respectively.

Both *L. maculata maculata* and *L. rubra* are more abundant at the lowland sites on the continuum toposequence on the WARDA Research Farm than at the hydromorphic and upland sites (Figs. 51–52; E.A. Heinrichs, WARDA, 1992, unpubl. data). Both species are distinctly more abundant in nonweeded plots than in weeded plots.

In the July and August 1995 surveys in Côte d'Ivoire, *L. maculata maculata* populations were two times as abundant in the lowlands as in the uplands. *Locris rubra* populations, however, were three to seven times higher in the uplands than in the lowlands.

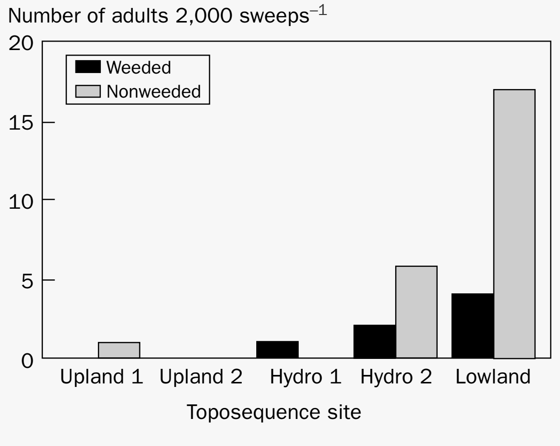


Fig. 51. Number of *Locris maculata maculata* F. adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

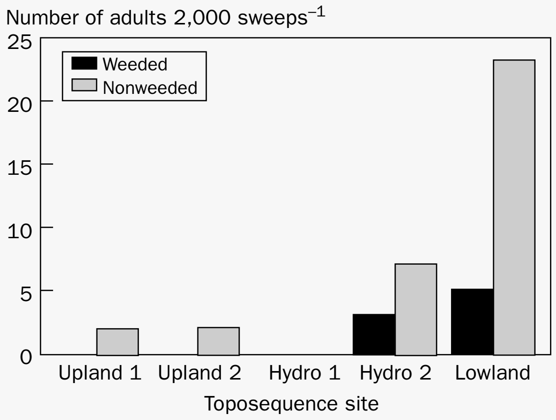


Fig. 52. Number of *Locris rubra* F. adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

Plant damage and ecology. Akingbohungbe (1983) reported *Locris* spp. as minor feeders on cereals in Nigeria. Although the host range is not well known, it is likely that they feed on a wide range of grasses. Egwuatu and Ita (1982) reported on damage on maize caused by *L. maculata* in Nigeria. Ajayi (2000) stated that *L. rubens* (=*rubra*) had a wide host range including sorghum, maize, millet, rice, sugarcane, and numerous grass species.

Locris maculata maculata populations in Sierra Leone, in a 120-d-duration rice crop (Tainan No. 5), were present throughout the crop period during both the wet and dry seasons. However, populations were highest during the wet season (Taylor and Kamara 1974). During the wet season, the insect was most abundant from the seedling stage to the end of tillering, peaking at 6 WAT, and dropping rapidly thereafter. During the dry season, populations continued to near harvest. Populations of both *Locris* spp. occur throughout most of the crop period on lowland rice on the WARDA Research Farm at M'bé but distinctly peak at 4 WAT (Figs. 53–54).

The seasonal occurrence of *L. maculata maculata* and *L. rubra* on lowland rice on the WARDA Farm is given in Figures 55–56. Populations occurred throughout the year but were low for most monthly transplanting dates. Both species were most abundant in the crop transplanted in November, the sampling of which covered the 12-wk period of 14 Nov to 14 Feb. These dates include the harmattan period in the middle of the dry season. In contrast, a study by Taylor and Kamara (1974) in Sierra Leone indicated that *L. maculata maculata* was most abundant during the wet-season crop with populations being three times those of the dry-season crop. The factors involved in the differing results in Côte d'Ivoire and Sierra Leone have not been determined.

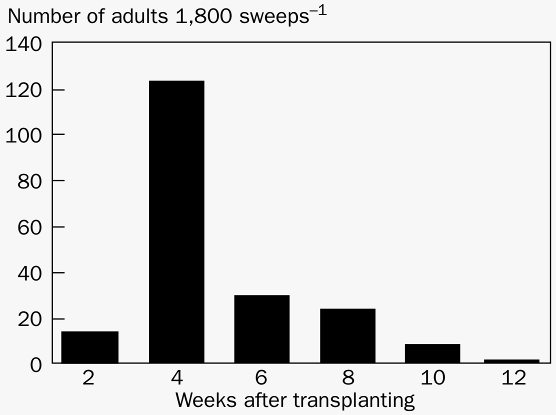


Fig. 53. Number of *Locris maculata maculata* F. adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

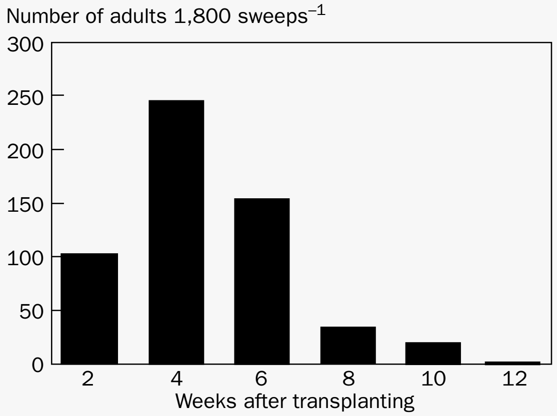


Fig. 54. Number of *Locris rubra* F. adults collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data)

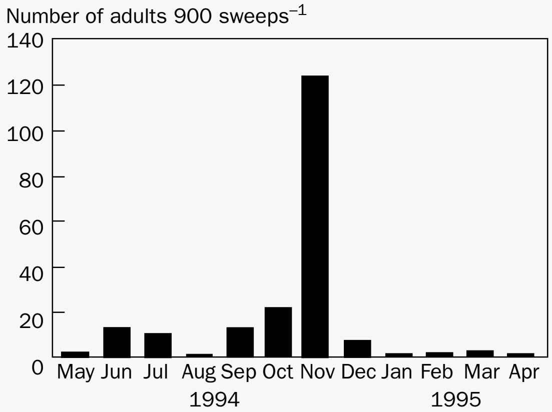


Fig. 55. Number of *Locris maculata maculata* F. adults collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

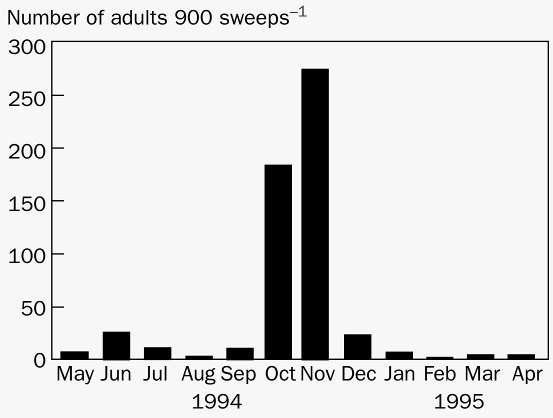


Fig. 56. Number of *Locris rubra* F. adults collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994 to April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

Locris spp. belong to the spittlebug group that sucks plant sap at the base of the stems. They are among the most abundant insects in lowland rice during the seedling stage and are easily seen because of their large size and because the adults readily fly from the plants when disturbed. Damage by spittlebugs to rice in West Africa has not been studied. In Australia, the cercopid, *Eoscarta carnifex* (F.) causes systemic damage to sugarcane by injecting an unidentified toxin into the plant (Rodman and Miller 1992).

The spittlebugs, *D. flavopicta* (Stål) and *D. schach* (F.) cause damage to rice fields that are adjacent to pastures in Brazil (Rosseto et al 1978). These insects have become severe pests of grassland pastures, especially *Brachiaria decumbens* Stapf, where they develop during the warm, humid months. Populations that build up on *B. decumbens* fly to neighboring rice fields where they cause severe damage. Feeding damage causes the rice leaves to turn yellow and dry and, subsequently, the entire plant is destroyed. The insect is considered to have a "toxic" effect on the plants. In the state of Mato Grosso do Sul, Brazil, 23,000 ha of rice were destroyed by spittlebugs during the 1983–84 growing season (Nilakhe 1985).

Foliage feeders

There are numerous insect species that feed on the foliage of rice in West Africa. Many of the species are of the orders Coleoptera, Lepidoptera, and Orthoptera, of which the adult beetles, larvae, and nymphs, respectively, feed on the leaves. In addition, sucking insects, such as whiteflies, suck sap from the leaves. However, most of the species are sporadic in occurrence and are not generally of economic significance.

Foliage feeding by insects with chewing mouthparts causes three types of damage: 1) removal of the chlorophyll layer of the leaves by scraping-like feeding, 2) actual consumption of portions of a leaf or entire leaves, and 3) leaf mining or feeding between the epidermal layers.

Removal of chlorophyll decreases the photosynthetic activity and thus reduces grain development. Extent of yield losses caused by defoliators depends on the age of the plant and extent of green matter removed. Young plants often produce new foliage, recuperate, and grain yields may not be affected. The amount of yield loss due to defoliation also depends on the other abiotic and biotic stresses that may occur simultaneously (Heinrichs 1988). For example, drought-stressed plants are more susceptible to insect defoliation because they are not able to recuperate from feeding as are nonstressed plants. Also, secondary pathogens may invade the feeding wounds left by defoliators. In addition to direct damage, some beetles mechanically transmit a virus that is usually more damaging than the feeding injury itself.

Rice caseworm, *Nymphula depunctalis* (Guenée); Lepidoptera: Pyralidae; Fig. 86

Nymphula depunctalis (Guenée) [= *N. stagnalis* (Zeller)] is an important pest of wetland rice in West Africa. It is widely distributed throughout many of the rice-growing regions of the world and has a range of host plants in addition to rice.

Country distribution. Benin, Cameroon, Côte d'Ivoire, Gambia, Ghana, Liberia, Nigeria, Sierra Leone, Senegal, Togo.

Nymphula depunctalis is a widely distributed species occurring not only in West Africa but also in South America (Argentina, Brazil, Uruguay, Venezuela), South and Southeast Asia, Central Africa (Madagascar, Malawi, Mozambique, Rwanda, and Zaire), and East Africa (Brenière 1983, Dale 1994). It has been reported from several West African countries and probably occurs throughout West Africa.

Description and biology. Brenière (1983), Dale (1994), and Litsinger et al (1994a) have described the biology of *N. depunctalis*. Adults are nocturnal in habit and are attracted to lights. They are small (10–12 mm in wingspan) with white fuscous markings and black specks on the wings (Fig. 86). Females are larger than males. Mating occurs during the night and egg laying begins—and usually concludes—the following night. Females lay about 60 eggs in batches of about 20, in closely packed rows, on the underside of leaves that are floating on the water surface. Eggs desiccate if laid on the aerial portions of plants and are thus more exposed to natural enemies. Females die 2–3 d after oviposition; males live for 4–5 d.

Freshly laid eggs are yellow, spherical, and smooth. As eggs mature, they turn dark yellow. The incubation period is 4 d.

Upon hatching, first-instar larvae are yellow to green with light brown heads. They climb onto a leaf and begin feeding on the green tissues by scraping the leaf surface. They then move to the leaf tip and cut a slit on the margin at a location 2–3 cm below the leaf tip. Then they make another cut about 1 cm below the first cut. Due to a lack of turgor pressure, the cut leaf segment rolls around a feeding larva to form a tubular case that is secured by silk spun by the larva. The inner surface of the leaf case is lined with silk to hold a thin film of water that is essential for respiration and to prevent desiccation of the larva. A new case is constructed after each larval molt.

All but the first-instar larvae respire by branched, filamentous, tracheal gills that project in pairs from the lateral margins of each body segment from the mesothorax to the eighth abdominal segment. The tracheal gills, which trail in the water, allow the larvae to remove oxygen from the water. The larvae move on the plant by their legs that stick out of the front of the case. The case helps the larvae to float on the water surface. During the day, larvae hide in cases, while at night, they crawl up rice plants and feed on the leaves with their head protruding from the case. Under dry conditions, feeding is reduced and the presence of water droplets on the leaves is helpful for larval feeding. Larvae are 20 mm long when fully grown. The duration of the larval stage is 15–30 d.

Pupation occurs within the tubular leaf case that has both ends closed and is attached to the rice stem just above the water level. The inner portion of the case has a silk lining with a slit-like opening at the anterior end. The young pupae are milky white but gradually turn to light yellow. The adult moths emerge from the leaf case within 4–7 d. Details on the number of generations and seasonal life history of this species in West Africa are not available.

Habitat preference. *Nymphula depunctalis* is reported to occur throughout the humid tropical, Guinea savanna, and Sudanian savanna climatic zones of West Africa but is least abundant in the latter (Table 2). A survey conducted in Côte d'Ivoire in July 1995 indicated that caseworm damage was more severe in the forest (humid tropical) zone than in the Guinea savanna. Defoliation by the caseworm was 34% in the forest and 7% in the savanna zone (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Because of their semiaquatic nature, the rice caseworm larvae occur only in lowland swamp, mangrove swamp, and irrigated environments. They are reported to be most abundant in irrigated environments (Table 4; Agyen-Sampong 1982). In the July 1995 survey in Côte d'Ivoire, caseworm defoliation was 0% in the upland fields and 23% in lowland fields (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Plant damage and ecology. Although there are other *Nymphula* spp. attacking rice, *N. depunctalis* is the major one (Brenière 1983). In Asia, numerous host plants of *N. depunctalis* other than rice have been reported including *Brachiaria*, *Cynodon*, *Cyperus*, *Cyrtococcum*, *Echinochloa*, *Isachne*, *Leersia*, *Panicum*, and *Paspalum* weed species (Litsinger et al 1993, Dale 1994). In Liberia, Stephen (1977) reported *Eragrostis* sp., *Panicum* sp., and *Paspalum* sp. as host plants in addition to rice.

Light trap records taken at the WARDA Farm at M'bé in 1995 indicated that the adults were present at the end of the wet season, from September to November (Fig. 57).

Caseworm damage is most severe when the rice plants are in the vegetative stage of crop growth. Plants that have recently been transplanted are preferred but larvae may also attack seedlings in the nursery. In a greenhouse study, Litsinger et al (1994a) found that moths preferred leaves at 4 WAT for oviposition in comparison with younger or older leaves. They also reported that the caseworm is better adapted to the vegetative stage than the reproductive stage of rice growth as indicated by the rate of larval development, survival, size of larvae, and the fecundity of the females.

Generally, several larvae attack the same plant. The first visible sign of caseworm damage in the field is the characteristic cut leaves. Leaf blade tips appear as if they have been cut with a scissors. Leaf damage is caused by the cutting off the leaf tips for making the characteristic leaf cases and the removal of green tissue. Infested fields are easily identifiable by the cut leaf tips, scraping of the leaves, presence of leaf debris

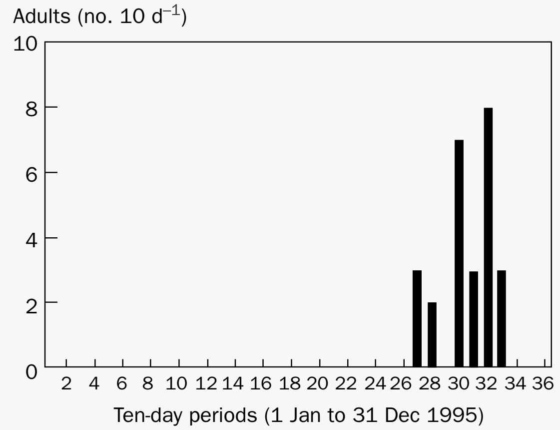


Fig. 57. Number of *Nymphula depunctalis* (Guenée) adults collected in a kerosene light trap over 10-d periods from 1 Jan to 31 Dec 1995. The trap was located in a hydromorphic rice plot, about 100 m from lowland rice (E.A. Heinrichs, WARDA, M'bé, 1996, unpubl. data).

on the water, and presence of larvae in tubular leaf cases on the plants and/or floating on the water. All that remains after the removal of the green tissue is a papery epidermis (Heinrichs and Viajante 1987). As larvae feed on the leaves, they leave patches or longitudinal streaks of light-colored, papery epidermis. Damaged areas appear as patches of whitish foliage.

Caseworm damage can be distinguished from that of other defoliators by the ladder-like appearance of the leaf tissue, resulting from the back and forth motion of the head during feeding. Unremoved, green tissue in the scraped patches provides the ladder-like feeding symptoms. Also, the pattern of damage within a field is not uniform because the larvae in cases may be carried to one side of a paddy by winds or water currents. Thus, damage is often severe along the levees on the leeward side of a paddy.

Heavy infestations on small seedlings may completely destroy a rice crop. Damaged plants may recover if no other defoliating insects are present, but crop maturation may be delayed about a week. Yield loss may occur when the caseworm occurs in combination with other nondefoliating insects such as whorl maggots and stem borers. Damaged plants are stunted and produce fewer tillers (Reissig et al 1986).

Spacing of transplanted seedlings has a distinct effect on the extent of damage caused by *N. depunctalis*. In a study conducted in lowland rice on the WARDA Farm, defoliation due to the caseworm ranged from 68% at a close spacing of 10 × 10 cm (100 hills m^{-2}) to 16% at a spacing of 40 × 40 cm (6 hills m^{-2}) (Fig. 58) (Heinrichs et al 1993b, Oyediran et al 1999b).

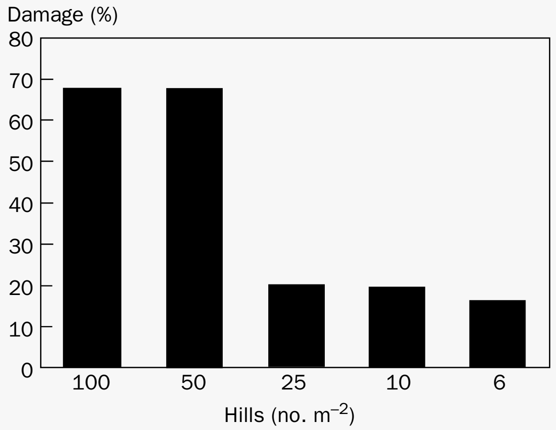


Fig. 58. Percent of rice leaf area damaged by caseworm *Nymphula depunctalis* (Guenée) larvae at different spacings between hills of lowland, irrigated rice (Bouaké 189). Hill densities range from 6 (40 × 40 cm spacing) to 100 m^{-2} (10 × 10 cm spacing), M'bé, WARDA (Heinrichs et al 1993b).

Rice leaffolders, *Marasmia trapezalis* (Guenée); Lepidoptera: Pyralidae; Fig. 89

Two genera of pyralid moths, *Cnaphalocrocis* and *Marasmia*, comprise an overlapping leaffolder/leafroller pest complex in rice throughout the world. The larvae roll or fold the leaves of Gramineae. Only three species, *Cnaphalocrocis medinalis* (Guenée), *Marasmia* (=*Susumia*) *exigua* (Butler), and *M. trapezalis* (Guenée) (Fig. 89), have attained major pest status on rice, the latter being the major rice leaffolder in West Africa (Khan et al 1988).

Cnaphalocrocis medinalis is the best-known rice leaffolder in the world and occurs in Asia and Madagascar. There are several species of *Marasmia* in the world that feed on rice (Dale 1994). *Marasmia exigua* is a pest of rice in Australia and Asia and *M. patnalis* Bradley is a pest of rice in Southeast Asia.

Country distribution. Cameroon, Nigeria, Senegal, Togo.

Marasmia trapezalis is distributed through the whole of tropical, equatorial, and southern Africa, Central and South America, and Asia. Khan et al (1988), in their bibliography of rice leaffolders, mentioned *M. trapezalis* as occurring in Nigeria. Alam (1992), Descamps (1956), and Etienne (1987) have reported this species occurring in Nigeria, Cameroon, and Senegal, respectively. Based on personal observations on leaffolder damage in the field, it is likely that this or another closely related species is present throughout most of West Africa. However, taxonomic confirmation is necessary.

Description and biology. The adults of the various leaffolder species differ in the number and length of the dark bands on the fore wings (Reissig et al 1986). Adults of *Marasmia* spp. (Fig. 89) are similar in appearance to those of *Cnaphalocrocis* spp. Brenière (1983) described *M. trapezalis* larvae as slender-bodied, about 20 mm long with a light, greenish-yellow color and stiff brown bristles. Larvae wiggle rapidly when disturbed.

The biology of *M. trapezalis* has not been studied. Joshi et al (1985), however, described the life cycle of a closely related species, *M. patnalis* in the Philippines. Eggs are laid singly or in groups of from 2 to 9 on the upper side of the leaves and occasionally on the leaf sheaths. Eggs hatch in 4 d and the larval period is 23 d. The larvae of *M. trapezalis* are typical rice leaffolders. The first-instar larvae move to young leaves and begin feeding by scraping the leaf surface. Larvae of the second and later instars fold leaves and feed from within. The leaf margins are drawn together and the leaf rolls when the silk that is spun by the larva dries and contracts. The larvae scrape the green parenchymal portion of the leaf from within the fold and the leaves take on a dried appearance. A larva may feed on several leaves during its lifetime. Another larva of the genus *Brachmia* (Gelechiidae) also rolls rice leaves in Africa.

Larvae of *Marasmia* spp. go through a prepupal resting stage of 1–2 d and then weave a silken cocoon. The pupae remain attached to the plant by their abdominal extremity, usually between leaves that have been stitched together with silk. After 9 d in the pupal stage, the adults emerge at night.

Habitat preference. According to Agyen-Sampong (1982), *M. trapezalis* occurs in low populations in the humid tropical and the Guinea savanna but not in the drier, Sudanian savanna in West Africa (Table 2). Alam (1992) reported the presence of low populations of *M. trapezalis* occurring in all three climatic zones in Nigeria. *Marasmia trapezalis* occurs at all sites on the continuum toposequence from upland to rainfed lowland and irrigated fields in Nigeria (Alam 1992).

Plant damage and ecology. Severe damage causes a decrease in panicle production and yield. Studies in Asia indicate that *M. trapezalis* has several hosts consisting of weeds and crops within the grass family in addition to rice. Khan et al (1988) reported *M. trapezalis* from *Brachiaria mutica* (Furshål), *Eleusine coracana* Gaertner, *Pennisetum typhoides* (Burman), *Setaria italica* (L.), *Sorghum bicolor* (L.), and *Zea mays* L.

Populations and damage by the rice leaffolder *C. medinalis* in Asia positively respond to increased levels of nitrogen fertilizer (Dale 1988). Also, *M. patnalis* populations are most abundant in shady areas (Dale 1994).

Green-horned caterpillar, *Melanitis leda ismene* Cramer; Lepidoptera: Satyridae

The green-horned caterpillar, *Melanitis leda ismene* Cramer, is among a number of defoliating insects that are minor feeders on rice in West Africa.

Geographical distribution. *Melanitis leda ismene* occurs in Asia and West Africa. In Asia, it occurs from Pakistan to Japan and south from India to Malaysia (Dale 1994). Although confirmed reports of *M. leda ismene* have only come from Nigeria, it is likely that this species occurs in most West African countries.

Description and biology. Alam (1974), Dale (1994), and Jana and Ghosh (1994) have described the biology of *M. leda ismene.* The adult is a large brown butterfly measuring 7.5 cm across expanded wings. It has round eyespots on the fore wings and hind wings. Hind wings have six prominent spots on their ventral side. The wings are folded above the body when the insect is at rest. The butterfly flies at dusk, making darting movements among the rice plants.

One generation takes about 30 d. The adult female lays pearl-like eggs singly or in rows on the rice leaves. One female lays 50–100 eggs in about 2 wk. Eggs hatch in 4 d. After hatching, the larvae begin to feed on the leaves.

The larvae are yellow-green and blend into the rice foliage. The body is covered with yellow hairs. The head is flat and quadrangular with a pair of prominent brown horns. The posterior extremity of the body has two slender spine-like structures. The full-grown larvae, in preparation for pupation, stop feeding and become sluggish for a 2-d prepupal stage.

Pupation occurs on the lower surface of the rice leaf. The pupae are about 20 mm long, dark green, and smooth. They hang from a leaf by their anal extremity for about 10 d.

Habitat preference. This insect occurs in all rice environments but is most prevalent in rainfed lowland rice in Asia (Reissig et al 1986) and in deepwater rice in Bangladesh (Alam 1974).

Plant damage and ecology. Host plants other than rice in West Africa are not known, but in Asia, *Imperata cylindrica* (L.), *Panicum maximum* Jacq*., Saccharum officinarum* L., and *Sorghum verticilliflorum* (Steud.) Stapf have been reported to be hosts (Dale 1994).

Observations in India (Singh 1979) showed that *M. leda ismene* occurs at the maximum tillering stage of the crop and continues to almost maturity.

Larvae feed on the margins and tips of leaves and remove leaf tissue and leaf veins. Damage is similar to that caused by grasshoppers and armyworms. After hatching, the first-instar larvae rest for a few hours and then begin scraping chlorophyll from the leaves. After a few days, they begin eating the edges of both sides of the leaf. The feeding rate gradually increases with larval development and with the third molt, the larvae become voracious feeders. Large larvae feed on the margins and the tips of leaf blades and remove leaf tissue and veins, leaving large areas with missing leaf tissue. When infestations are severe, yield loss occurs because of the removal of chlorophyll-bearing leaf tissue.

African rice hispids; Coleoptera: Chrysomelidae; Figs. 281–294

Several species belonging to the subfamily Hispinae, commonly referred to as 'hispids,' feed on rice in Africa. The term 'hispa' means spiny and characterizes the adults of this group, which have numerous spines on the thorax and abdomen. As reported by Brenière (1983), this group consists of *Trichispa sericea* Guerin-Meneville (Figs. 281–282), *Dicladispa viridicyanea* (Kraatz) (Figs. 283–285), and *Dactylispa bayoni* Gestro (Figs. 288–289). Additional Hispinae in the WARDA Arthropod Reference Collection (Table 5) are *Agonita* sp., *Chysispa viridicyanea* Weise, *Dactylispa spinigera* Gyllenhall (Figs. 292–294), *Dicladispa paucispina* (Weise), and *Dorcathispa bellicosa* (Guerin). There are likely additional Hispinae species in rice in West Africa whose taxonomic determinations have not yet been made. *Trichispa sericea* is the species described in detail below because it is a major pest of rice in West Africa, causing severe defoliation, and because of its potential as a rice yellow mottle virus (RYMV) vector.

Country distribution. *Trichispa sericea:* Burkina Faso, Cameroon, Côte d'Ivoire, Mali, Nigeria, Senegal, Siera Leone, Togo. In addition to West Africa, *T. sericea* occurs in many countries throughout Central, East, and South Africa (Dale 1994).

Description and biology. The *T. sericea* adult is a dark gray beetle covered with spines (Figs. 281–282) and is about 3–4 mm long. Adult females live for 2 wk and lay about 100 eggs during this period. The eggs are white and boat-shaped and are about 1 mm long. The eggs are laid singly in slits made under the epidermis of the upper portion of the leaf. The wound left by the ovipositor is sometimes covered by a dark spot of excreta by the female. The larvae hatch in 3 or 4 d.

Trichispa sericea larvae, which are referred to as 'grubs,' are slender, yellow, and about 6 mm long. The grubs mine from within the epidermal layer of the leaf. When infested leaves are held against the light, the dark spot of the larva or the pupa in the mine may be visible. The larval period lasts 10 d.

Pupation, which lasts about 6 d, takes place in the last mine bored by the larva and within those portions of the leaf lamina that are not submerged. After pupation, the emerging adults migrate to alternate host plants. In Madagascar, *T. sericea* completes a generation in about 1 mo (Ravelojaona 1970).

Habitat preference. *Trichispa sericea* and *Dicladispa* sp. occur in the humid tropical and Guinea savanna climatic zones in West Africa but not in the Sudanian savanna zone (Table 2).

Hispids are prevalent in wetland environments, especially irrigated lowland fields (Reissig et al 1986). Studies conducted on the continuum toposequence on the WARDA M'bé Farm indicated that damage caused by *T. sericea* is most prevalent in the lowlands. Percent leaf area damaged by *T. sericea* was about 15% in the lowlands and 1% in the uplands (Fig. 59). The effect of soil moisture on the extent of *T. sericea* damage was studied on the WARDA Farm (Heinrichs 1991a). An upland rice variety (IDSA 6) was planted at various intervals along the continuum toposequence from the valley bottom to the hydromorphic zone. *Trichispa sericea* damage was significantly (positively) correlated with soil moisture percentage. High leaf damage (100%) occurred only at high soil moisture levels. The results indicated that upland plants growing in standing water constitute attractive hosts for ovipositing *T. sericea* adults.

Plant damage and ecology. Hispids are serious pests of rice in some countries. In addition to rice, a number of grassy weeds serve as hosts for *T. sericea* (Zongo 1993). In Swaziland, when rice leaves harden and become unattractive for adult feeding and oviposition, *T. sericea* adults migrate to other plants such as *Chloris virgata* Sw, *Echinochloa holubii* (Stapf), *Eragrostis aethiopica* Chiov., *Eragrostis heteromera* Stapf, *Digitaria zeyheri* (Nees Hend.), and *Diplachne fusca* (L.) Beauv. ex Stapf (COPR 1978). However, rice is the preferred host plant.

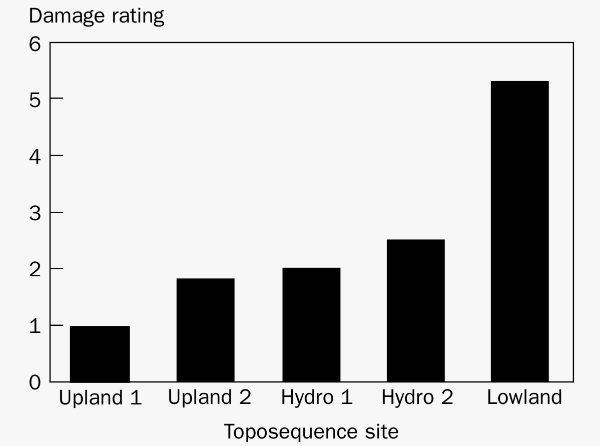


Fig. 59. Damage ratings resulting from the feeding of *Trichispa sericea* Guerin-Meneville on rice as affected by toposequence site on the continuum. A rating of 1 = 0–1% of leaf area damaged; 3 = 1–5%; 5 = 5–25%; 7 = 25–50%; and 9 = 50–100% (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

Trichispa sericea is generally most abundant during the rainy season. However, obtaining detailed data on the seasonal occurrence of *T. sericea* on the WARDA M'bé Farm has been difficult because of the sporadic nature of its occurrence. Annual populations of *T. sericea* in the monthly planting experiment have been generally low. However, in 1993, extremely high populations were observed during the rainy months of July and August (Fig. 60).

Trichispa sericea attacks the rice crop in the early growth stages. In Côte d'Ivoire (E.A. Heinrichs, WARDA, 1990, personal observation), adults are observed in the rice field shortly after transplanting when they attack small seedlings. Larval feeding occurs through the tillering phase. Both the adults and the larvae feed on the leaf tissues of young rice plants (COPR 1976, Dale 1994). The first attack in a field is highly localized, but the infested area spreads rapidly. Attacked plants have narrow white streaks on the leaves and irregular pale brown patches. Adults feed on the green portion of the leaves, leaving only the epidermal membranes. Adult feeding damage is evident by the characteristic narrow white streaks, or feeding scars, that run along the long axis of the leaf.

The pale brown patches, which appear as blisters, are the larval mines within the leaf. The larvae mine into the leaf between the epidermal membranes and the mining results in brown, blister-like areas. Feeding results in a loss of chlorophyll and the plants wither and die. The most serious damage occurs in nurseries that may be completely destroyed. Severe infestations sporadically occur on transplanted rice and can kill the plants. When the plants survive, they usually recuperate and produce some grain. However, damaged plants often mature late.

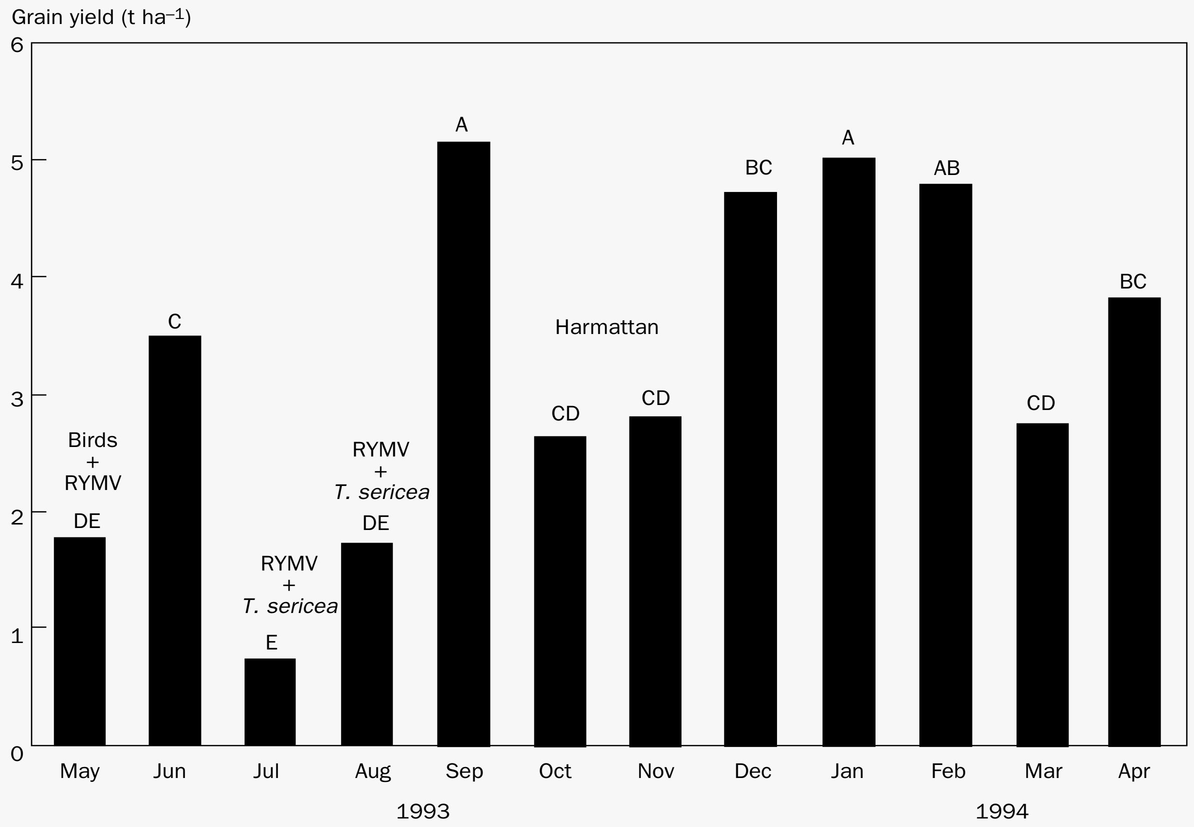


Fig. 60. Grain yields of the rice variety Bouaké 189 under lowland irrigated conditions at WARDA, M'bé, as affected by month of transplanting, May 1993–April 1994. Bars with a common letter are not significantly different at the 0.05 probability level by Duncan's multiple range test (E.A. Heinrichs, WARDA, M'bé, 1994, unpubl. data).

Trichispa sericea, along with *Dactylispa bayoni* and *Dicladispa viridicyanea*, has been reported to transmit rice RYMV in Kenya in East Africa (Bakker 1971). Reckhaus and Andriamasintseheno (1997) list *Dicladispa gestroi* (Chapman) and *T. sericea* as RYMV vectors in Madagascar where the disease has significantly impacted rice yields. RYMV was first reported on rice in West Africa in 1976 (Raymundo and Buddenhagen 1976). Monnet (1979) reported RYMV from Côte d'Ivoire.

Symptoms of the virus disease are pale yellow mottled leaves, stunted growth, reduced tillering, asynchronous flowering, poor panicle exsertion, spikelet discoloration, and sterility (see Role in disease transmission, page 16). RYMV was reported in lowland irrigated rice and in mangrove and inland swamps in Guinea during 1982-86 (Fomba 1990), and in upland rice in Cote d'Ivoire in 1985 and Sierra Leone during 1987 (Awoderu et al 1987). From a distance, infected fields appear yellow. Symptoms on the leaves are linear, chlorotic mottles that coalesce into broken or continuous pale green to yellowish streaks up to 10 cm long. Later, whole plants become light green and then turn to pale yellow.

The author's observations on the WARDA Farm and in farmers' lowland irrigated fields at Sakassou, near Bouaké, Côte d'Ivoire, indicate that high populations of *T. sericea* are usually associated with high incidence of RYMV. In plots planted at WARDA in July and August of 1993, *T. sericea* populations and RYMV incidence were high and grain yields were low (Fig. 60). However, high incidence of RYMV is not always associated with high *T. sericea* populations, indicating that other insects may be vectors or other means of transmission may occur.

Populations of adult *T. sericea* adults are affected by the spacing of transplanted seedlings. Adults in sweep net collections in lowland rice on the WARDA Farm were higher in close spacings of 10 × 10 cm (100 hills m^{-2}) than in wider spacings of 20 × 20 (25 hills m^{-2}) or 40 × 40 cm (6 hills m^{-2}) (Heinrichs et al 1993b).

Flea beetles, *Chaetocnema* spp.; Coleoptera: Chrysomelidae; Figs. 269–280

The term 'flea beetle' is applied to a group of small beetles that have enlarged hind legs and jump when disturbed. This group consists of several chrysomelid genera, including *Chaetocnema*, which make small holes in the leaf when feeding. Although *Chaetocnema* spp. are extremely abundant in upland rice, in West Africa, the feeding damage that they cause is minimal and they are considered to be minor pests. However, they are potential vectors of RYMV.

Country distribution. *Chaetocnema pulla* Chapuis (= *C. zeae* Bryant) (Figs. 273–274): Burkina Faso, Côte d'Ivoire, Mali; *Chaetocnema pusilla* Laboissiere (Figs. 271–272): Burkina Faso, Côte d'Ivoire, Mali; *Chaetocnema* sp.: Burkina Faso, Côte d'Ivoire, Guinea, Guinea-Bissau, Nigeria.

Morphologically *Chaetocnema* spp. are difficult to separate and the African species are not sufficiently well known to develop a good taxonomic key (Bakker 1974). *Chaetocnema* can be separated from the *Longitarsus*, a genus of flea beetles common in West Africa, by the incision on the apical half of the dorsal surface of the adult hind tibia (Gressitt and Kimoto 1963). Because of the difficulty in separating the species, there may be additional, unidentified *Chaetocnema* species in rice in West Africa and they, along with those mentioned above, are likely distributed throughout most, if not all, of the West African countries. Several species of *Chaetocnema* have been recorded as minor feeders of rice throughout the world. Grist and Lever (1969) mention *C. obesula* Lec., *C. basalis* (Baly), and *C. gregaria* Weise. Bakker (1974) reported *C. abyssinica* Jac. (Figs. 269–270), *C. concinnipennis* Baly, *C. kenyensis* Bryant, *C. pallidipes* Fairm., *C. pulla*, and *C. pusilla* on rice and grasses around rice fields in Kenya.

Description and biology. *Chaetocnema* spp. are called flea beetles because of the metathoracic femora that are enlarged for jumping (Barrion and Litsinger 1994) (Fig. 271). *Chaetocnema* are very small black beetles measuring about 0.2 mm in length and 0.1 mm in width. The life cycle, biology, and ecology of *Chaetocnema* spp. in West African rice have not been studied.

Doval et al (1975) reported on the biology of *C. basalis* in wheat in India. Eggs are laid singly or in batches of 20–200 in soil crevices or on the upper soil surface during the early morning. After about 5 d, the eggs hatch and the creamy white larvae feed on root hairs. After three molts, during a period of 10–20 d, the larvae pupate in soil crevices 5–7 cm deep or under loose stubble. The pupal period lasts 7–15 d. Adults are active during the day. There are two generations during the crop season. The adult hibernates or migrates to alternate host plants during the dry season.

Habitat preference. In three surveys conducted in Côte d'Ivoire and one in Guinea during the 1995 rainy season, *Chaetocnema* adults were among the most abundant group in sweep net collections (E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data). In both countries, they were equally abundant in the humid tropical (forest) and the savanna zone. Published information indicating the occurrence of *Chaetocnema* spp. in the Sudanian savanna has not been found.

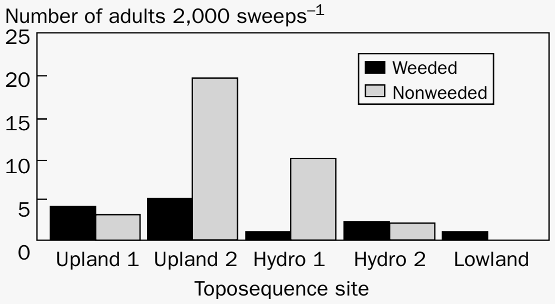


Fig. 61. Number of *Chaetocnema* spp. adults collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

Results of the Côte d'Ivoire survey and studies on the continuum toposequence on the WARDA Farm have distinctly shown that *Chaetocnema* spp. are upland pests. In the survey, populations of *Chaetocnema* spp. in sweep net collections were 62 per 500 sweeps in the uplands and 0 per 500 sweeps in the lowland fields. Populations on the continuum toposequence were highest in the lower portion of the upland (upland 2) and near the upper portion of the hydromorphic zone (hydro 1; Fig. 61). In Asia, *C. basalis* is reported to be an upland pest, but it also occurs in early season deepwater rice (Shepard et al 1995).

Plant damage and ecology. Although flea beetles are often very abundant, they are very small and the amount of damage is usually minimal. However, their potential as a vector of RYMV is of extreme importance.

Having numerous host plants, *Chaetocnema* spp. are polyphagous. According to Bakker (1974), plants belonging to families Polygonaceae and Chenopodiaceae are often preferred host plants, but several species feed on cereals. *Chaetocnema pulla*, in addition to feeding on rice, is reported as a serious pest of maize and millet in Sierra Leone (Hargreaves 1936 as cited in Bakker 1974). Furth (1985) reported *Cyperus* sp. as the food plant of *C. conducta suturalis* Bryant, *C. ljuba* Bechyne, and *C. nigripennis* Lab. in East Africa and grasses as hosts of *C. wollastoni* Baly in Chad, South Africa, Sudan, and Zaire.

Preliminary studies indicate that *Chaetocnema* spp. may be present in upland fields throughout the crop but are more abundant at later growth stages. In the 1995 Côte d'Ivoire survey, beetles were present in vegetative, booting, and ripening crops with slightly larger populations in the latter. Studies on the continuum toposequence, on the WARDA Farm, indicated that the beetles were first collected in sweep nets at 9 WAS. Beetles were present to near harvest (15 WAS; Fig. 62). In India, *C. concinnipennis* attacks primarily young, transplanted rice seedlings (Kulshreshtha and Mishra 1970).

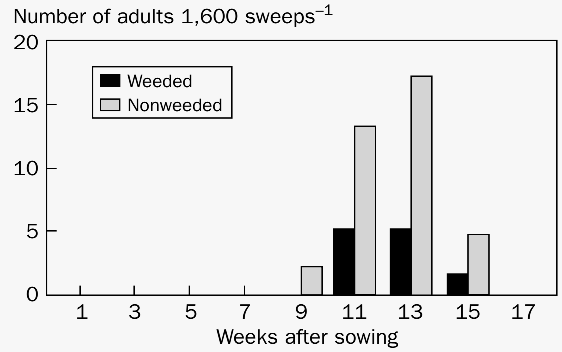


Fig. 62. Number of *Chaetocnema* spp. adults collected with a sweep net in weeded and nonweeded rice plots of upland rice at the indicated weeks after sowing (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

Chaetocnema spp., being pests of upland rice, are present during the rainy season when upland rice is grown in West Africa. Studies to determine their activity during the dry season have not been conducted in West Africa.

The feeding of the adult beetle produces distinctive narrow scraped areas on the leaves. The beetle causes plant damage similar to that of the ladybird beetle, *Chnootriba similis* (Mulsant). However, damage differs from that of *C. similis* in that the whitish streaks on the leaves, where the green material has been removed, are narrower because of the beetle's small size. Larvae develop on the roots of grasses in fallow upland areas and are not rice pests (Shepard et al 1995).

Chaetocnema spp. are primarily pests of economic significance because they mechanically transmit RYMV, a serious rice disease. Bakker (1974) mentioned *C. abyssinica*, *C. kenyensis*, and *C. pulla* as the *Chaetocnema* spp. transmitting RYMV in Kenya; Reckhaus and Andriamasintseheno (1997) reported *C. pulla* as an RYMV vector in Madagascar; and Banwo et al (2001b) reported *C. pulla* and *Chaetocnema* sp. as vectors in Tanzania. The role of *Chaetocnema* spp. in transmitting RYMV in West Africa has yet to be determined.

In Latin America, intensification of crop management practices has been shown to result in decreasing importance of *Chaetocnema* spp. in lowland rice (Weber and Parada 1994). Crop management practices mentioned were land preparation, high seeding density, and high water level.

Ladybird beetle, *Chnootriba similis* (Mulsant); Coleoptera: Coccinellidae; Fig. 261

This species was formerly known as *Epilachna similis* Mulsant. It is one of the most common insect pests of upland rice in West Africa but plant damage it causes is generally minimal.

Country distribution. Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Niger, Nigeria, Senegal, Togo.

Chnootriba similis (Mulsant) occurs in West Africa, East Africa, and in the Ethiopian region (Raimundo 1992). It is generally distributed throughout West Africa and probably occurs in all countries.

Description and biology. A survey conducted by the Commonwealth Institute of Biological Control in 1970 recorded *C. similis* for the first time as a serious pest of rice in the Accra plains of Ghana (Scheibelreiter and Inyang 1974). Abu (1972) later studied its bionomics on rice in the Accra plains.

The adult is an orange-red beetle with six black spots on each wing cover (Brenière 1983). There is variability in the arrangement of the spots on the wing cover (Raimundo 1992). Certain spots on the wing cover are isolated or more or less coalesced in some individuals (Fig. 261).

The incubation period is 3–4 d. Upon hatching, the young larvae from one egg batch remain aggregated for a period and then disperse. Their body is covered with stiff, short bristles or spines. The larvae are dark gray to black with white spines when they are young but become whitish as they develop. In laboratory studies on maize (Scheibelreiter and Inyang 1974), the larval period was 9–17 d. Due to temperature differences, time for development from egg to adult takes 4–5 wk in the dry season and 7–8 wk in the wet season.

Habitat preference. *Chnootriba similis* occurs in all climatic zones, from the humid tropical to the Sudanian savanna, in Nigeria (Alam 1992). However, populations of *C. similis* are lower than that of most other pests reported in Nigeria. Akinsola (1984b) reported similar observations for West Africa as a whole. In the July 1995 survey in Côte d'Ivoire, populations were 10 times higher in the forest (humid tropical) zone than in the Guinea savanna (E.A. Heinrichs, WARDA, 1995, unpubl. data). In the 1995 survey of Guinea, populations were similar in both the forest and savanna zones.

Chnootriba similis is primarily a pest of upland rice. Alam (1992) reports populations in both upland and lowland rice with highest populations in the former. In the 1995 Côte d'Ivoire survey, *C. similis* populations were 11 per 500 sweeps in the upland fields and 1 per 500 sweeps in lowland fields (E.A. Heinrichs, WARDA, 1995, unpubl. data). Studies on the continuum toposequence on the WARDA M'bé Farm indicated a trend similar to that of *Chaetocnema*. Populations occurred in all ecologies but were highest in the uplands (Fig. 63). Nonweeded plots had populations two to three times those of the weeded plots. In another study at WARDA (WARDA 1990), *C. similis* numbers in sweep net collections peaked at the lower portion of the upland, near the hydromorphic zone.

Plant damage and ecology. Although most species in the family Coccinellidae are predators, feeding on other insects, some of the Epilachninae subfamily are phytophagous. *Chnootriba similis* is polyphagous and,

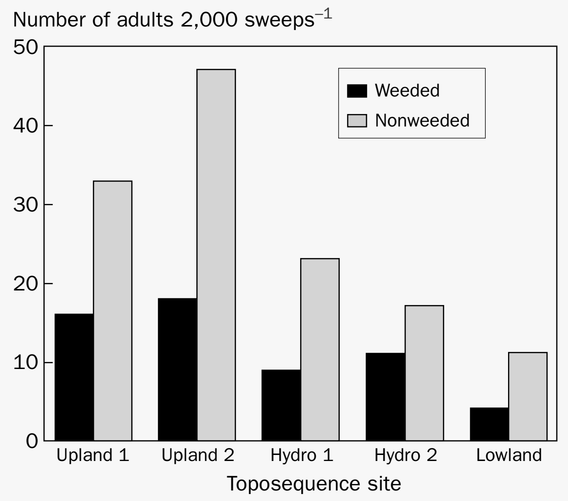


Fig. 63. Number of adult *Chnootriba similis* (Mulsant) collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

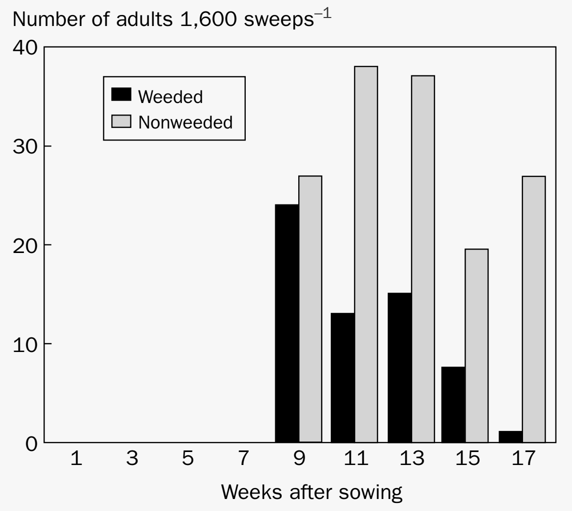


Fig. 64. Number of adult *Chnootriba similis* (Mulsant) collected by sweep net in weeded and nonweeded upland rice at indicated weeks after sowing (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

according to Brenière (1983), is particularly attracted to gramineous plants especially rice, sugarcane, maize, and sorghum. In laboratory studies in Ghana, Scheibelreiter and Inyang (1974) found that the insects feed on wheat, sorghum, rice, maize, and elephant grass but not on sugarcane.

In a study in lowland rice at WARDA, *C. similis* attacked the crop in the vegetative stage (Heinrichs 1991b). The adult beetle population in sweep net collections was highest in the first 2 WAT and continued at low levels until 5 WAT.

Populations of *C. similis* adults on the continuum toposequence at WARDA, where the insect was most abundant in the upland sites (Fig. 63), were highest in the later crop growth stages (Fig. 64). The insects were first collected at the panicle initiation stage (9 WAS), and collections continued to near harvest (17 WAS).

Chnootriba similis is primarily an upland pest so the insect is present during the rainy season. However, details on the occurrence of this pest throughout the year are lacking. Observations on its occurrence in lowland irrigated rice, during the dry season, have not been made due to low populations in lowland rice on the WARDA Farm. Since it is not attracted to kerosene light traps, this precluded a study of its seasonal occurrence on the WARDA Farm.

Studies on the length of fallow periods in slash-and-burn agriculture in the forest zone near Gagnoa, Côte d'Ivoire indicate a weak negative (r= –0.23, p= 0.32) correlation between length of fallow (1–35 years) and *C. similis* populations in upland rice (E.A. Heinrichs, WARDA, 1994, unpubl. data).

The adult and larval stages of this beetle are severe pests of nursery rice. They feed on the leaves, scraping off sections along the length of the leaf leaving white streaks or irregular patches where the chlorophyll-bearing tissue has been removed. Severely infested nurseries take on a silvery appearance. Feeding studies on maize (Scheibelreiter and Inyang 1974) indicate that one larva can eat a section of leaf 3 cm long (1,000 mm^2) in about 12 d. The fourth-instar larvae do about 80% of the feeding damage within 4–5 d. Thus, the larvae from four to five egg batches are able to destroy the total leaf surface of 2–3-wk-old maize plants, which often kills them.

Leaf miner, *Cerodontha orbitona* (Spencer); Diptera: Agromyzidae

Cerodontha orbitona (Spencer) is one of few dipterans that feed on rice foliage. It is a minor feeder of no apparent economic importance.

Country distribution. Ghana.

Spencer (1990) reported *C. orbitona* to be in South, East, and West Africa. In West Africa, *C. orbitona* has only been reported from Ghana, where it is widely spread throughout the rice-growing regions (Scheibelreiter 1973). Most information reported herein is from the study by Scheibelreiter (1973) in Ghana.

Description and biology. The adult is a small fly, which varies in size from 1.6 to 1.8 mm. Spencer (1960) provides a detailed description of the adult. The adults copulate shortly after emergence and lay eggs on the upper leaf surface. The egg is inserted into the spongy layer near the epidermis of the lower surface and towards the leaf tip. The size of the egg is 0.2 × 0.12 mm.

Larvae emerge 3–4 d after oviposition and begin feeding on the parenchymatous cells, tunneling toward the leaf tip. As the larvae develop, they enlarge their mines; thus the end where they pupate is the widest. The larval period is 12–16 d.

Pupation takes place inside the mine. The pupa is fixed to the dorsal leaf epidermis by the long posterior spiracular processes, which can be seen protruding from the leaf. The pupa is about 2 mm in length and 1 mm in width. It is light to dark brown in color. Development from oviposition to the emergence of the adult varies from 3 to 4 wk.

Habitat preference. *Cerodontha orbitona* has been reported from lowland irrigated rice fields.

Plant damage and ecology. The primary host plant for *C. orbitona* is *Oryza* but it has been reported to feed on a grass, *Hyparrhenia* (Poaceae), in Uganda and *Zea mays* in Réunion (Spencer 1985). Although plant damage was easily recognizable, this insect was reported to be a pest of no apparent economic importance in fields observed in Ghana (Scheibelreiter 1973). Infestation of hills varied from 0 to 20%. However, 50% of ratooned rice hills were infested at Dawhenya. This insect was found on all stages of crop growth but appeared to have a slight preference for younger plants. One puparium was found on maize, east of Kumasi, which suggests that other gramineous plants also serve as hosts for *C. orbitona*.

Studies on the seasonal occurrence of *C. orbitona* at Dawhenya showed that it was present on both the wet- and dry-season crops but was most abundant during the wet season. The population increased during the wet season, reaching 15% hill infestation in November and decreasing to about 0.1% of hills infested with mines during the dry season the following April. Symptoms of plant damage are the transparent, light brown mines that are elongated along one side of the midrib reaching up to 6 cm in length. The mine is narrow at one end and wide at the other.

Rice whorl maggot, *Hydrellia prosternalis* Deeming; Diptera: Ephydridae

A new species of *Hydrellia* discovered on rice at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria, was described and named *Hydrellia prosternalis* Deeming in 1977 (Deeming 1977). The genus *Hydrellia* contains more than 100 species that feed on gramineous crops (Deeming 1977). *Hydrellia philippina* Ferino, *H. griseola* (Fallen), *H. sasakii* (Yuasa et Isitani), and *Hydrellia* spp. feed on rice in the Philippines, USA, Japan, and South America, respectively (Dale 1994, Weber and Parada 1994). Although at least eight *Hydrellia* species have been recorded in Africa south of the Sahara, only *H. prosternalis* feeds on rice in this region.

Country distribution. Burkina Faso, Côte d'Ivoire, Ghana, Nigeria.

Hydrellia prosternalis may be widely distributed in West Africa, but taxonomic confirmations from other countries have not been published. Although whorl maggot damage was reported from Côte d'Ivoire, Liberia, and Sierra Leone, no taxonomic identifications were made (Deeming 1977). It is reported as a pest in Egypt (Isa et al 1979, Ismail 1979, Zatwarnicki 1988, Yanni and Abdallah 1990); thus its distribution in Africa may be broad.

Description and biology. Ismail et al (1979) studied the biology of *H. prosternalis* in Egypt. Moyal (1982) reported on the biology and ecology of *H. prosternalis* in Côte d'Ivoire and described the morphological features of the various stages. White, cigar-shaped eggs are laid singly and parallel to the veins on the leaves of young seedlings. Eggs are 0.7–0.8 mm long and 0.2 mm wide. Upon hatching, the larva penetrates the leaf tissue parallel to the veins. In the second instar, the larva moves to the base of the plant to the level of the axillary bud where it enters the leaf sheath. The whitish-yellow third instar is 3 mm long and 0.7 mm wide. Two, distinct, black spine-like structures are readily observed protruding from the extremity of the abdomen. The third-instar larva moves up the leaf sheath and pupates underneath the ligule. The larvae, when ready to pupate, often leave the mines in which they are feeding and bore into a plant of another species. Thus rearing an adult specimen from a plant does not mean that the plant is its host plant (Deeming 1977). The duration of one generation from egg to adult is 30–40 d and there is one generation per rice crop.

Habitat preference. *Hydrellia prosternalis* is reported to occur in both the humid tropical and the Guinea savanna zones in West Africa with highest populations in the former (Table 2). In Nigeria, it is present, with equal incidence, in all three climatic zones, the humid tropical, Guinea savanna, and the Sudanian savanna (Alam 1992). In Côte d'Ivoire, it is most important in the Korhogo area in the north, which is in the Guinea savanna (Moyal 1982).

The whorl maggot occurs in aquatic habitats and thus is a pest of both, rainfed lowland and irrigated lowland rice.

Plant damage and ecology. Moyal (1982) conducted a detailed study of *H. prosternalis* in three regions of Côte d'Ivoire—Kotiessou in the south, Bouaké in the center, and Korhogo in the north. Host plants other than rice reported were the grasses *L. hexandra* Swartz and *P. purpureum* (Schumacher). He reported it as a pest occurring at the seedling stage until booting, being most abundant during the tillering phase of crop growth.

Detailed studies on the seasonal occurrence of this pest have not been conducted but it is present in lowland rice throughout most, if not all, of the year. Moyal (1982) reported that it occurred in Côte d'Ivoire, in both the dry and wet seasons, from February to November.

According to Yanni and Abdallah (1990), the introduction of indica rice into Egypt intensified the damage caused by *H. prosternalis* as it is highly susceptible compared with the japonica rice. Damage by *H. prosternalis* is similar to that of *H. philippina*, which is a widespread pest in Asia. When larvae hatch, they begin feeding on the foliar tissue. First-instar larvae mine in the leaves moving parallel to the leaf veins. Feeding damage by this pest retards plant development, reduces plant vigor, and renders infested plants less competitive with weeds. Effects of this pest in causing yield loss have not yet been determined. It is considered a potentially serious pest whose biology and ecology should be studied more (Moyal 1982). In the Philippines, however, feeding by populations of *H. philippina* failed to reduce rice yields on the IRRI Farm (Shepard et al 1990).

In Egypt, Isa et al (1979) reported that applications of N fertilizer caused an increase in the percentage of infested tillers and in the number of *H. prosternalis* mines per tiller. Application of manure, however, had no effect on degree of infestation.

Rice grasshoppers

Nearly 30 grasshopper species, belonging to the short-horned (Acrididae and Pyrgomorphidae) and the long-horned (Tettigoniidae) families, attack rice plants in West Africa (Table 5). However, most species are not of economic importance on rice because they occur in low populations. Among the most important species are the short-horned ones, *Atractomorpha* spp. (Figs. 146–148), *Chrotogonus* spp., *Hieroglyphus africanus* Uvarov (Figs. 129–130), *H. daganensis* Krauss, *Oxya hyla* Serville (Figs. 141–142), and *Zonocerus variegatus* (L.) (Figs. 143–145) and the long-horned ones, *Conocephalus* spp. (Figs. 119–122).

Grasshoppers rarely cause significant damage other than along field margins. They chew angular holes in leaves, causing an injury similar to that caused by armyworms. These insects are polyphagous and, in addition to rice, feed on many other hosts including maize, millet, sugarcane, and many grasses.

In West Africa, grasshoppers are most important on irrigated rice grown in the dry zones of the Sahel. In these regions, rice is a major form of green vegetation during the hot dry season and grasshoppers congregate on these fields.

(See Table 5 for country listings of the various grasshoppers mentioned above and in the following sections.)

Short-horned grasshoppers, *Hieroglyphus daganensis*; Orthoptera: Acrididae

Country distribution. Cameroon, Ghana, Nigeria, Senegal.

Description and biology. Agyen-Sampong (1975) described the biology of *H. daganensis* in Ghana where it has caused significant damage in rice. The adult is pale greenish-yellow or light orange with yellow patches. It has distinct, dark lateral markings on the pronotum that resemble hieroglyphs. The head is ochraceous (dark yellow) with light brown eyes, greenish mandibles and a black band under the back of the genae. The male is 3–4 cm long and the female is longer at 4–6 cm. Adults are more commonly found in the short-winged form (brachypterous) than in the long-winged (macropterous) form. In September-October, the grasshopper population is higher in rice fields than grasses, but the reverse is true during November-December. Mating and oviposition occur from October to early December. Eggs are laid in egg pods in the soil and they hatch at the beginning of the rainy season in July of the following year.

Habitat preference. *Hieroglyphus daganensis* is found primarily in swampy areas.

Plant damage and ecology. *Hieroglyphus daganensis* has a wide host range and feeds on a number of grassy weeds and gramineous crops. Among these alternate hosts are *Andropogon gayanus* Kunth, *Arachis hypogaea* L., *Chrysopogon aciculatus* (Retz.), *Diectomis fastigiata* (Sw.), *Hyparrhenia chrysargyrea* (Stapf), *Pennisetum subangustum* Stapf and Hubb., *Rottboellia exaltata* L., *Setaria sphacelata* (Schumacher) Moss, and *Sorghum bicolor* (L.) Moench (Dale 1994).

Both the nymphs and the adults feed on rice leaves. When populations are high, the stems and panicles are also attacked. In Ghana, this insect has appeared in large populations since 1972 and has damaged large areas of rice. Yield losses of about 10% have been estimated in outbreak areas (Dale 1994).

Short-horned grasshoppers, *Oxya* spp.; Orthoptera: Acrididae; Figs. 141–142

Several short-horned grasshoppers in the *Oxya* genus occur on rice throughout the world. *Oxya hyla* Stål (Figs. 141–142), *O. chinensis* (Thunberg), and *O. velox* (F.) occur in both Africa and Asia (Delvi and Pandian 1971, Reissig et al 1986, Dale 1994, Heinrichs and Kassoum 1996). *Oxya hyla intricata* (Stål), and *O. japonica japonica* (Thunberg) are additonal *Oxya* species that occur in Asia (Reissig et al 1986).

Country distribution. *Oxya hyla* Stål: Burkina Faso, Côte d'Ivoire, Mali, Nigeria. The distribution of the various other *Oxya* species in West Africa is not well known.

Description and biology. Dale (1994) described the biology of *Oxya chinensis*. Adult *Oxya* are bright green and have a distinct dark band running laterally from behind each compound eye through the thorax to the base of the wings, e.g., *O. hyla* (Fig. 141). The male is about 20 mm long and the female about 30 mm.

Eggs are laid in masses or pods consisting of 10–30 eggs. The egg masses are covered with a white, frothy secretion that hardens to form an ootheca. The ootheca protects the eggs from drying. Eggs are laid behind rice leaf sheaths, among rice stems, in rice leaf folds, and in grass clumps above the water level. In dry conditions, the eggs are located just below the surface of the soil. Eggs hatch in 2–3 wk. Generally, there are six nymphal instars over a period of about 100 d.

Habitat preference. In surveys conducted in Côte d'Ivoire and Guinea (E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data), *Oxya* spp. occurred in both the humid forest zone and in the Guinea savanna. Populations were four times as high in Guinea as in Côte d'Ivoire but were similar in both climatic zones. In the 1995 Côte d'Ivoire surveys, these grasshoppers were collected in both upland and lowland fields. In the August survey, the population was highest in the lowland fields. According to Shepard et al (1995), *Oxya* spp. are adapted to aquatic environments.

Plant damage and ecology. *Oxya* spp. are general feeders (Alam 1992) consuming foliage of grass species in addition to rice. *Oxya chinensis* feeds on *Cyperus rotundus* L., *Saccharum officinarum* L., and *Zea mays* L. (Dale 1994).

Studies on lowland irrigated rice on the WARDA Farm showed that *Oxya hyla* was present throughout the crop period but populations peaked at 8 WAT (Fig. 65). WARDA studies on seasonal occurrence indicated that *O. hyla* was present throughout the year with peak populations occurring in October and March (Fig. 66).

Plant damage is the same as that caused by other grasshoppers. Both the nymphs and adults feed on leaf tissue, consuming large sections from the edges of leaf blades. Nurseries suffer severe damage when attacked by high *Oxya* populations. According to IRRI (1983) and Reckhkaus and Andriamasintseheno (1997), *Oxya* spp. transmit rice RYMV. However, in studies conducted in a monthly planting experiment on the WARDA Farm, there was no correlation between the incidence of RYMV and *Oxya* populations. The *Oxya* population was highest in October when RYMV was low, and lowest in June, when the RYMV incidence was high (Heinrichs et al 1997). Further studies conducted at WARDA have shown that *Oryza hyla* Serville is a RYMV transmission agent (F.E. Nwilene, K.F. Nwanze, and A.K. Traore, WARDA, 2002, unpubl. data).

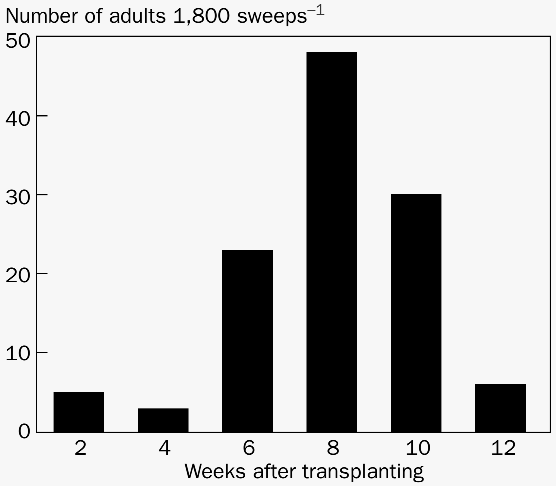


Fig. 65. Number of adult *Oxya hyla* Stål collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent a total of 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

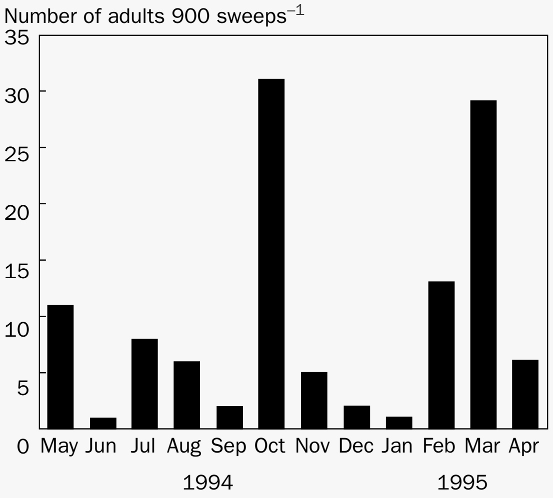


Fig. 66. Number of adult *Oxya hyla* Stål collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

Meadow grasshoppers, *Conocephalus* spp.; Orthoptera: Tettigoniidae; Figs. 119–122

Meadow grasshoppers, which belong to the long-horned group of grasshoppers, are minor pests of rice in West Africa.

Country distribution. *Conocephalus* sp.: Cameroon, Côte d'Ivoire; *Conocephalus longipennis* (de Haan): Gambia; *Conocephalus maculatus* (Le Guillou) (Fig. 119): Ghana.

Description and biology. The meadow grasshoppers, also called katydids, are distinguished from other grasshoppers by the long thread-like antennae, the elongated, sickle-shaped ovipositor, and the four-segmented tarsi (Figs. 119, 120, 122). Body color is bright green and wings are brown.

Conocephalus is a diurnal, grass-frequenting genus (Key 1970). *Conocephalus* spp. lay eggs in grass stems and feed on grasses and their seeds (Scholtz and Holm 1985). The biology of the *Conocephalus* spp. in rice has not been documented in West Africa.

Habitat preference. *Conocephalus* spp. occur in both the forest (humid tropical) and Guinea savanna climatic zones. In surveys in Côte d'Ivoire and Guinea, *Conocephalus* populations were highest in the Guinea savanna zone (E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data). The status of this pest in the Sudanian savanna has not been reported.

Conocephalus spp. prefer the more moist habitats of the continuum toposequence. Extremely low populations were observed in the upland sites (E.A. Heinrichs, 1992, WARDA, unpubl. data). Populations were higher in the hydromorphic and lowland sites, with the highest incidence in the latter (Fig. 67). Incidence was similar in both the weeded and nonweeded plots.

Plant damage and ecology. Although the host range of *Conocephalus* spp. has not been reported, grasshoppers, in general, have a wide range of hosts and it is likely that this also holds true for *Conocephalus* spp.

This grasshopper was the most abundant orthopteran occurring in the monthly planting test on the WARDA Farm. *Conocephalus* spp., at WARDA, occurred in lowland rice throughout the crop growth period. Peak populations were recorded at 8 WAT in 1994–95 (Fig. 68).

Conocephalus are present throughout the year at WARDA, but populations vary greatly within the year (Fig. 69). Peak populations were observed in the plots transplanted in October and November and lowest numbers were collected in the January transplanted plots.

Little research has been done on the feeding damage in rice caused by the various *Conocephalus* spp. in Africa. *Conocephalus longipennis* has been reported to damage rice plants (Grist and Lever 1969). In Asia, *C. longipennis* feeds on rice, but it is also a predator of the rice seed bug, stem borer eggs, and the nymphs of leafhoppers and planthoppers (Barrion and Litsinger 1987). On rice, this species feeds on both the foliage and rice panicles (Rothschild 1971, Barrion and Litsinger 1987). It eats the highly nutritive rice anthers by cutting through the lemma or palea, thus, damaging the rice spikelets. *Conocephalus* damage is distinguished from bird, rat, or rice bug damage by the small holes eaten in each spikelet. Birds and rats strip off many spikelets and bugs feeding on the seeds do not make observable holes. Feeding holes on damaged 1-d-old spikelets are observed to turn from white to brown by

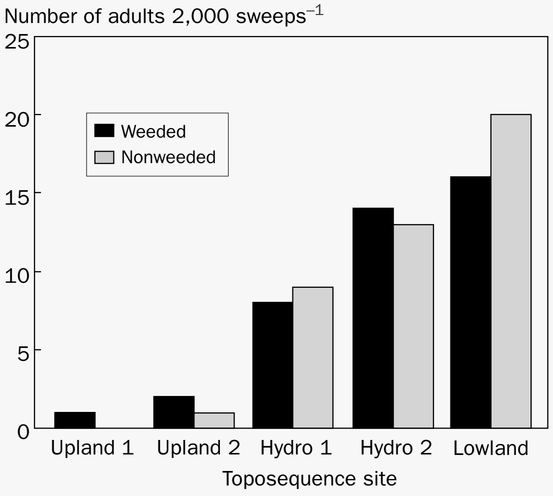


Fig. 67. Number of adult *Conocephalus* spp. collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

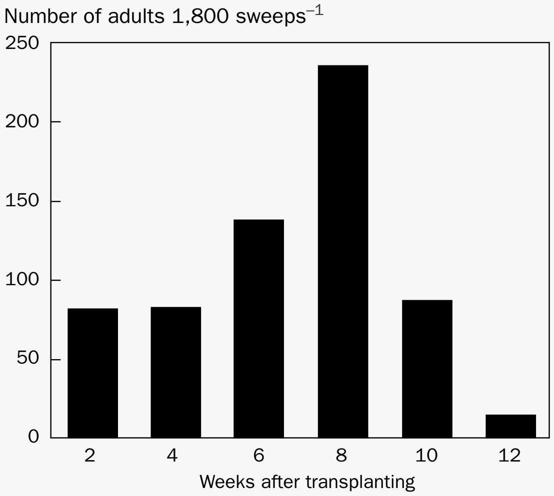


Fig. 68. Number of adult *Conocephalus* spp. collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

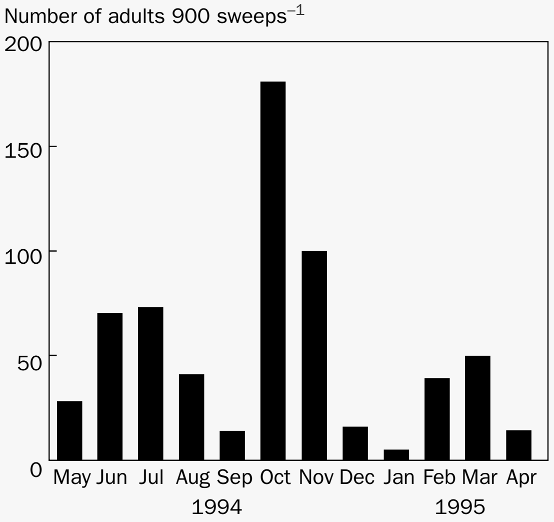


Fig. 69. Number of adult *Conocephalus* spp. collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent total adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

the third day. Caged adults can destroy 10–28 spikelets daily.

It appears that its role as a predator of other rice pests may be more important than its role as a rice pest itself. Rothschild (1970) reported that *C. longipennis* is an important predator of rice insects in Malaysia. In laboratory and field observations conducted in Malaysia, Ito et al (1995) observed *C. longipennis* feeding on eggs of the rice bug, *Leptocorisa oratorius* (F.). In field tests conducted in the Philippines, *C. longipennis* destroyed 46% of the egg masses of yellow stem borer, *Scirpophaga incertulas* (Walker) (Pantua and Litsinger 1984). In another study, one grasshopper consumed more than eight yellow stem borer egg masses in 3 d (Rubia et al 1990). *Conocephalus maculatus* is a predator of the striped stem borer *Chilo suppressalis* (Walker) in Japan (Miyata and Saito 1982).

Conocephalus longipennis has been reported as being a transmission agent RYMV in West Africa (Abo 1998, Abo et al 1998, Nwilene 1999). Among the various insects tested by Bakker (1971, 1974) in Kenya, only the chrysomelid beetles and the grasshopper *Conocephalus merumontanus* (Sjöstedt) transmitted RYMV. Information regarding the role of other *Conocephalus* spp. in the transmission of RYMV in West Africa is needed.

Variegated grasshopper, *Zonocerus variegatus* (L.); Orthoptera: Pyrgomorphidae; Figs. 143–145

The variegated grasshopper, *Zonocerus variegatus*, which belongs to the short-horned group, is one of the most common grasshopper species occurring in lowland rice in the forest and Guinea savanna zones of West Africa. It is readily seen because of its large size and striking colors. Another *Zonocerus* species, *Z. elegans* (Thunberg), also occurs in Africa.

Country distribution. Cameroon, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal, Sierra Leone, Togo.

Zonocerus variegatus is distributed between the Tropic of Cancer and the Tropic of Capricorn, with a predominant occurrence in West Africa. It is distributed throughout West Africa south of the Sahara and spreads east to Uganda and north to Sudan (Page 1978). *Zonocerus elegans* occurs between the Equator and the Tropic of Capricorn and is restricted to eastern and southern Africa (Toye 1982).

Description and biology. The appearance of *Z. variegatus* nymphs and adults is distinct because of the bright yellow and black pattern on the body and legs (Figs. 143, 145). They are large insects, measuring about 25 mm in length as adults.

The life cycle of *Z. variegatus* varies with latitude in West Africa (Iheagwam 1983). According to de Grégorio (1988), rainfall and humidity regulate the life cycle of the variegated grasshopper in Togo. In the savanna regions of Cameroon, Mali, and Nigeria, where the rainy season is well defined, development is similar to that of other grasshoppers (Chapman et al 1986). First-instar nymphs hatch in April or May, just before rains begin. Nymphal development continues through the wet season and the adults mature. The females mate and lay eggs in the soil in pods containing about 50 eggs (see below) in October with the onset of the dry season. The eggs survive the dry season only if the soil remains moist.

In the forest region, and associated derived savanna, the life cycle is more complex. Rainfall is bimodal and the dry season is shorter and less defined than in the north. At least in the region extending from Nigeria west to Guinea, some eggs hatch from September to April. Insects that hatch early in this period (September to November) develop during the dry season. Nymphs that hatch from eggs in March and April develop wholly in the wet season. Oviposition may occur at any time of the year. Populations in different localities may be at different stages of development even though they are only separated by a few kilometers. In Côte d'Ivoire, populations separated by only 3 km were more than a month out of phase (Vuillaume 1954).

The biology of *Z. variegatus* is well documented (Toye 1971, 1982; Page 1978; de Grégorio 1982; McCaffery and Page 1982; Chapman et al 1986). Intense oviposition follows periods of heavy rainfall. Oviposition sites are usually in shady areas beneath woody plants and are close to cultivated plants such as cassava. The female lays eggs after mating two or three times; an individual might lay up to six egg pods in a lifetime. Egg pods are injected into the soil. There are about 50 eggs per pod and pod densities may exceed 500 m^{-2}.

Eggs usually undergo diapause before development of the embryo. Eggs laid in November develop through the dry season and hatch in March. Eggs laid in February develop through the wet season and hatch in September. Eggs only survive when and where soil remains moist for long periods. Because eggs are clumped together, first-instar nymphs, upon hatching, aggregate in large numbers on low, herbaceous vegetation. There are usually six nymphal instars. All nymphal stages and adults are gregarious and the first through third instars are distinctly so. The nymphs aggregate in the morning and in the early evening, but during the hours of bright sunshine, they disperse to feed on weeds. There is little activity between 2100 and 0600. Later instars disperse to feed on rice and other crops. They disperse about 500 m or more between hatching and becoming adults. Adults of the dry-season population, which appear in February, are dimorphic in wing length, the long wing forms being capable of flights exceeding 100 m.

Habitat preference. *Zonocerus variegatus* usually occurs on cultivated land with the nymphs and the adults sharing the same habitat. Evidence suggests that this species originated in the forest zone. It is primarily associated with forest regions, but its distribution extends into the savanna, where it is restricted to river habitats (Chapman et al 1986). Studies in Nigeria indicate that the habitat of *Z. variegatus* extends from the lowland rainforest zone to the Guinea savanna in the north (Toye 1982). The distribution map in Page (1978) shows that its range extends into the Sudanian savanna in Mali. In Côte d'Ivoire, *Z. variegatus* occurs in both upland and lowland rice habitats (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Plant damage and ecology. In Nigeria, especially in the more tropical south, *Z. variegatus* causes considerable damage to crops that are grown during the dry season months of October to March (Nwana 1984). *Zonocerus variegatus* is polyphagous, feeding on a wide range of wild and cultivated plant species. Reports from Nigeria (Page 1978, Toye 1982, Nwana 1984) list its hosts as banana, cassava, citrus, cocoa, cola, cotton, cowpea, citrus, maize, okra, oil palm, pawpaw, pepper, pineapple, plantain, rice, soybean, teak, yam, and various green vegetables. In southern Nigeria, cassava is the major crop damaged but serious damage to other crops has also been observed (Page 1978). Feeding on a mixed diet of even relatively poor food-quality species such as the weed *Chromolaena odorata* (L.) and another plant species is generally more beneficial to *Z. variegatus* than feeding on a single species (Modder and Tamu 1996).

Zonocerus variegatus feeds around the clock but is most active during the day, resting a good part of the time from dusk until morning. Modder (1984a) found that, in Nigeria, most feeding activity takes place between 1300 and 1900. *Zonocerus variegatus* occurs on lowland rice throughout the entire crop growth period. However, populations in the monthly planting experiment at WARDA in 1994–95 (Fig. 70) peaked at 8 WAT with low populations at the beginning and the end of the crop growth cycle. In the forest region in the southern portion of its range, *Z. variegatus* occurs in both the dry and wet seasons, but it is most abundant during the dry season. In the savanna, it is mostly restricted to the wet season (Chapman et al 1986). Observations on seasonal occurrence at WARDA, which is in the transition between the forest and Guinea savanna zones, showed that peak populations were present at the beginning of the dry season in plots transplanted in September and October (Fig. 71). No *Z. variegatus* were collected in sweep net samples in August, March, and April. The low population observed in plots transplanted in May to July is apparently the wet-season population, the nymphs of which hatch in February to April. The high populations observed in September to November plantings are apparently the dry-season population of which the nymphs hatch in October to November.

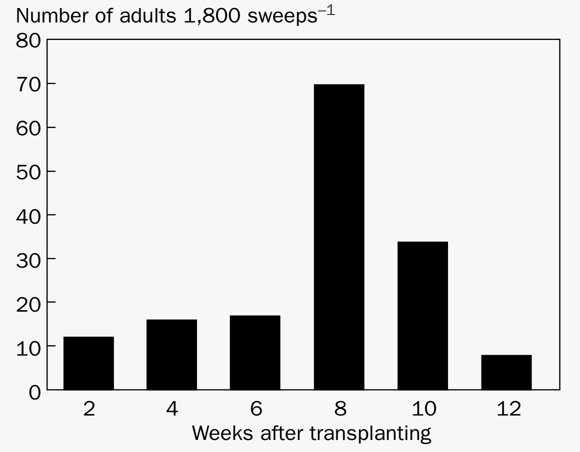


Fig. 70. Number of adult *Zonocerus variegatus* (L.) collected by sweep net at the indicated weeks after transplanting of lowland rice (variety Bouaké 189) plots. Numbers represent 12 monthly transplanting dates throughout 1 yr, May 1994–April 1995 (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

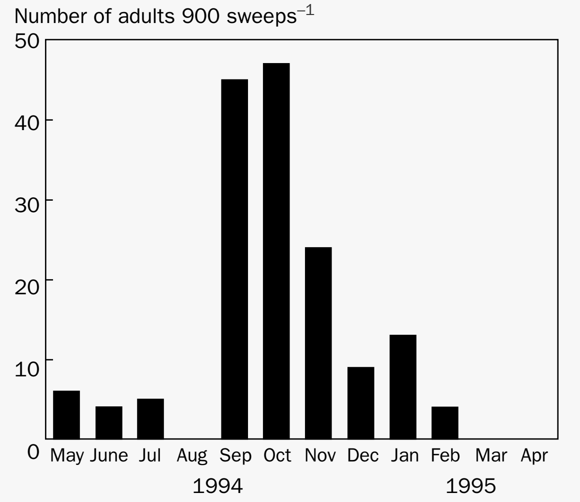


Fig. 71. Number of adult *Zonocerus variegatus* (L.) collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

Results of seasonal occurrence studies conducted in Ibadan, Nigeria, were similar to those conducted at WARDA in Bouaké, Côte d'Ivoire. *Zonocerus variegatus* populations in lowland irrigated rice were observed from the beginning of the dry season in October to the end of the dry season in April with peak populations occurring at mid-dry season from December to January (Page 1978).

The pest status of *Z. variegatus* appears to have increased in the forest zone of West Africa since the 1960s (Modder 1984b). Three interrelated factors may be involved (Chapman et al 1986): 1) a reduction in the dense evergreen forest area, 2) an increase in the growing area of cassava, and 3) the spread of the 'Siam weed', *Chromolaena odorata* (formerly *Eupatorium odoratum* L.).

During the 1976–80 period, the area of closed forest in Nigeria, Côte d'Ivoire, and Cameroon decreased at an annual rate of 300,000; 285,000; and 80,000 ha, respectively. *Zonocerus variegatus* has become an important pest in these countries. Closed forests favor a fungal disease, *Entomophaga grylli* (Fres.), which normally controls *Z. variegatus*. Areas cleared of trees become drier and the *Z. variegatus* population is no longer restricted by the fungus.

The reduced forest area is attributed to shifting cultivation, which involves increased cassava production. In the forest regions where cassava is widely grown, it probably contributes to the dry-season survival of *Z. variegatus*. Cassava-fed *Z. variegatus* have high fertility (Chapman et al 1986) and this may be contributing to the increase in populations.

The weed, *Chromolaena odorata*, which was introduced into West Africa from Sri Lanka in the 1930s, quickly colonizes areas cleared of forest. The spread of this broadleaf in West Africa corresponds to the apparent increase in *Z. variegatus* populations. Toye (1974) suggested that the spread of this weed in Nigeria might have been at least partly responsible for the increasing occurrence of *Z. variegatus* outbreaks. Modder (1984b) found that the tops of *C. odorata* plants, especially the inflorescence, are favored roosting sites for *Z. variegatus* nymphs. The genus *Chromolaena* produces pyrrolizidine alkaloids and it is believed that *Z. variegatus* uses them for some nonnutritional purpose, such as an attractant pheromone. Thus, *Chromolaena,* being a ready source of the alkaloids, may have contributed to an increase in the populations of this grasshopper (Chapman et al 1986).

Zonocerus variegatus damage in rice is sporadic and depends on the availability of other plant hosts adjacent to rice fields. Nymphs and adults feeding on rice remove large areas of foliage, typical of other grasshopper species. Although damage is usually light, severe attacks can cause plant death. There is a lack of data on the yield losses caused by *Z. variegatus* in rice and other crops.

Whitefly, *Aleurocybotus indicus* David and Subramaniam; Hemiptera: Aleyrodidae

Members of the Aleyrodidae family usually appear white on account of the powdery or waxy material that covers their wings, hence the name whitefly. Few species of these small insects have been recorded on rice; however, Williams and Diop (1981) reported *Aleurocybotus indicus* David and Subramaniam to be an important pest of rice in West Africa. In Coimbatore, India, *A. indicus* was described on rice and the grasses *Chloris barbata* Swartz and *Dactyloctenium aegyptium* (L.) Willdenow. The only other whitefly species previously recorded on rice are the polyphagous species *Bemisia tabaci* Gennadius found at Madras, India, in 1970 (Zoological survey of India 70:133–233 cited in Williams and Diop 1981) and *Trialeurodes oryzae* (Westwood) reported by Chia-Hwa (1973) on the Chinese Agricultural Mission farms in Bobo Dioulasso, Burkina Faso.

Country distribution. Burkina Faso, Gambia, Mali, Mauritania, Niger, Nigeria, Senegal.

In West Africa, *A. indicus* was first reported on rice in Senegal in 1977 (Alam 1989). It has since been reported from Bobo-Dioulasso in Burkina Faso; Kogoni, Mali; Basse, Georgetown, and Kolikunda, Gambia; Kaedi, Lamin, Sapir, and Sankuli Kinda, Mauritania; Niger; Ibadan and Badeggi, Nigeria; and Richard-Toll, Fanaye, and Guede-Podor, Senegal (WARDA 1981, Williams and Diop 1981, Abdou 1992, Dingkuhn 1992).

Description and biology. Whiteflies are minute insects measuring 2–3 mm in length as adults (Borror et al 1981). The adults resemble tiny white moths with their wings covered by a white dust or waxy powder. Adults are active and readily fly from leaves of rice when disturbed. Eggs are laid on the plant.

Metamorphosis of whiteflies differs from that of other members of the suborder Homoptera. The first instars are active, but subsequent instars are sessile and have the appearance of scales. The scale-like covering is a waxy secretion of the insect. The early instars are called larvae. The next to the last instar is quiescent and is called a pseudopupa. Details on the biology of *A. indicus* in rice in West Africa have not been published.

Habitat preference. Whiteflies are rice pests in the Guinea and Sudanian savannas but not in the humid tropical (forest) zone of West Africa (Table 2). They occur in the irrigated Sahel and the mangrove swamp areas but are not found in the upland and inland swamp areas of the continuum (WARDA 1988).

Plant damage and ecology. Alternate host plants of *A. indicus* in West Africa have not been reported. However, reports of the grasses *Chloris barbata* and *Dactyloctenium aegyptium* as being host plants in India indicate that grass species in West Africa are most likely hosts as well.

The whitefly is a dry-season insect. High temperatures and low humidity favor its buildup. During the 1982–83 dry season at Fanaye, Senegal, the whitefly was present on the rice crops planted from September to February and was most severe on the crop planted in September.

The whitefly occurs on the plant from the seedling to the maturity stage (Alam 1984) and damages plants by sucking sap from the leaves. Honeydew, which is excreted on the leaves by the feeding nymphs and adults, has a high sugar content and a black sooty mold fungus grows on it. Extensive feeding and high amounts of sooty mold may eventually lead to wilting and death of the plants (Alam 1989).

Trinh (1980) reported *A. indicus* as a new insect problem in the Senegal River Basin. *Aleurocybotus indicus* is considered a major pest at Fanaye and NDiaye, Senegal, and in Niger where yield losses attributed to this pest have reached 80% (Abdou 1992). Total destruction of the rice crop at Fanaye, Senegal, was reported during the 1982-83 season (Akinsola and Coly 1984). In considering the entire Sahel region, Dingkuhn (1992) listed the whitefly to be a major constraint to rice production only in Fanaye and NDiaye, Senegal. Populations at Fanaye have been reported to vary greatly from one year to another. Infestations in 1978, 1979, and 1980 were considered to be medium, low, and high, respectively (WARDA 1981).

Spider mites, *Oligonychus pratensis* Banks, *O. senegalensis* Gutierrez and Etienne, *Tetranychus neocaledonicus* Andre; Acari:Tetranychidae

The spider mites are extremely small arthropods that are important pests of rice in the Sahel area of West Africa. As implied by their common name, these mites spin silk webs on the plant.

Country distribution. *Oligonychus pratensis* Banks: Senegal; *O. senegalensis* Gutierrez and Etienne: Senegal; *Tetranychus neocaledonicus* Andre: Benin, Côte d'Ivoire, Ghana, Senegal.

In addition to Senegal, *O. pratensis* is a widely distributed species occurring in North, Central, and South America; Hawaii; Madagascar; and South Africa.

Gutierrez and Etienne (1981a) described *O. senegalensis* as a new species based on a holotype collected at Ziguinchor, Senegal. It has only been reported on rice in Senegal.

Tetranychus neocaledonicus has been reported on rice in four West African countries as listed above and has also been reported from the Canary Islands (Pande and Hernandez 1989), Madagascar (Gutierrez and Chazeau 1973), and India (Bharodia and Talati 1976).

Description and biology. Gutierrez and Etienne (1981a) have described *O. senegalensis*. As are all mites, this species is very small, the male being 295 m long and 125 m wide. The female is slightly larger.

The biology of the spider mites on rice has not been published. Pande and Sharma (1986) described the biology of *T. neocaledonicus* on cucurbits. Spherical, smooth eggs of 0.12 mm in diameter are deposited singly on the web, generally on the lower leaf surface. Eggs are at first pale yellow but later turn brown. The incubation period at 30 °C is about 3 d. Newly hatched larvae have three pairs of legs and are about 0.16 mm in length. They pass through three larval, protonymphal, and deutonymphal stages. Duration of the life cycle, from egg to adult, is 10 d. *Tetranychus neocaledonicus* can have up to 32 generations per year under ideal conditions (Jeppson et al 1975). Spider mite development is favored by hot, dry conditions. Gutierrez (1976) in Senegal found, that at a temperature of 27 °C and 50% humidity, *T. neocaledonicus* completes a life cycle of one generation in 2 wk.

Habitat preference. Spider mites generally occur within the same rice ecosystem as the whiteflies. They have pest status in the irrigated Sahel ecosystem but not in the mangrove swamps or the upland/inland swamp continuum (WARDA 1988). The spider mites are more important constraints to rice production in the Sahel than are the whiteflies.

***Plant damage and ecology*.** Leaf-feeding spider mites of the Tetranychidae family are severe pests. The spider mite species have different host plants. *Oligonychus pratensis* and *T. neocaledonicus* have a wide host range. *Oligonychus pratensis* feeds on maize, sugarcane, sorghum, and wheat, in addition to rice (Gutierrez and Etienne 1981b). It is a pest of cereals in the southern United States and also feeds on pasture and ornamental grasses, such as Bermuda grass, and on weeds (Jeppson et al 1975).

Oligonychus senegalensis has only been reported as a pest of rice while *T. neocaledonicus* is a polyphagous species and has been reported on 59 botanical families in Madagascar alone (Gutierrez and Etienne 1981b). It feeds on cucumber in the Casamance, Senegal (Gutierrez and Etienne 1981b) and on tomato in the Canary Islands (Pande and Hernandez 1989). It is considered a major pest of crops including cotton in India (Jeppson et al 1975, Bharodia and Talati 1976).

Spider mites can generally feed on the rice crop at all growth stages. *Oligonychus oryzae* (Hirst), a rice pest in India, begins feeding on plants in the nursery and continues feeding on transplanted seedlings in the field (Jeppson et al 1975).

In seasonal occurrence studies in the Casamance at Djibelor, Senegal, *O. pratensis* and *T. neocaledonicus* were collected on rice during the dry season in March and *O. senegalensis* was collected on rice in March, June, and October (Gutierrez and Etienne 1981b).

Oligonychus pratensis populations are concentrated along the central vein and at the base of the leaf (Gutierrez and Etienne 1981b). Mites suck sap from the parenchymatous cells of the leaves and produce large masses of webbing on the leaves. They often feed on the under surface of the leaves. Leaves become discolored with white patches and dry up starting from the leaf tip. Plants become stunted with deformed panicles and empty spikelets (E.A. Akinsola, Côte d'Ivoire, 1994, pers. commun.).

An unidentified species, *Oligonychus* sp. was reported as a severe pest in Mauritania, Gambia, and

Senegal in a survey conducted in 1980 (WARDA 1981). Infestations were severe at all Senegal locations surveyed. Populations in Gambia were highest at Kolikunda and in Mauritania at Kaedi. Dingkuhn (1992) considered spider mites to be an important constraint to rice production at Kogoni, Mali, and at Fanaye and NDiaye, Senegal.

Insects that attack panicles

Insects that attack rice panicles can be separated into those that feed on the floral parts (mostly the pollen) and the stink bugs that suck the milk-like sap from the developing grains. Insects that feed on the floral parts, such as earwigs, blister beetles, and panicle thrips, prevent the spikelet from filling and thus it remains empty and aborts.

Numerous hemipteran insect species belonging to the Alydidae, Coreidae, Pentatomidae, and Pyrrhocoridae families suck the milk-like sap from the developing rice grains. Depending on the time of attack, in relation to stage of grain development, direct damage by milk (liquid endosperm) removal may completely or partially destroy the grain. In addition to the direct damage caused by the feeding of the bugs, secondary pathogens may enter the feeding wounds left by the bugs and cause a staining of the grain that cannot be removed in milling. This is referred to as 'pecky rice' that is prone to breakage in milling and lowering of the grain quality. The 'dirty-panicle' symptom often observed in rice fields is believed to be caused by a combination of bug feeding and fungal infection (Agyen-Sampong and Fannah 1980).

In this section, the floral feeders are discussed first, followed by the grain-sucking bugs.

Earwigs, *Diaperasticus erythrocephalus* (Olivier); Dermaptera: Forficulidae

The common name, 'earwig,' was given to these insects because of the superstition that they crawl into the ears of sleeping persons (Little 1963). Their food varies considerably ranging from living and dead insects to decaying and living plants. Although they are commonly seen on the floral parts of rice, the damage that they cause is minimal and they are considered as minor pests of rice in West Africa.

Country distribution. Cameroon, Côte d'Ivoire, Liberia.

Earwigs occur primarily in the tropics and warmer temperate zones (Giles 1970). Steinmann (1977) reported *D. erythrocephalus* Olivier to be distributed throughout the Ethiopian region and Madagascar. Its distribution in West Africa is not well known but it probably occurs in most West African countries.

Description and biology. Earwigs are elongated, slender insects with a flattened and heavily sclerotized body. They are beetle-like in appearance, but easily distinguished from the Coleoptera by the presence of distinct cerci, or pincers, that appear as forceps at the tip of the abdomen (as represented by two Labiduridae earwigs, *Euboriella annulipes* and *Labidura riparia* in Figs. 108–109, respectively). The pincers are used in defense; to fold the soft, membranous, fan-shaped, hind wings beneath the fore wings; and to catch and hold prey while it is consumed. 'Dermaptera' means 'skin wings', referring to the leather-like texture of the fore wings.

Female earwigs are maternal in that they protect the eggs that are laid in burrows on the ground and feed the nymphs until they are strong enough to take care of themselves. Metamorphosis is simple and the nymphs are similar in appearance to the adults, except for an increase in the number of antennal segments and the progressive development of the wings until maturity. Nymphs molt four to five times before reaching adulthood. Development takes about 4 wk (Giles 1970).

Habitat preference. Detailed studies on the distribution of *D. erythrocephalus* in the various climatic zones of West Africa have not been conducted. In a survey of farmers' fields in Côte d'Ivoire, populations in the humid forest zone were 5 per 500 sweeps, whereas they were only 1 per 500 sweeps in the Guinea savanna (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Diaperasticus erythrocephalus occurs at all sites on the continuum toposequence. However, they appear to be more abundant in the upland/hydromorphic zones than in the lowlands. In two surveys (July and August 1995) conducted in farmers' fields in Côte d'Ivoire, sweep net counts were 2.4 and 3.3 per 500 sweeps in the upland/hydromorphic sites, respectively, while they were only 0.7 and 1.6 per 500 sweeps, respectively, in the lowland fields (E.A. Heinrichs, WARDA, 1995, unpubl. data). Similar results were obtained in studies on the continuum toposequence at WARDA (E.A. Heinrichs, WARDA, 1992, unpubl. data) where the *D. erythrocephalus* population was highest in the lower portion of the uplands and in the hydromorphic zones (Fig. 72). In studies conducted in slash-and-burn ecosystems in Côte d'Ivoire (Oyediran et al 1999c), *Diaperasticus* populations were higher in the upland than in the hydromorphic sites.

Plant damage and ecology. *Diaperasticus erythrocephalus* is found on rice plants at all stages of crop growth. However, it is most abundant during the flowering stage. In an October survey conducted in Côte d'Ivoire (E.A. Heinrichs, WARDA, 1995, unpubl. data), populations based on sweep net counts were 0.3, 1.8, and 3.1 per 500 sweeps in fields at the vegetative, booting, and flowering stages, respectively. In the monthly planting experiment at WARDA (E.A. Heinrichs, WARDA, 1995, unpubl. data), *D. erythrocephalus* were observed throughout the crop

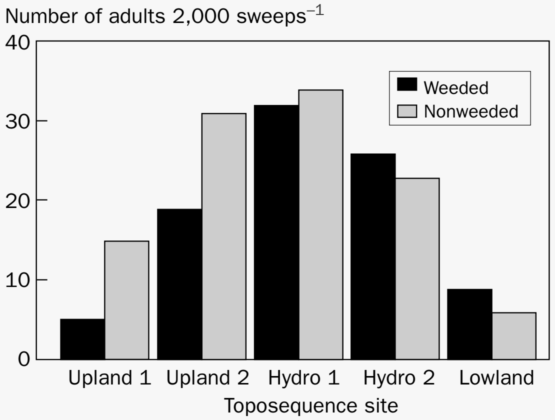


Fig. 72. Number of adult *Diaperasticus erythrocephalus* (Olivier) collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

growth cycle with highest populations at 10 WAT, which coincides with the flowering phase.

The seasonal occurrence of *D. erythrocephalus* was studied in the monthly planting experiment at WARDA from May 1993 to April 1994 (E.A. Heinrichs, WARDA, 1994, unpubl. data). It was collected throughout the year, except for plots planted in January. Peak populations were observed in the plots planted in May and June 1993 (wet season) and February 1994 (dry season).

Spacing of transplanted seedlings in lowland fields has an effect on the number of *D. erythrocephalus* caught in sweep net samples. Studies at WARDA (E.A. Heinrichs, WARDA, 1993, unpubl. data) showed that closely spaced plants of 10 × 10 cm had higher populations than plants spaced at 30 × 30 or 40 × 40 cm (Fig. 73).

Earwigs generally hide in dark spaces during the day and feed at night. They are mostly scavengers. *Diaperasticus erythrocephalus* also feeds on the floral parts, pollen, stamens, and pistils of rice when the glumes open. Such feeding damage causes sterility.

Occurrence on plants at the vegetative stage is an indication that earwigs are also predaceous on smaller insects (E.A. Akinsola, WARDA, 1994, per. commun.). Alghali (1984d) observed *D. erythrocephalus* preying on newly emerged adults of the sorghum midge, *Contarinia sorghicola* Coquillett, in Kenya.

Blister beetles; Coleoptera: Meloidae; Figs. 225–237

Blister beetles are large, distinctly colored beetles that are general feeders on various plant species. Blister beetle adults are found on flowers and on foliage on which they feed. Meloids produce a body fluid containing cantharidin that is highly toxic and causes large, watery blisters when it comes in contact with human skin.

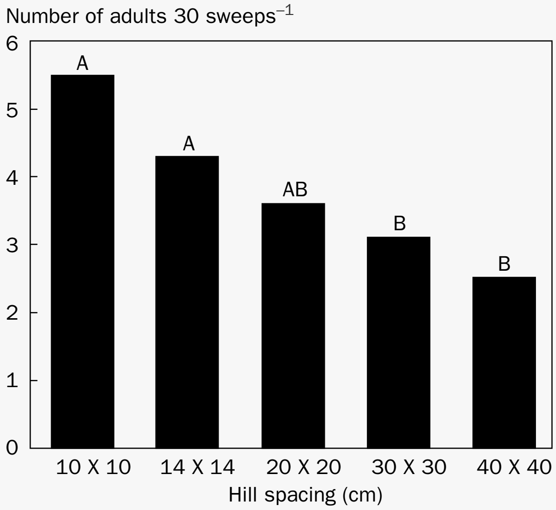


Fig. 73. Number of adult *Diaperasticus erythrocephalus* (Olivier) collected with a sweep net as affected by hill spacing of irrigated lowland rice (variety Bouaké 189). Bars with the same letter are not significantly different at the 0.05 probability level by Duncan's multiple range test (E.A. Heinrichs, WARDA, M'bé, 1993, unpubl. data).

Country distribution. *Cylindrothorax melanocephala* F. (Figs. 227–228): Côte d'Ivoire, Nigeria; *C. spurcaticollis* F. (Figs. 229–231): Burkina Faso, Cameroon, Côte d'Ivoire, Guinea, Guinea-Bissau, Liberia, Mali; *C. westermanni* Mäklin: Cameroon; *Epicauta canescens* Klug: Nigeria; *Mylabris* sp. (Figs. 234–237): Cameroon, Côte d'Ivoire.

Cylindrothorax melanocephala has also been reported on *Pennisetum glaucum* (L.) and *Sorghum bicolor* Moench in Ghana and Senegal and *C. westermanni* has been reported on *P. glaucum*, *S. bicolor*, and *Zea mays* L. in Côte d'Ivoire, Ghana, Nigeria, and Senegal (Selander 1988).

Description and biology. Blister beetles vary in color with the head and pronotum being yellow or black and the elytra being reddish yellow, bluish, or greenish black. Their bodies are cylindrical (Britton 1970). The head is large and constricted to a narrow 'neck' where it joins the prothorax. The thorax is narrower than the head or wing covers (Figs. 227, 229, 232, 234, 236).

Cylindrothorax melanocephala is a large, slender beetle (Fig. 227). The elytra (fore wings) are metallic pine-green, while the dorsal portion of the prothorax has a bright orange color; the head is black. Adults lay eggs in the soil where the larvae and pupae also occur. Larvae generally pass through six instars before pupating.

Habitat preference. Information on the relative abundance of blister beetles in the different climatic zones and rice land ecosystems in West Africa is not available.

Plant damage and ecology. Blister beetle adults are very mobile and often suddenly appear in large numbers and cause severe damage to the floral parts of the rice plant. In addition to rice, they feed on the flowers of other crops; they are well known to feed on maize tassels. Whereas the adult blister beetles are phytophagous, the larvae are predaceous on grasshopper eggs in the soil.

Okwapam (1971) reported on an outbreak of *C. melanocephala* at the Federal Rice Research Station, Badeggi, Nigeria, in September 1965. The beetle population was high, ranging from 2 to 10 beetles panicle^{-1}. The beetles ravenously ate the developing grains (milk stage), which became empty and white in color. They destroyed almost 100% of the grains after feeding in a field for 48 h and then moved on to adjacent fields on the research station.

Panicle thrips, *Haplothrips* spp.; Thysanoptera: Phlaeothripidae

Panicle thrips are generally minor and occasional pests of rice. They are extremely small (1–2 mm long) insects that are distinct because of their long, narrow, membranous wings, which are fringed with long hairs.

Country distribution. *Haplothrips avenae* (Priesner): Senegal; *H. gowdeyi* (Franklin): Senegal; *Haplothrips* sp.: Liberia.

Description and biology. Panicle thrips in Liberia are reported to be small (1 mm long), black insects that lay their eggs on the surface of the rice plant, usually in the flowering panicles (Stephen 1977). In the Asian species, dark brown adults, measuring 1.3–6 mm, lay eggs on the outer surface of the lemma and the palea, mostly in groups of 4, 8, and 12 (Ananthakrishnan and Thangavelu 1976). Eggs hatch in 2–4 d. The larvae pass through two instars over a period of 8–11 d. After the larval stage, there is a prepupal stage of 1 d after which the prepupae pass to the pupal stadium. The pupal period is 3–4 d. Adult female thrips live for 12–15 d while the males only live 3–5 d.

Habitat preference. No reports have been published on the occurrence of rice panicle thrips in relation to climatic zones and rice ecosystems in West Africa.

Plant damage and ecology. Little information is available regarding the damage caused *by Haplothrips* spp. in West Africa. In India, *H. ganglbaueri* Schmutz [= *H. aculeatus* (F.)] was reported as an extremely polyphagous species, which feeds on 53 plant species, including rice, wheat, sorghum, and millet (Abraham et al 1972, Kulshrestha et al 1984, Dale 1994). In rice, it feeds on both the inflorescence and tender leaves. In India, there is a strong correlation between thrip populations on rice field weeds, such as *Echinochloa crus-galli* (L.) and on rice plants (Ananthakrishnan and Thangavelu 1976).

Studies on the seasonal occurrence of panicle thrips in West Africa are lacking. In India, *H. ganglbaueri* populations on rice begin at the end of the wet season in August and continue into September and October (Kulshrestha et al 1984). Thrip populations on rice were negatively correlated with rainfall. When the panicles mature in October, they become unsuitable for the thrips and they then move on to other suitable host plants.

Thrips have a single functional mandible, which is used to scrape living plant material. Due to the lacerations caused by the feeding activities of the larvae and adults, the rice flower is variously affected. Damage to the lemma and palea causes the development of oval brown patches. In India, Vidayasagar and Kulshreshtha (1983) reported three types of damage: 1) light brown spots with a perforation at the proximal part of the unopened spikelets, 2) sterile spikelets that retain their green color throughout development, and 3) oozing of milk over the grain without leaving any external feeding marks. Affected panicles turn a premature whitish color and are erect due to the dropping of damaged grains. Continuous feeding causes chaffy or malformed grains. Some species have been reported to feed on pollen grains (Kirk 1984) but this has not been verified for rice panicle thrips.

Hsieh et al (1980) reported an association between rice sheath rot caused by *Acrocylindrium oryzae* Sawada and two rice thrips, *Thrips oryzae* Williams and *Haplothrips aculeatus*. The disease infected the leaf sheath, spikelets, and grains. About 80% of each of the two thrips species collected from the infected rice plants carried the *A. oryzae* pathogen. Rice thrips infested with the pathogen were also shown to be able to transmit the disease to the rice plant. Infected panicles were sterile.

Stink bugs, *Aspavia* spp.; Hemiptera: Pentatomidae; Figs. 393–396

Four species of *Aspavia* have been reported on rice in West Africa (Table 5). The biology and the damage caused by the various *Aspavia* species are believed to be similar. *Aspavia armigera* F. appears to be the most common species.

Country distribution. *A. armigera*: Cameroon, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Senegal, Togo; *A. acuminata*: Côte d'Ivoire, Ghana, Mali; *A. brunnea*: Côte d'Ivoire, Mali, Senegal; *A. hastator*: Côte d'Ivoire.

Description and biology. The characteristic odor that is produced by the scent glands, located on the lower side of the body near the middle coxae, has given the pentatomids the common name of 'stink bug.' Adult *Aspavia* spp. are brown bugs with a large scutellum (triangular shield) having three yellow spots and a pointed projection or spine at each side of the prothoracic plate (Figs. 393–396). Three species of *Aspavia* can be distinguished by the nature of the three spots on the scutellum. In *A. armigera* (Fig. 396), the spots are small and located at each corner of the scutellum. In *A. acuminata* Montandon (Fig. 395), the spots are larger and in *A. brunnea* (Signoret) (Fig. 393), the spots fuse together to form a t- or v-shape.

Ewete and Olagbaju (1990) studied the development of *A. armigera* on rice and cowpea in Nigeria. The female lays eggs singly on the plant after a preoviposition period of 12–19 d, depending on the rice variety. Incubation takes about 1 wk. The nymphs pass through five instars over a period of 20–25 d.

Habitat preference. Surveys conducted in Côte d'Ivoire and Guinea (E.A. Heinrichs and C. Williams, WARDA, 1995, unpubl. data) showed that *A. armigera* is equally abundant in the humid forest zone and in the Guinea savanna. Highest populations were observed in Côte d'Ivoire.

Aspavia armigera occurs in both upland and lowland ecosystems but is more abundant in the latter. Alam and Lowe (1989) studied the relative abundance of *A. armigera* on irrigated lowland and upland rice in Nigeria. Populations were about five times higher on irrigated rice than on upland rice. Studies on the continuum toposequence at WARDA (E.A. Heinrichs, WARDA, 1992, unpubl. data) indicated very low populations in the upland, and high populations in the lower portion of the hydromorphic and in the lowland plots (Fig. 74). In two surveys of farmers' fields in Côte d'Ivoire, *A. armigera* populations were 1.1 and 4.8 per 500 sweeps in the uplands and lowlands, respectively, in July, and 1.6 and 10.3 per 500 sweeps, respectively, in the uplands and lowlands in August (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Plant damage and ecology. The grain-sucking bugs that attack rice have a wide host range. In Nigeria, *A. armigera* is a major pest of soybean and cowpea in addition to rice (Ewete and Olagbaju 1990, Ogunwolu 1992). It has been reported on cotton in Ghana (Forsyth 1966 as cited in Cobblah 1991).

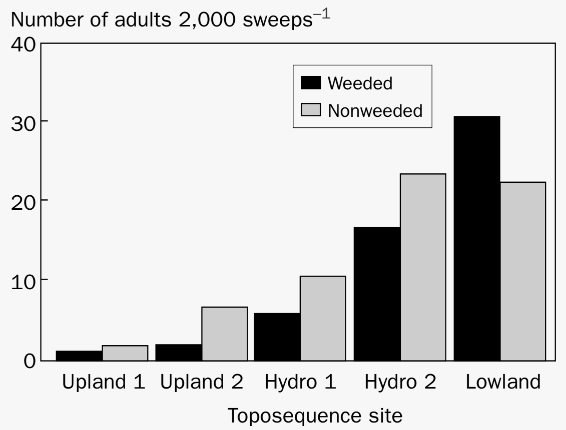


Fig. 74. Number of adult *Aspavia armigera* F. collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

Alam and Lowe (1989) studied the relative abundance of *A. armigera* and *Stenocoris claviformis* Ahmad on irrigated and upland rice in Nigeria. Peak populations of both species occurred at 70-90 DAT. In studies in lowland fields at WARDA (E.A. Heinrichs, WARDA, 1995, unpubl. data), *A. armigera* was collected throughout the crop growth cycle with a peak at 8 WAT. In a survey of farmers' rice fields conducted in Côte d'Ivoire in October (E.A. Heinrichs, WARDA, 1995, unpubl. data), the *A. armigera* population was 1.5, 2.4, and 12.9 per 500 sweeps at the vegetative, booting, and flowering stages, respectively.

Results of seasonal occurrence studies in lowland rice on the WARDA Farm are shown in Fig. 75. *Aspavia armigera* sweep net collections were highest in plots transplanted during the wet season, May to October, with a peak near the end of the wet season in October.

Agyen-Sampong and Fannah (1980) described damage caused by the feeding of *Aspavia* spp. Both nymphs and adults attack rice grains as soon as the panicle is exserted and continue to feed until the hard dough stage. Nymphs prefer to feed on grain immediately after flowering and the adults prefer grain in the milk stage. Grains at the hard dough stage are rarely punctured. The glumes are punctured and the bugs suck the contents of the developing grain. Although the alydid bugs, *Riptortus* and *Stenocoris* spp., feed on any site on the grain, *Aspavia* spp. primarily puncture the grain at the apical end. Only part of the milk is sucked out at each feeding and the same grain may be punctured several times. Signs of attack by *Riptortus* spp. are stylet puncture marks with milk

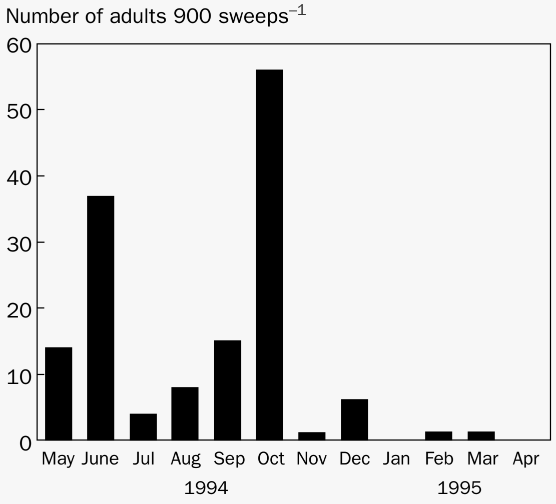


Fig. 75. Number of adult *Aspavia armigera* F. collected by sweep net in lowland rice (variety Bouaké 189) plots transplanted at monthly intervals throughout 1 yr, May 1994–April 1995. Numbers represent adults collected at biweekly intervals from 2 to 12 WAT over six sample dates (E.A. Heinrichs, WARDA, M'bé, 1995, unpubl. data).

exudate on the outer glumes, but these signs were not observed in feeding by *Stenocoris* or *Aspavia* spp. Within 2–3 d after the grain is punctured, the glumes begin to change color, first to light brown, and then gradually darker. In severe cases, the glumes become gray after 1 wk. Severity of the damage depends on the stage of grain development and on the number of punctures in the grain. It is believed that *Aspavia* spp. feeding contributes to the incidence of the 'dirty panicle' syndrome mentioned earlier.

There appear to be varietal differences in the effect of *A. armigera* feeding on the extent of grain damage. In studies by Ewete and Olagbaju (1990), 4 bugs panicle^{-1} caused significant grain damage in cultivar ITA 257 while 8 bugs panicle^{-1} were required to cause significant grain damage in ITA 128. Mean percentage grain damage at 4 bugs panicle^{-1} was 14 and 39% for ITA 128 and ITA 257, respectively.

Green stink bug, *Nezara viridula* (L.); Hemiptera: Pentatomidae

The green stink bug is a polyphagous pest attacking a large number of plant species throughout the world. Populations are generally low in West African rice fields.

Country distribution. Burkina Faso, Cameroon, Côte d'Ivoire, Nigeria.

Nezara viridula (L.) occurs in all of the rice-growing regions of the world. Its range in West Africa is likely much greater than is indicated in the literature.

Description and biology. The adult is readily recognized by its green color. However, phenotypes differing in intensity of coloration may occur in the same population (Pathak 1968). In West Africa, they range from plain green to green with yellow stripes or yellow with green spots (E.A. Akinsola, WARDA, 1994, pers. commun.). The adult is about 12 mm long.

Females start mating about 1 wk after emergence and they begin laying eggs 2–3 wk after mating. Eggs are laid in parallel rows on the lower surface of leaves in masses containing 70–130 each. Each female usually lays two to eight egg masses. Eggs, which are yellow but turn red or bright orange just before hatching, are often heavily parasitized.

Newly hatched nymphs remain aggregated around their empty eggshells before they disperse for feeding. No feeding activity occurs during the first instar stage. Feeding begins in the second instar when the nymphs move away from their empty eggshells. After the fourth instar, the nymphs feed solitarily. Nymphs usually pass through five instars during a 35- to 45-d period before becoming adults. The nymphal population exhibits varied color patterns (Dale 1994).

Habitat preference. Information on the distribution of *N. viridula* in the various climatic zones and different rice ecosystems in West Africa is lacking. Litsinger et al (1987) report that, in Asia, it is more abundant in the uplands than in the lowlands.

Plant damage and ecology. In West Africa, *N. viridula* populations on rice are generally lower than those of the other grain-sucking bugs, such as *Aspavia*, *Stenocoris*, *Mirperus*, and *Riptortus* spp., so *N. viridula* can be considered as a minor rice pest (E.A. Heinrichs, WARDA, 1995, personal observation). In addition to rice, *N. viridula* has many host plants and is especially common on legumes, cotton, and tomato (Dale 1994). Rice fields surrounded by wild vegetation are especially vulnerable to *N. viridula* infestations. Mass migrations of this bug from vegetable fields to rice crops have been observed.

The feeding behaviors of the nymphs and adults are similar. Both suck the milk from developing grains and cause pecky rice that is partially or wholly stained by bacteria or fungi. Damaged grains are shriveled and unfilled. When grains are in the milky stage, they are fed upon, but when grains have ripened, the bugs feed on panicle stalks and pedicels. When restricted to rice stems and leaves, they will feed on these plant parts with a preference for leaves over stems (Lim 1970). Studies on wheat indicate that *N. viridula* feeding at the milk grain stage causes severe damage, but grain at the soft dough stage tolerates feeding damage (Viator et al 1983).

Studies in Arkansas, USA, indicated that discoloration in pecky rice results from fungi that are introduced at the time of feeding by a pentatomid, the rice stink bug, *Oebalus pugnax* (F.) (Lee et al 1993). Similar fungi were cultured from pecky rice grain and from the stylets and saliva of *O. pugnax*. The fungus, *Fusarium oxysporum* Schlect., caused the greatest discoloration in pecky rice.

In studies conducted in Japan, one *N. viridula* adult could produce 1.5 pecky rice grains d^{-1} (Kisimoto 1983). The pest has assumed great economic significance in Japan since 1956 when the introduction of early transplanting resulted in the flowering of the rice crop at the same time as the emergence of first-generation adults.

Alydid bugs, *Stenocoris* spp. (Figs. 434–438), *Mirperus* spp. (Figs. 441–442), and *Riptortus dentipes* (Figs. 439–440); Hemiptera: Alydidae

Various alydid bugs are pests of rice worldwide. The alydids are distinguished from the pentatomids by their long, slender body and lack of a large scutellum. There are several alydids in the genera *Riptortus* and *Stenocoris* in rice in West Africa (Table 5) and their biology, ecology, and the damage they do to plants are similar. Thus, a representative genus, *Stenocoris*, which is extremely abundant in Côte d'Ivoire, is discussed primarily.

Country distribution. *Mirperus jaculus* Thunberg (Fig. 442): Côte d'Ivoire, Guinea, Guinea-Bissau, Togo; *M. varipes* Thunberg: Côte d'Ivoire, Ghana, Guinea Bissau, Sierra Leone; *Riptortus dentipes* (F.) (Figs. 439–440): Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Nigeria, Togo; *Stenocoris apicalis* (Westwood): Cameroon, Côte d'Ivoire, Gambia, Togo; *S. claviformis* Ahmad (Figs. 436–438): Burkina Faso, Côte d'Ivoire, Liberia, Nigeria, Sierra Leone; *S. elegans* (Blöte): Côte d'Ivoire, Liberia, Nigeria.

The distribution of the alydids on rice in West Africa is likely much more widespread than what the literature indicates.

Description and biology. Linnavuori (1987) published notes on the taxonomy, habitats, and distribution of the Alydidae in West and Central Africa. *Stenocoris* spp. closely resemble the Asian rice stink bugs, *Leptocorisa* spp. The body is elongated and slender (Fig. 436). Nymphs are reddish. The three pairs of legs are similar in shape and size, which distinguishes *Stenocoris* from some of the other bugs on rice, such as *Riptortus dentipes*. *Riptortus* is stout and varies from light to dark brown and has an enlarged third pair of legs (Fig. 440). *Stenocoris* may also be identified by the three white spots on the lateral side.

Alydid eggs are laid in small groups on the leaves (Reissig et al 1986). One female may lay many groups of eggs and each group hatches in about 6 d. During hatching, the upper half of the egg breaks away, leaving a characteristic hole. Nymphs aggregate on the foliage and because they are green, they blend in with the rice foliage. The nymphs pass through five instars (E.A. Akinsola, WARDA, 1994, pers. commun.). When adults are disturbed, they give off an offensive odor that is as strong as that given off by the pentatomids.

Habitat preference. *Stenocoris* spp. are present in both the humid forest zone and Guinea savanna in Côte d'Ivoire. In three surveys conducted in 1995, populations were highest in the savanna in July, but in August and October, they were highest in the forest zone. In an October survey in Guinea (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data), populations were twice as high in the savanna as in the forest zone.

The alydid bugs inhabit all rice ecosystems from the uplands to the lowlands. Studies on the continuum toposequence at WARDA (E.A. Heinrichs, WARDA, 1992, unpubl. data) indicated very low populations in the uplands with highest populations occurring in the lowlands, especially in the nonweeded plots (Fig. 76). Surveys in farmers' fields in Côte d'Ivoire indicated that populations of *Stenocoris* spp. were distinctly higher in lowland than in upland fields. In July 1995, there were 0.7 per 500 sweeps in the uplands and 4.8 per 500 sweeps in the lowlands, while in August there were 0.7 in the uplands and 13.2 in the lowlands per 500 sweeps (E. A. Heinrichs, WARDA, 1992, unpubl. data). In studies at Ibadan, Nigeria (Alam and Lowe 1989), *S. claviformis* populations were about four times higher in irrigated lowlands than in upland rice fields.

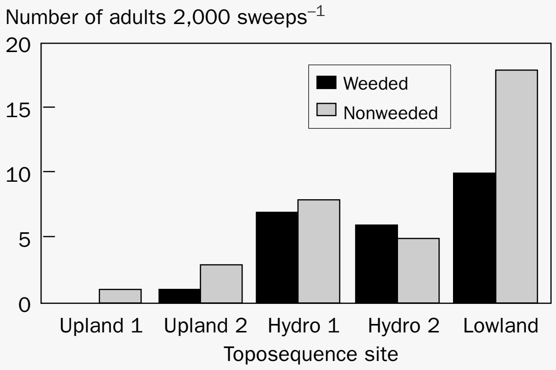


Fig. 76. Number of adult *Stenocoris* spp. collected by sweep net in weeded and nonweeded rice plots at five toposequence sites on the continuum (E.A. Heinrichs, WARDA, M'bé, 1992, unpubl. data).

Plant damage and ecology. Many grasses serve as hosts for the alydids with rice and *Echinochloa* being important (Reissig et al 1986). *Riptortus dentipes* is also a pest of soybean (Ogunwolu 1992) and cowpea (Kaemba and Khamala 1981) in Nigeria. They occur throughout the crop cycle in irrigated lowland rice at WARDA but peak populations generally occur at 10–12 WAT (E.A. Heinrichs, WARDA, 1995, unpubl. data). October surveys in farmers' fields in Côte d'Ivoire showed that the population was highest in crops at the flowering stage when they were about six times that of crops in the vegetative or booting stage (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Plant density appears to have an effect on the *Stenocoris* spp. population. In a direct seeding experiment, in lowland irrigated rice, *Stenocoris* spp. populations were significantly higher at wider plant spacings with a seed density of 60 kg ha^{-1} as compared with a more dense spacing at 120 kg ha^{-1} (E.A. Heinrichs, WARDA, 1995, unpubl. data).

Both nymphs and adults prefer to feed on the endosperm of rice grains but will also suck plant sap. The presence of *Stenocoris* spp. in the crop at the vegetative stage indicates that they may be feeding on the sap from rice leaves or stems. They have sucking mouthparts. The alydids do not bore a hole through the rice hulls but insert their stylets into the grain through a space between the lemma and the palea. As they feed, they secrete a liquid that forms a stylet sheath that hardens around the feeding point and holds the mouthparts in place. The white stylet sheaths left in the grain are visible with the naked eye. The nymphs and adults both prefer rice at the milk stage but may also feed on soft and hard dough rice grains. Nymphs are more active feeders than adults, but adults cause more damage because they feed over a longer period of time. Removal of the milky white endosperm results in reduced grain size. When feeding on the grain at the soft or hard dough endosperm stage, they inject enzymes to predigest the carbohydrate. This process results in the contamination of the grain with microorganisms that cause grain discoloration or pecky rice. Feeding at this stage reduces grain quality but does not reduce grain weight.

According to Agyen-Sampong and Fannah (1980), *Stenocoris* spp. remove only a portion of the grain milk at one feeding and the grain may be fed upon several times. They report that a few days after the grain is punctured, the glumes begin to change color, first to light brown and then to dark brown. Severity of the damage depends on the stage of grain development at the time of attack and on the number of times that the grain is fed upon.

Cotton stainers, *Dysdercus* spp.; Hemiptera: Pyrrhocoridae; Fig. 408

Dysdercus spp. are distributed throughout the tropics where they are best known for the damage that they cause when feeding on cotton bolls (Taylor 1982). Four species have been collected from rice, in West Africa, where they are believed to be minor pests feeding on the grain.

Country distribution. *Dysdercus superstitiosus*: Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Liberia, Mali; *D. melanoderes* Karsch: Liberia; *D. nigrofasciatus* Stäl: Cameroon, Côte d'Ivoire; *D. voelkeri* Schmidt: Côte d'Ivoire.

Description and biology. Species in the cotton stainer family, Pyrrhocoridae, have a four-jointed antenna and distinct venation in the hemelytra (e.g., *D. superstitiosus*, Fig. 408), are generally rather large, and are marked with contrasting colors such as red and black. *Dysdercus superstitiosus* has a large distinct spot on each fore wing (Fig. 408).

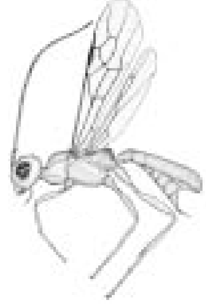
The biology of *Dysdercus* spp. on rice has not been published. The following is taken from the account of Taylor (1982) about *D. fasciatus* on cotton in Zimbabwe. They mate within a few days of becoming adults and may remain in copulation from 3 to 8 d. Eggs are deposited in batches of 50 in hollows or crevices in the soil. Up to 350 eggs are laid over a 3-wk period. Nymphs emerge within 6 d of oviposition. First-instar nymphs do not feed and remain in groups in the soil near where the eggs were laid. The remaining four instars feed and disperse widely and tend to be gregarious. Development may take from 25 to 53 d. Young adults are strong fliers and disperse.

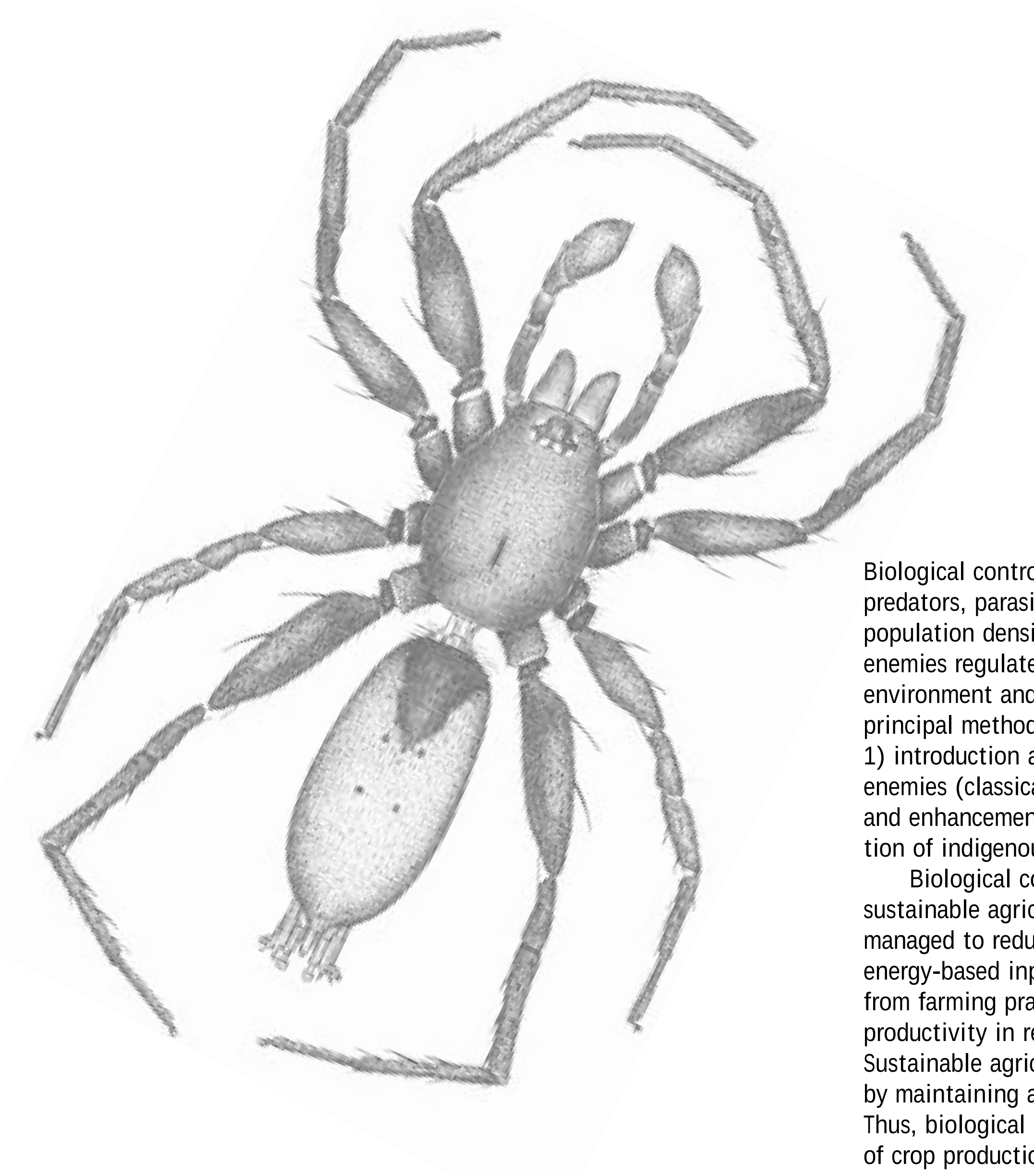
Habitat preference. Populations of *Dysdercus* spp. have been too low in sweep net collections made in surveys conducted in Côte d'Ivoire and Guinea to determine their distribution in relation to climatic zone and toposequence site. In Côte d'Ivoire, low numbers have been found in upland fields in the forest zone (E.A. Heinrichs, WARDA, 1995, unpubl. data). Emosairue and Usua (1994, 1996) reported *D. superstitiosus* to be an important pest of upland rice in southeastern Nigeria. Populations of *D. superstitiosus* were reported to be high in late-planted upland rice where they were the most abundant species (32% of all insects collected).

Duviard (1977) reported that *Dysdercus* spp. in West Africa differ in relation to their abundance in the various climatic zones. *Dysdercus melanoderes* is a forest species, seldom found in the savannas of northern Côte d'Ivoire; *D. haemorrhoidalis* Signoret is mostly present in the savannas of the central part of Côte d'Ivoire; and *D. voelkeri* is more numerous in the savanna than in the forest. Duviard (1977) also reported on the relationship between the movement of the intertropical convergence zone and the migration of *Dysdercus* spp. in West Africa. Migration of *D. voelkeri* in the Ferkessedougou, Côte d'Ivoire, area occurs between the time of the harmattan and the beginning of the wet season.

Plant damage and ecology. *Dysdercus* spp. have many hosts, the most common being cotton (Edmunds 1978, Nwana and Youdeowei 1978, Taylor 1982, Atachi and Segbede 1990). Their feeding behavior on rice grains has not been described. On cotton, they pierce the green boll wall and feed on the unripe seeds, causing the boll to abort. Their feeding damage provides an entry point for a yeast-like fungus, *Nematospora* sp., which stains the lint (Taylor 1982). Studies are necessary to determine their role as rice pests.

Natural Enemies of West African Rice-Feeding Insects





Biological control employs natural enemies such as predators, parasites, and pathogens to reduce pest population density and/or pest damage. Natural enemies regulate organisms in their natural environment and interactions are relatively stable. The principal methods employed in biological control are 1) introduction and establishment of exotic natural enemies (classical biological control), 2) augmentation and enhancement of natural enemies, and 3) conservation of indigenous natural enemies.

Biological control is a major component of sustainable agricultural systems that are designed and managed to reduce dependence on chemical and other energy-based inputs, minimize ecological risk resulting from farming practices, and enhance agricultural productivity in relation to the resources available. Sustainable agriculture attempts to prevent pest losses by maintaining a healthy and balanced agroecosystem. Thus, biological control is central to the management of crop production systems for long-term sustainability (Mackauer 1989).

To ensure that biological control will contribute to sustainable agriculture, several steps must be taken. These steps apply to both native and introduced pests and to biological control involving the introduction of exotic natural enemies and the augmentation and conservation of indigenous natural enemies (Mackauer 1989). First, it is necessary to establish an inventory of all the natural resources. Knowledge of the indigenous natural enemies is needed to assess environmental changes and the risks associated with various crop production systems. Biological control of rice-feeding insects in West Africa is at the inventory phase where some knowledge is available on the natural enemy species present in the various rice ecosystems.

The second step involves research to identify the agricultural practices that contribute to pest outbreaks. This may include rice cultivars that are poorly adapted to local conditions and agronomic practices that adversely affect natural enemies. The importance of natural enemies in regulating pest populations must be determined. The proper assessment of biological control requires the measurement of the impact of natural enemies on pest numbers over time (Waage and Schulthess 1989).

Third, the relative economic importance of the various pests must be assessed to identify those that are key pests for which control intervention must be established. If the key pest has been introduced, a classical biological control program involving the introduction of exotic natural enemies can be considered. However, most key rice pests in West Africa are believed to be native species and thus a biological control program involving the release of laboratory-produced natural enemies to augment populations and/or the conservation or enhancement of indigenous natural enemy populations should be employed (Yaninek and Cock 1989).

For augmentative biological control, there are only two categories of natural enemies that can be reliably mass-produced: trichogrammatid egg parasitoids and some groups of insect pathogens (Yaninek and Cock 1989). To provide an effective control strategy using these agents, it is necessary to have an appropriate infrastructure and social organization to mass produce the organisms, to maintain them until used, to get them to the target area when needed, and to release them. These conditions are not available in West Africa, at present, and until they are, augmentation is not considered an effective means of biological control of rice insect pests. Conservation and enhancement of indigenous natural enemies offer the greatest potential for control of insect pests in West African rice ecosystems. The important insect pests in West African rice ecosystems require detailed ecological research to evaluate their indigenous natural enemies. Based on this information, methods can be developed to conserve or enhance them, and thus increase their effectiveness within the context of an integrated rice crop protection program.

Inventory of natural enemies of West African rice-feeding insects

Most of the research on natural enemies of rice-feeding insects in West Africa has been devoted to the identification of natural enemies attacking stem borers. According to the literature (Polaszek 1998a), numerous egg, larval, and pupal parasitoids belonging to the insect orders Diptera and Hymenoptera, and predators belonging to the insect order Hemiptera, have been reported as natural enemies of rice stem borers (Table 6). One mite species, *Pyemotes ventricosus* (Newp.), and two nematodes, *Hexamermis* sp., and *Mermis* sp., have been recorded as feeding on rice stem borers.

Several rice insect pathogens have been identified in West Africa but this area of research has received little emphasis. The pathogens known to attack stem borers consist of the bacterium, *Bacillus thuringiensis* Berliner; three fungal species, *Aspergillus flavus* Link, *A. sydowi* (Bainier and Sartory) Thom and Church, and *Metarrhizium anisopliae* (Metch.); a protozoan, *Nosema manierae* (Toguebaye and Bouix); and a virus, the cytoplasmic polyhedrosis virus. The cytoplasmic polyhedrosis virus may be an important factor in the control of rice-feeding insects (Pollet 1981). This disease reduces the host insect's resistance to unfavorable factors such as microclimate and reduces its feeding on stressed rice plants.

Dipteran and hymenopteran parasitoids mentioned in the literature as attacking various rice insect hosts, other than stem borers, in Cameroon and Sierra Leone, are listed in Table 7. Although numerous insect species have been recorded as parasitoids of rice-feeding insects in West Africa, it is likely that detailed surveys will result in the identification of many additional species. Potential predators and parasitoids (they have not been confirmed to feed on rice insect pests) collected in rice fields of West Africa are listed in Table 8.

Predators

Potential predators collected in West African rice fields are in the insect orders Coleoptera, Dermaptera, Hemiptera, Hymenoptera, Mantodea, Odonata, and Orthoptera (Table 8) and also consist of numerous spider species.

Coleoptera. Four coleopteran families present in rice in West Africa are the Anthicidae, Carabidae, Coccinellidae, and Staphylinidae (Table 8). The anthicid, *Anthicus* is reported as a predator of injured *Agrotis* larvae in India (Mathur et al 1971). The ground beetles (Carabidae) are abundant in upland rice in West Africa. Species of *Calleida* (Godfret et al 1989) and *Cicindela* (Whitcomb et al 1973) in the USA have been reported as predators of fire ants *Solenopsis invicta* Buren and of noctuid larvae, respectively, in soybean.

Pitfall-trapping studies on the continuum toposequence at WARDA (Oyediran et al 2000b) indicated that carabids were present in upland rice throughout the cropping period and increased toward harvest (Fig. 77). Populations were highest in the hydromorphic (hydro 1) zone located between the upland and the lower hydromorphic (hydro 2) zone (Fig. 78).

Table 6. Natural enemies of rice stem borers in West Africa.

Natural enemy	Host(s)	Stage(s) attacked	Country/ continent	Reference(s)
INSECTA				
DIPTERA				
Chloropidae				
Aphiocheta xanthina	*Sesamia* spp.	NM[a]	Africa	Appert (1964)
Epimadiza sp.	*Coniesta ignefusalis*	NM	Africa	Appert (1964)
Oscinosoma risbeci	*Coniesta ignefusalis*	NM	Africa	Appert (1964)
Diopsidae				
Diopsis apicalis	*Diopsis longicornis*	Larva	Ghana	Scheibelreiter (1974)
Tachinidae				
Actia cuthbertsoni	*Chilo zacconius*	Larva	Sierra Leone	Harris (1998), Jordan (1966)
Actia sp.	*Eldana saccharina*	Larva	Africa	Betbeder-Matibet (1981)
Descampsina sesamiae	*Eldana saccharina*	Larva	Africa	Betbeder-Matibet (1981)
	Sesamia botanephaga	Larva	Ghana	Sampson and Kumar (1986)
	Sesamia calamistis	Larva	Ghana	Sampson and Kumar (1986)
Metagonistylum minense	*Coniesta ignefusalis*	Larva	Nigeria	Harris (1962)
Siphona murina	*Eldana saccharina*	NM	Africa	Betbeder-Matibet (1981)
Sturmiopsis parasitica	*Coniesta ignefusalis*	Larva/pupa	Nigeria	Harris (1962), Grist and Lever (1969)
	Busseola fusca	Pupa	Nigeria	Harris (1962), Mohyuddin and Greathead (1970)
	Eldana saccharina	Larva	Africa	Betbeder-Matibet (1981)
	Sesamia sp.	Pupa	Nigeria	Harris (1962), Mohyuddin and Greathead (1970)
HEMIPTERA				
Anthocoridae				
Orius punctaticollis	*Diopsis longicornis*	Egg	Cameroon	Descamps (1956)
HYMENOPTERA				
Bethylidae				
Goniozus garouae	*Eldana saccharina*	Larva	Africa	Betbeder-Matibet (1981)
Goniozus indicus	*Adelpherupa* sp.	NM	Cameroon	Descamps (1956)
	Chilo sp.	Larva	West Africa	Vercambre (1977), Akinsola and Agyen-Sampong (1984)
	Chilo zacconius	NM	Cameroon	Descamps (1956)
		NM	Senegal	Vercambre (1977)
	Maliarpha separatella	Larva	West Africa	Akinsola and Agyen-Sampong (1984), Polaszek et al (1994)
		NM	Senegal	Vercambre (1977), Polaszek et al (1994)
	Scirpophaga sp.	NM	Cameroon	Descamps (1956), Mohyuddin and Greathead (1970)
		NM	Senegal	Vercambre (1977)
Goniozus sp.	*Chilo diffusilineus*	NM	Burkina Faso	Bonzi (1982)
		Larva	West Africa	Bonzi (1982)
	Chilo sp.	Larva/pupa	Sierra Leone	Jordan (1966)
		Larva	West Africa	Vercambre (1977), Akinsola and Agyen-Sampong (1984)
	Coniesta ignefusalis	Larva	Nigeria	Appert (1964), Harris (1962)
	Maliarpha separatella	Larva	Mali, Senegal, Sierra Leone	Brenière (1969)
		Larva	Sierra Leone	Grist and Lever (1969)
		Larva/pupa	Sierra Leone	Jordan (1966)
Braconidae				
Bracon brevicornis	*Sesamia* sp.	NM	Africa	Appert (1964)
Bracon testaceorufatus	*Chilo diffusilineus*	Larva	Burkina Faso	Bonzi (1982)
	Chilo sp.	Egg	Ghana	Agyen-Sampong (1977b)
		Larva	West Africa	Brenière (1969), Akinsola and Agyen-Sampong (1984)
	Chilo zacconius	NM	Cameroon	Descamps (1956)
		Larva	Senegal	Appert (1952), Vercambre (1977)
	Maliarpha separatella	Larva	Côte d'Ivoire	Pollet (1978a, 1981)
		Larva	Senegal	Brenière (1969), Vercambre (1977)
		Larva	Cameroon, Côte d'Ivoire, Ghana, Mali, Nigeria, Senegal	Achterberg and Polaszek (1996)

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Table 6 continued.

Natural enemy	Host(s)	Stage(s) attacked	Country/ continent	Reference(s)
Bracon testaceorufatus (continued)	*Scirpophaga* sp.	NM	Senegal	Vercambre (1977)
	Sesamia calamistis	NM	Senegal	Vercambre (1977)
	Sesamia inferens	Larva	Cameroon	Descamps (1956), Nickel (1964), Nishida and Torii (1970)
	Sesamia sp.	NM	Cameroon	Descamps (1956), Risbec (1956)
Chelonus curvimaculatus	*Busseola fusca*	Pupa	Africa	Mohyuddin and Greathead (1970)
	Chilo diffusilineus	NM	Africa	Appert (1964)
	Chilo zacconius	Larva	Senegal	Nickel (1964), Brenière (1969)
Chelonus maudae	*Maliarpha separatella*	Egg/larva	Senegal	Polaszek et al (1994)
Chelonus sp.	*Chilo zacconius*	NM	Senegal	Vercambre (1977)
Cotesia ruficrus	*Chilo zacconius*	NM	Cameroon	Descamps (1956), Nickel (1964), Brénière (1969), Polaszek et al (1994)
	Maliarpha separatella	Larva	Côte d'Ivoire	Polaszek et al (1994)
Cotesia sesamiae	*Coniesta ignefusalis*	Larva	West Africa	Risbec (1960), Appert (1964), Mohyuddin and Greathead (1970)
		Larva	Nigeria	Harris (1962)
	Chilo diffusilineus	NM	Burkina Faso	Bonzi (1982)
	Chilo sp.	Larva	West Africa	Agyen-Sampong (1979), Akinsola and Agyen-Sampong (1984)
		Larva	Sierra Leone	Agyen-Sampong (1979), Jordan (1966)
	Eldana saccharina	Larva	Africa	Betbeder-Matibet (1981)
		Larva	Cameroon	Descamps (1956), Nickel (1964)
		Larva	Côte d'Ivoire	Appert (1971a)
		Larva	Nigeria	Harris (1962)
	Sesamia spp.	Larva	West Africa	Brenière (1983)
	Sesamia sp.	Larva	Sierra Leone	Jordan (1966)
Cotesia sp.	*Chilo zacconius*	NM	Senegal	Appert (1952), Vercambre (1977)
Dolichogenidea aethiopica	*Chio zacconius*	Larva	Côte d'Ivoire, Sierra Leone	Achterberg and Polaszek (1996)
Dolichogenidea oryzae	*Chilo aleniellus*	Larva	Sierra Leone	Jordan (1966)
	Chilo diffusilineus	Larva	Côte d'Ivoire	Walker (1994)
	Chilo zacconius	Larva	Côte d'Ivoire, Niger, Senegal	Walker (1994)
Dolichogenidea polaszeki	*Sesamia* spp.	Larva	Benin, Ghana, Nigeria	Achterberg and Polaszek (1996)
Iphiaulax dubiotusus	*Chilo zacconius*	Larva	Senegal	Achterberg and Polaszek (1996)
Iphiaulax sp.	Stem borers	Larva	Nigeria	Jerath (1965)
Mesobraconoides psolopterus	*Maliarpha separatella*	Larva	West Africa	Polaszek et al (1994)
		Larva	Sierra Leone	Sarhan and Quicke (1990)
Opius annulicornis	*Diopsis apicalis*	Pupa	Cameroon	Risbec (1956)
	Diopsis macrophthalma	Pupa	Cameroon	Descamps (1956)
	Diopsis sp.	Pupa	Cameroon	Descamps (1956)
Perilitus sp.	*Sesamia* sp.	NM	Africa	Appert (1964)
Phanerotoma saussurei	*Chilo suppressalis*	Larva	Nigeria	Akinsola (1979)
		Larva	Sierra Leone	Jordan (1966), Brenière (1969), Grist and Lever (1969)
		Larva	West Africa	Agyen-Sampong (1979), Akinsola and Agyen-Sampong (1984)
	Chilo zacconius	Larva	Benin, Mali, Senegal, Sierra Leone	Achterberg and Walker (1998)
	Sesamia cretica	Larva	Senegal	Appert (1952)
	Maliarpha separatella	Larva	Côte d'Ivoire	Pollet (1978a, 1981)
		Larva	Senegal	Brenière (1969)
		NM	Senegal	Vercambre (1977)
		Larva	West Africa	Akinsola and Agyen-Sampong (1984)
	Stem borers	Larva	Nigeria	Bess (1972)
Phanerotoma sp.	*Maliarpha separatella*	Larva	Africa	Brenière (1983)
		Larva	Mali	Brenière (1969)
Rhaconotus carinatus	*Chilo zacconius*	Larva	West Africa	Polaszek et al (1994)
	Maliarpha separatella	Larva	Cameroon, Ghana, Nigeria, Senegal, Sierra Leone, Togo	Polaszek et al (1994)
		Larva	Côte d'Ivoire	Pollet (1981)
Rhaconotus scirpophagae	*Chilo* sp.	Larva	Nigeria	Jerath (1965)
	Coniesta ignefusalis	NM	Africa	Risbec (1960), Mohyuddin and Greathead (1970)
	Maliarpha separatella	Larva	Nigeria	Akinsola (1979)
		Larva	Senegal	Brenière (1969)

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Table 6 continued.

Natural enemy	Host(s)	Stage(s) attacked	Country/ continent	Reference(s)
Rhaconotus scirpophagae (continued)	*Maliarpha separatella* (continued)	Larva	West Africa	Agyen-Sampong (1979), Akinsola and Agyen-Sampong (1984), Polaszek et al (1994)
		Larva	Côte d'Ivoire, Ghana, Nigeria, Senegal, Sierra Leone	Achterberg and Polaszek (1996)
	Scirpophaga sp.	Larva	West Africa	Polaszek et al (1994)
	Stem borers	Larva	Sierra Leone	Nickel (1964)
Rhaconotus sp.	*Chilo* sp.	Larva	West Africa	Brenière (1969), Akinsola and Agyen-Sampong (1984)
		Larva	Sierra Leone	Jordan (1966)
	Chilo zacconius	NM	Senegal	Vercambre (1977)
	Maliarpha separatella	Larva	Côte d'Ivoire	Pollet (1978a)
		NM	Senegal	Vercambre (1977)
		Larva	Sierra Leone	Jordan (1966)
	Stem borers	Larva	Nigeria	Bess (1972)
Rhaconotus nr. *sudanensis*	*Chilo* sp.	Larva	Sierra Leone	Jordan (1966)
	Chilo zacconius	Larva	Senegal	Appert (1952), Nickel (1964)
	Maliarpha separatella	Larva	Sierra Leone	Jordan (1966), Brenière (1969)
Stenobracon rufus	*Coniesta ignefusalis*	Larva	Nigeria	Harris (1962), Mohyuddin and Greathead (1970)
	Sesamia calamistis	Larva	Côte d'Ivoire	Achterberg and Polaszek (1996*)*
	Chilo zacconius	NM	Senegal	Vercambre (1977)
Syenobracon unifasciatus	*Chilo* sp.	Larva	Sierra Leone	Jordan (1966)
	Coniesta ignefusalis	Larva	Nigeria	Harris (1962)
Tropobracon antennatus	*Chilo aleniellus*	Larva	Sierra Leone	Jordan (1966)
	Maliarpha separatella	Larva	West Africa	Polaszek et al (1994)
	Stem borers	Larva	Nigeria	Bess (1972)
	Stem borers	Larva	Cameroon, Côte d'Ivoire, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo	Achterberg and Polaszek (1996)
Tropobracon sp.	*Sesamia* sp.	Larva	Sierra Leone	Jordan (1966)
Tropobracon sp. nr. *schoenobii*	*Maliarpha separatella*	Larva	Sierra Leone	Jordan (1966), Brenière (1969)
	Sesamia sp.	Larva	Sierra Leone	Jordan (1966)
Chalcididae				
Brachymeria feae	*Sesamia calamistis*	Pupa	Nigeria	Harris (1962), Appert (1964), Rao and Nagaraja (1969)
Brachymeria sp.	*Chilo diffusilineus*	NM	Burkina Faso	Bonzi (1982)
Dirhinus garouae	*Diopsis longicornis*	NM	Cameroon	Descamps (1956)
Psilochalcis soudanensis	*Chilo partellus*	Pupa	Nigeria	Neupane (1982)
	Chilo zacconius	NM	Cameroon, Senegal	Brenière (1969)
		NM	Cameroon	Risbec (1956)
		Larva/pupa	Senegal	Nickel (1964)
	Coniesta ignefusalis	Pupa	Nigeria	Appert (1964), Harris (1962)
	Eldana saccharina	Pupa	Africa	Betbeder-Matibet (1981)
Psilochalcis sp. A	*Eldana saccharina*	Pupa	Africa	Betbeder-Matibet (1981)
	Maliarpha separatella	Larva/pupa	Cameroon, Ghana, Mali, Niger, Nigeria, Senegal	Polaszek et al (1994)
Diapriidae				
Galesus silvestrii	*Diopsis longicornis*	NM	Cameroon	Descamps (1956)
Trichopria oriphila	*Diopsis apicalis*	Pupa	Cameroon	Risbec (1956)
Trichopria sp.	*Diopsis* spp.	Pupa	Ghana	Agyen-Sampong (1977b)
Elasmidae				
Elasmus sp. A	*Maliarpha separatella*	NM	Senegal	Polaszek et al (1994)
Eulophidae				
Aprostocetus brevistylus	*Diopsis longicornis*	Pupa	Benin, Burkina Faso, Cameroon Côte d'Ivoire Liberia, Mali Nigeria, Senegal Sierra Leone	Brenière (1983)
Aprostocetus procerae	*Chilo zacconius*	NM	Senegal	Brenière (1969)

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Table 6 continued.

Natural enemy	Host(s)	Stage(s) attacked	Country/ continent	Reference(s)
Aprostocetus sp.	*Diopsis longicornis*	Pupa	Sierra Leone	Jordan (1966)
	Diopsis spp.	Pupa	Ghana	Agyen-Sampong (1977b)
Neotrichoporoides confusus	*Diopsis longicornis*	Larva	Cameroon	Schulten and Feijen (1984b)
Neotrichoporoides diopsis	*Diopsis longicornis*	Larva/pupa	Cameroon	Descamps (1956)
	Diopsis servillei	Pupa	Cameroon	Risbec (1956)
Neotrichoporoides flavobrunneus	*Diopsis ichneumonea*	Pupa	Cameroon	Schulten and Feijen (1984b)
Pediobius dipterae	*Diopsis longicornis*	Pupa	Cameroon	Descamps (1956)
Pediobius furvus	*Busseola fusca*	Pupa	Nigeria	Harris (1962)
	Coniesta ignefusalis	Pupa	Nigeria	Harris (1962), Appert (1964)
	Sesamia calamistis	Larva	Cameroon, Niger, Nigeria, Senegal, Côte d'Ivoire	Brenière (1983)
		NM	Cameroon	Appert (1971b)
	Sesamia spp.	Pupa	Cameroon	Descamps (1956), Nickel (1964)
		Pupa	Nigeria	Harris (1962), Appert (1964)
		Pupa	Sierra Leone	Jordan (1966)
Pediobius sp.	*Sesamia calamistis*	NM	Senegal	Vercambre (1977)
Tetrastichus atriclavus	*Coniesta ignefusalis*	Pupa	Nigeria	Harris (1962), Appert (1964), Grist and Lever (1969)
	Busseola fusca	Pupa	Nigeria	Harris (1962), Appert (1964), Mohyuddin and Greathead (1970)
	Eldana saccharina	Pupa	Africa	Betbeder-Matibet (1981)
	Sesamia sp.	Pupa	Nigeria	Harris (1962), Nickel (1964)
Tetrastichus risbeci	*Diopsis apicalis*	Pupa	Cameroon	Schulten and Feijen (1984b)
Tetrastichus sesamiae	*Chilo zacconius*	Larva	Cameroon	Descamps (1956), Grist and Lever (1969)
	Diopsis longicornis	NM	Cameroon	Descamps (1956)
	Diopsis servillei	Pupa	Cameroon	Risbec (1956)
	Sesamia calamistis	NM	Senegal	Appert (1952)
	Sesamia spp.	NM	Cameroon	Descamps (1956)
Tetrastichus soudanensis	*Chilo zacconius*	NM	Senegal	Brenière (1969)
Tetrastichus sp.	*Diopsis longicornis*	Pupa	Cameroon	Descamps (1956)
		Pupa	Sierra Leone	Agyen-Sampong (1979)
	Diopsis sp.	Pupa	West Africa	Agyen Sampong (1979), Akinsola and Agyen-Sampong (1984)
Tetrastichus variabilis	*Diopsis longicornis*	Larva	Cameroon	Schulten and Feijen (1984a)
Trichospilus vorax	*Eldana saccharina*	Pupa	Africa	Betbeder-Matibet (1981)
Eupelmidae				
Eupelmella predatoria	*Diopsis longicornis*	Pupa	Cameroon, Benin	Descamps (1956)
		Pupa	Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Liberia, Mali, Nigeria, Senegal, Sierra Leone	Brenière (1983), Risbec (1956)
Eupelmus sp.	*Busseola fusca*	Larva/pupa	Nigeria	Harris (1962), Appert (1964)
Macroneura sp.	*Maliarpha separatella*	NM	Senegal	Polaszek et al (1994)
Eurytomidae				
Eurytoma diopsisi	*Diopsis longicornis*	Pupa	Cameroon	Descamps (1956)
Eurytoma oryzivora	*Adelpherupa* sp.	Larva	Cameroon	Descamps (1956)
	Chilo sp.	Larva	Sierra Leone	Jordan (1966)
	Chilo zacconius	Larva	Cameroon	Risbec (1956), Nickel (1964)
		Pupa	Cameroon	Descamps (1956), Nickel (1964)
	Eldana saccharina	NM	Africa	Betbeder-Matibet (1981)
	Maliarpha separatella	NM	Cameroon, Senegal, Sierra Leone	Polaszek et al (1994)
		Larva	Sierra Leone	Jordan (1966)
Ichneumonidae				
Amauromorpha sp. A	*Maliarpha separatella*	NM	Togo	Polaszek et al (1994)
Charops sp.	*Chilo diffusilineus*	NM	Senegal	Appert (1964)
	Chilo zacconius	NM	Cameroon	Descamps (1956)
		Pupa	Senegal	Appert (1952)
		NM	Senegal	Brenière (1969)
Charops nr. *spinitarsus*	*Sesamia* sp.	Larva	Nigeria	Jerath (1965)
Dentichasmias busseolae	*Sesamia* sp.	NM	Sierra Leone	Heinrich (1968)

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Table 6 continued.

Natural enemy	Host(s)	Stage(s) attacked	Country/ continent	Reference(s)
Gambroides nimbipennis-complex	*Maliarpha separatella*	Egg	Ghana	Agyen-Sampong (1977a)
		Larva	West Africa	Agyen-Sampong (1980)
		Larva/pupa	Sierra Leone	Jordan (1966)
		Larva/pupa	West Africa	Polaszek et al (1994)
Pristomerus africator	*Maliarpha separatella*	Larva	Côte d'Ivoire, Senegal, Sierra Leone	Polaszek et al (1994)
Pristomerus sp.	*Maliarpha separatella*	Larva	Sierra Leone	Jordan (1966)
Syzeuctus sp.	*Busseola fusca*	Larva	Nigeria	Harris (1962), Appert (1964), Grist and Lever (1969)
	Chilo sp.	Larva	Sierra Leone	Jordan (1966)
	Coniesta ignefusalis	Larva	Nigeria	Harris (1962), Appert (1964), Grist and Lever (1969)
	Maliarpha separatella	Larva	Nigeria	Akinsola (1979)
	Eldana saccharina	Larva	Africa	Betbeder-Matibet (1981)
Syzeuctus sp. B	*Chilo zacconius*	Larva	Sierra Leone	Zwart (1998)
	Maliarpha separatella	Larva	Côte d'Ivoire, Nigeria	Zwart (1998)
Venturia jordanae	*Maliarpha separatella*	Larva	Côte d'Ivoire, Sierra Leone	Agyen-Sampong (1980), Polaszek et al (1994)
		Larva	Sierra Leone	Jordan (1966), Grist and Lever (1969), Brenière (1969)
		NM	Sierra Leone	Appert (1970)
Venturia sp. A.	*Sesamia* spp.	Larva	Sierra Leone	Zwart (1998)
Pteromalidae				
Dinarmus	*Adelpherupa* sp.	Larva/pupa	Cameroon	Descamps (1956), Nickel (1964)
Norbanus sp.	*Sesamia* sp.	Larva/pupa	Nigeria	Harris (1962), Appert (1964)
Scelionidae				
Telenomus applanatus	*Maliarpha separatella*	Egg	Côte d'Ivoire	Bin and Johnson (1982)
Telenomus bini	*Maliarpha separatella*	Egg	Côte d'Ivoire, Ghana, Senegal	Polaszek et al (1994)
Telenomus busseolae	*Busseola fusca*	Egg	Nigeria	Harris (1962), Appert 1964
	Sesamia sp.	Egg	Cameroon	Descamps (1956)
Telenomus creusa	*Chilo diffusilineus*	Egg	NM	Polaszek and Kimani (1990)
Telenomus nephele	*Scirpophaga subumbrosa*	Egg	Ghana	Agyen-Sampong (1977b)
		Egg	West Africa	Akinsola and Agyen-Sampong (1984)
			Cameroon	Descamps (1956)
	Scirpophaga spp.	Egg	Cameroon, Côte d'Ivoire, Ghana, Mali, Senegal	Polaszek and Kimani-Njogu (1998)
Telenomus sp.	*Eldana saccharina*	Egg	Africa	Betbeder-Matibet (1981)
	Maliarpha separatella	Egg	West Africa	Brenière (1983), Akinsola and
Telenomus sp. nr. *dignusi*	*Maliarpha separatella*	Egg	West Africa	Agyen-Sampong (1984)
Telenomus soudanensis	*Chilo zacconius*	NM	Senegal	Brenière (1969)
Telenomus thestor	*Scirpophaga subumbrosa*	Egg	Ghana, Côte d'Ivoire, Mali	Brenière (1983)
Telenomus versicolor	*Scirpophaga melanoclista*	Egg	Côte d'Ivoire	Bin and Johnson (1982)
Trichogrammatidae				
Lathromeris ovicida	*Chilo auricilius*	Egg	Ghana	Rao and Rao (1980)
	Chilo zacconius	Egg	West Africa	Polaszek et al (1994)
	Maliarpha separatella	Egg	West Africa	Akinsola and Agyen-Sampong (1984), Akinsola (1979)
		Egg	Benin, Cameroon, Côte d'Ivoire, Ghana, Nigeria	Polaszek et al (1994)
	Scirpophaga subumbrosa	Egg	Ghana	Agyen-Sampong (1977b)
	Sesamia calamistis	Egg	West Africa	Polaszek et al (1994)
Trichogramma aethiopicus	*Chilo zacconius*	Egg	Cameroon	Risbec (1956)
	Diopsis longicornis	Egg	West Africa	Brénière (1983)
Trichogramma ethiopicum	*Chilo zacconius*	Egg	Cameroon	Descamps (1956), Nickel (1964), Brenière (1969)

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Table 6 continued.

Natural enemy	Host(s)	Stage(s) attacked	Country/ continent	Reference(s)
Trichogramma ethiopicum (continued)	*Diopsis longicornis*	Egg	Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Liberia, Mali, Nigeria, Senegal, Sierra Leone	Brénière (1983)
	Scirpophaga sp.	Egg	Cameroon	Descamps (1956), Nickel (1964)
Trichogramma japonicum	*Scirpophaga subumbrosa*	Egg	Ghana	Agyen-Sampong (1977b)
Trichogramma nr. *kalkae*	*Diopsis longicornis*	NM	Nigeria	Joshi et al (1991)
Trichogramma sp.	*Diopsis* spp.	Egg	Ghana	Agyen-Sampong (1977b)
ACARI (MITES)				
Pyemotidae				
Pyemotes ventricosus	*Coniesta ignefusalis*	Larva	Nigeria	Harris (1962)
NEMATODA				
Mermithidae				
Hexamermis sp.	*Eldana saccharina*	Larva	Côte d'Ivoire	Poinar (1998), Polaszek (1998a,b)
Mermis sp.	*Coniesta ignefusalis*	Larva	Senegal	Polaszek (1998a,b)
BACTERIA				
Bacillus thuringiensis	*Busseola fusca*	Larva	Nigeria	Harris (1962)
FUNGI				
Aspergillus flavus	*Busseola fusca*	Larva/pupa	Nigeria	Harris (1962)
Aspergillus sydowi	*Busseola fusca*	Pupa	Nigeria	Harris (1962)
Metarrhizium anisopliae	*Coniesta ignefusalis*	Larva	Nigeria	Harris (1962)
PROTOZOA				
Nosema manierae	*Chilo zacconius*	NM	Africa	Toguebaye and Bouix (1983), Rombach (1987)
VIRUS				
Cytoplasmic polyhedrosis	*Maliarpha separatella*	Larva	Côte d'Ivoire	Pollet (1981)

[a]NM= stage attacked not mentioned in the literature.

Of the coccinellids (Table 8), *Cheilomenes lunata* F. (Fig. 259) is a predator of aphids in South Africa (Brown 1972). A related species, *C. sexmaculata* (F.) feeds on rice planthoppers and leafhoppers in India (Parasuraman 1989). *Micraspis* spp. are reported as predators of rice leafhoppers in Bangladesh (Ahad et al 1995), brown planthoppers, *N. lugens* in Indonesia, and on noctuid eggs in the Philippines (van den Berg et al 1992). *Scymnus* spp. have been reported as feeding on eggs and young nymphs of mealybugs (Tranfaglia and Viggiani 1972). The staphylinid beetle, *Paederus fuscipes* Curtis (Fig. 200) is a common predator in rice fields in the Philippines, which feeds on many hosts including noctuid eggs (van den Berg et al 1992), newly hatched stem borer larvae, brown planthopper nymphs and adults, and green leafhoppers (Ooi and Shepard 1994). In China, it is a polyphagous predator feeding on rice leafhoppers, planthoppers, leafrollers, lepidopterous defoliators, and thrips (Luo et al 1990) and is considered as the third most important predator in rice fields as based on populations and predation efficiency (Gu et al 1989).

Dermaptera. Earwigs (Dermaptera) are abundant in West African rice fields. Two dermapteran species in the family Labiduridae (Table 8) are *Euborellia annulipes* (Lucas) (Fig. 108) and *Labiduria riparia* Pallas (Fig. 109). *Euborellia annulipes* generally feeds on plant material and occasionally preys on insects including lepidopterous larvae (El-Husseini and Tawfik 1971). *Labiduria riparia,* a widely distributed species, has a broad host range and its prey includes lepidopterous eggs, larvae, and pupae (Tawfik et al 1973). It is the most prominent predator collected from pitfall traps located in South African groundnut fields (van Eeden et al 1995). *Labiduria riparia* is considered as an excellent biological control agent for arthropod pests in row crops in the USA (Kharboutli and Mack 1993) where its prey includes small larvae of the velvetbean caterpillar, *Anticarsia gemmatalis* Hübner, in soybean fields (Godfret et al 1989) and pupae of the armyworm, *Spodoptera frujiperda* (J.E. Smith), in maize fields (Pair and Gross 1989). In Asia, *Euborellia stali* (Dohrn) preys on stem borer larvae in tunnels within the rice stem and on leaffolder larvae within folded leaves (Shepard et al 1991).

Hemiptera. Numerous hemipteran predators have been collected in West African rice fields. These include the families Gelastocoridae, Lygaeidae, Miridae, Nabidae, Ochteridae, and Reduviidae (Table 8*).*
The lygaeid *Geocoris* sp. preys on larvae of the rice

Table 7. Parasitoids of rice-feeding insects, other than stem borers, in West Africa.

Natural enemy	Host	Stage(s) attacked	Country	Reference
Diptera				
Pipunculidae				
Tomosvaryella singula	*Tettigoniella albida*	Larva	Cameroon	Descamps (1956)
Tachinidae				
Cuphocera varia	*Cirphis loreyi*	Larva	Cameroon	Descamps (1956)
Eucarcelia evolans	*Rigema ornata*	Larva	Cameroon	Descamps (1956)
Theocarcelia pelmatoprocta	*Gegenes niso*	Larva	Cameroon	Descamps (1956)
	Pelopidas mathias	Larva	Cameroon	Descamps (1956)
Platymya anomala	*Cirphis loreyi*	Larva	Cameroon	Descamps (1956)
Pseudoperichaeta laevis	*Pelopidas mathias*	Larva	Cameroon	Descamps (1956)
Stomatomyia acuminata	*Ancylolomia uniformella*	Larva	Cameroon	Descamps (1956)
Hymenoptera				
Braconidae				
Apanteles aethiopicus	*Diacrisia scotillum*	Pupa	Cameroon	Descamps (1956)
	Laphygma exigua	Larva	Cameroon	Descamps (1956)
Apanteles osinis	*Cirphis loreyi*	Larva	Cameroon	Descamps (1956)
Apanteles procerae	*Diacrisia scotillum*	Pupa	Cameroon	Descamps (1956)
Meteorus testaceus	*Marasmia trapezalis*	Larva	Cameroon	Descamps (1956)
Chalcididae				
Brachymeria albisquama	*Brachmia* sp.	Pupa	Cameroon	Descamps (1956)
Brachymeria globata	*Gegenes niso*	Pupa	Cameroon	Descamps (1956)
	Pelopidas mathias	Larva/pupa	Cameroon	Descamps (1956)
Brachymeria olethrius	*Marasmia trapezalis*	Pupa	Cameroon	Descamps (1956)
Brachymeria sesamiae	*Pelopidas mathias*	Larva/pupa	Cameroon	Agyen-Sampong(1980)
Encyrtidae				
Goencyrtus epulus	*Chnootriba similis*	Egg	Cameroon	Agyen-Sampong(1980)
Paralitomastix polyphaga	*Chnootriba similis*	Egg	Cameroon	Descamps (1956)
Eulophidae				
Aplastomorpha camerunus	*Orseolia oryzivora*	Larva	Cameroon	Brenière (1969)
Euplectrus laphygmae	*Laphygma exigua*	Larva	Cameroon	Descamps (1956)
Nioro elegantula	*Brachmia* sp.	Larva	Cameroon	Descamps (1956)
Pediobius telenomis	*Pelopidas mathias*	NM[a]	Cameroon	Agyen-Sampong (1980)
Pediobius sp.	*Orseolia oryzivora*	NM	Cameroon	Vercambre (1977)
Pleurotropis mediopunctata	*Chnootriba similis*	Larva	Cameroon	Descamps (1956)
Tetrastichus cydoniae	*Chnootriba similis*	Larva	Cameroon	Descamps (1956)
Tetrastichus pachydiplosisae	*Orseolia oryzivora*	Larva	Cameroon	Brenière (1969)
Tetrastichus sesamiae	*Diacrisia scotillum*	Pupa	Cameroon	Descamps (1956)
	Ancylolomia uniformella	Pupa	Cameroon	Descamps (1956)
Tetrastichus sp.	*Orseolia oryzivora*	NM	Cameroon	Vercambre (1977)
Eurytomidae				
Eurytoma syleptae	*Marsamia trapezalis*	Larva	Cameroon	Descamps (1956)
	Pelopidas mathias	Pupa	Cameroon	Descamps (1956)
Ichneumonidae				
Charops spinitarsus	*Pelopidas mathias*	Larva	Sierra Leone	Agyen-Sampong (1980)
Ischnojoppa flavipennis	*Pelopidas mathias*	Larva	Sierra Leone	Agyen-Sampong (1980)
Mymaridae				
Gonatocerus africanus	*Tettigoniella albida*	Egg	Cameroon	Descamps (1956)
Disophrys lutea	*Laphygma exigua*	Larva	Cameroon	Descamps (1956)
Platygasteridae				
Platygaster diplosisae	*Orseolia oryzivora*	Larva	Cameroon	Descamps (1956)
Scelionidae				
Hadronotus antestiae	*Aspavia armigera*	Egg	Cameroon	Descamps (1956)
	Agnoscelis versicolor	Egg	Cameroon	Descamps (1956)
Microphanurus aliferti	*Dalsira modesta*	Egg	Cameroon	Descamps (1956)
Microphanurus danaus	*Scotinophara* sp.	Egg	Cameroon	Descamps (1956)
Microphanurus descampsi	*Durmia haedula*	Egg	Cameroon	Descamps (1956)
Microphanurus mopsus	*Durmia haedula*	Egg	Cameroon	Descamps (1956)
Platyscelio sp.	*Conocephalus conocephalus*	Egg	Sierra Leone	Agyen-Sampong (1980)

continued on next page

Table 7 continued.

Natural enemy	Host	Stage(s) attacked	Country	Reference
Scelionidae (continued)				
Telenomus sp.	*Conocephalus conocephalus*	Egg	Sierra Leone	Agyen-Sampong (1980)
Telenomus corani	*Leptocorisa apicalis*	Egg	Cameroon	Descamps (1956)
Trichogrammatidae				
Trichogramma aethiopicus	*Gegenes niso*	Egg	Cameroon	Descamps (1956)
	Diacrisia scotillum	Egg	Cameroon	Descamps (1956)
	Lema sp.	Egg	Cameroon	Descamps (1956)

[a]NM = stage attacked not mentioned in the literature cited.

caseworm, *Nymphula depunctalis*, in the Philippines (Litsinger et al 1994b). Mirids are important predators of rice insect pests in Asia. *Cyrtorhinus lividipennis* Reuter (Miridae) feeds on the eggs and small nymphs of leafhoppers and planthoppers (Shepard et al 1991). The importance of *C. rectangulus* Ghauri (Fig. 426) (Table 8) as a predator of rice-feeding insects in West Africa has not been determined. Several species of Reduviidae, the assassin bugs, occur in rice (Table 8). A *Coranus* sp. is predaceous on leafhoppers on a variety of crops in India (Singh et al 1993), and a *Rhinocoris* species is predaceous on the cotton stainer, *Dysdercus* spp. (Ambrose and Kumaraswami 1990).

Orthoptera. Of the orthopteran species, crickets (Gryllidae) are abundant in pitfall traps and long-horned grasshoppers (Tettigoniidae) are abundant in sweep net collections. The cricket, *Metioche* sp. (Fig. 125, Table 8) is among a group of *Metioche* species that is believed to be predaceous on rice insects. Adults and nymphs of *M. vittaticollis* (Stål) prey on a wide range of rice insects including stem borer and leaffolder eggs and leafhopper nymphs (Shepard et al 1991). Tettigoniids of the genus *Conocephalus* (Figs. 119–122) feed on rice but are also predators of rice enemies. In Asia, *C. longipennis* (de Haan) is a phytophagous feeder on rice leaves and panicles and is a predaceous feeder on stink bugs, stem borer larvae, and leafhopper nymphs (Shepard et al 1991) and on noctuid eggs (van den Berg et al 1992).

Hymenoptera. Ants (Hymenoptera: Formicidae) are extremely abundant in upland rice in West Africa. Species collected in pitfall traps in upland rice at WARDA (identified by H.G. Robertson, South African Museum, Capetown) include *Camponotus sericeus* (F.), *Camponotus* sp. (*maculatus*-group), *Dorylus* sp., *Odontomachus troglodytes* Santschi, *Pachycondyla caffraria* (F. Smith), *P. sennaarensis* Mayr, and *P. tarsata* (F.). Ant activity, as indicated by pitfall trapping in upland rice on the continuum toposequence at WARDA, occurs throughout the crop period and increases at harvest (Fig. 79, E.A. Heinrichs, WARDA, 1996, unpubl. data). Ground-dwelling ants are most active in the drier portion of the continuum toposequence with activity being highest in the upland 1 and 2 zones and dropping to low levels in the wetter hydromorphic 2 zone, next to the lowland irrigated zone (Fig. 80, E.A. Heinrichs, WARDA, 1996, unpubl. data).

Predaceous spiders. Spider populations are extremely high in both irrigated and upland rice in West Africa. Among the most abundant surface spiders in upland rice fields at the WARDA M'bé farm, based on pitfall trap activity (Oyediran et al 2000b), are several Lycosidae including the species *Pardosa injucunda* (O.P.-Cambridge) (Fig. 522). This species is active in upland rice throughout the crop period but is most active at harvest time (Fig. 81, E.A. Heinrichs, WARDA, 1996, unpubl. data). It is active at all zones of the continuum toposeqence but is most active in the drier zones, upland 1 and upland 2 (Fig. 82, E.A. Heinrichs, WARDA, 1996, unpubl. data).

Ly (1978) conducted a detailed study on the abundance of spider species in irrigated rice fields in Côte d'Ivoire (Table 9). The sweep net and the visual count methods proved to be the most efficient for estimating populations. Of the more than 30 species collected, several lycosid species, a thomisid, *Runcinia*; the araneid *Argiope trifasciata* (Forskal); the tetragnathids, *Leucauge* sp. (Fig. 577), and *Tetragnatha jaculator* Tullgren (Fig. 570); and the theridid, *Theridion* sp., were the most abundant. Observations based on visual counts at different growth stages of irrigated rice indicated that spiders are abundant throughout all crop growth stages (Ly 1978).

Parasitoids

Information is lacking on the importance of the various natural enemy species and their role in the biological control of West African rice-feeding insects. The few reports that are available concern parasitoids and they indicate that parasitism plays a major role in the regulation of rice insect pest populations. Parasitoids collected in West African rice fields are in the orders Hymenoptera and Strepsiptera (Table 8, E.A. Heinrichs and A.T. Barrion, Côte d'Ivoire, 1996, unpubl. data). Hymenopteran families include braconids, chalcidids, eulophids, ichneumonids, a platygasterid, and a scoliid.

The eulophid, *Aprostocetus procerae* (Risbec) (=*A. pachydiplosisae* Risbec; LaSalle and Delvare 1994)

Table 8. Potential predators and parasitoids of rice insect pests collected in rice fields in West Africa (E.A. Heinrichs and A.T. Barrion, WARDA, 1996, unpubl. data).

Order	Family	Species
PREDATORS		
Coleoptera	Anthicidae	*Anthicus* sp. (Fig. 238)
		Formicomus sp. (Figs. 239–240)
	Carabidae	*Archicolliuris* cf. *dimidiata* Chaudoir (Fig. 180)
		Calleida sp. (Fig. 188)
		Calleida fasciata Dejean (Fig. 190)
		Cicindela luxeri Dejean (Fig. 170)
		Cicindela cf. *catena* F. (Fig. 174)
		Drypta sp. (Fig. 182)
		Eucolliuris spp. (Fig. 184)
		Odacantha sp. (Fig. 178)
		Prothymus cf. *versicolor* Dejean (Fig. 169)
	Coccinellidae	*Cheilomenes lunata* F. (Fig. 259)
		Chilocorus sp. (Fig. 255)
		Micraspis sp. (Fig. 252)
		Micraspis cf. *vincta* (Gorham) (Fig. 254)
		Scymnus sp. (Fig. 251)
		Xanthadalia effusa Erichson (Fig. 256)
	Staphylinidae	*Paederus fuscipes* Curtis (Fig. 200)
Dermaptera	Labiduridae	*Euborellia annulipes* (Lucas) (Fig. 108)
		Labiduria riparia Pallas (Fig. 109)
Hemiptera	Gelastocoridae	*Nerthra grandicollis* Germar (Fig. 380)
	Lygaeidae	*Geocoris* sp. (Fig. 457)
	Miridae	*Proboscidocoris fuliginosus* Reuter (Fig. 424)
		Cyrtorhinus rectangulus Ghauri (Fig. 426)
	Nabidae	*Arbela* sp. (Fig. 427)
		Gorpis sp. (428)
		Stenonabis sp. (Fig. 433)
		Stenonabis conspurcatus Reuter (Fig. 432)
	Ochteridae	*Ochtera* sp. (Fig. 378)
	Reduviidae	*Coranus palliadus* Reuter (Fig. 421)
		Coranus varipes Stål (Fig. 419)
		Hediocoris tibialis Stål (Fig. 416)
		Nagusta sp. (Fig. 410)
		Peprius nodulipes Signoret (Fig. 411)
		Rhinocoris albopilosus Signoret (Fig. 422)
		Rhinocoris segmentarius Germar (Fig. 423)
		Sphedanolestes spp. (Figs. 414–415)
		Sphedanolestes picturellus Schouteden (Fig. 413)
		Vestula obscuripes Stål (Fig. 418)
Hymenoptera	Formicidae	*Anoplolepis* sp. (Fig. 462)
Mantodea	Hymenopodidae	*Pseudocreobotra* sp. (Fig. 167)
Odonata	Coenagrionidae	*Agriocnemis* sp. (Fig. 102)
		Pseudagrion sp. (Fig. 105)
	Lestidae	*Lestes* sp. (Fig. 101)
	Libellulidae	*Palpopleura* sp. (Fig. 100)
Orthoptera	Gryllidae	*Metioche* sp. (Fig. 125)
	Tettigoniidae	*Conocephalus conocephalus* L. (Fig. 120)
		Conocephalus maculatus maculatus (Le Guillou) (Fig. 119)
PARASITOIDS		
Hymenoptera	Braconidae	*Bracon* sp. (Fig. 498)
		Cotesia sesamiae Cameron (Fig. 495)
		Habrobracon sp. (Fig. 504)
		Phanerotoma sp. (Fig. 493)
		Stenobracon deesae (Cameron) (Fig. 502)
	Chalcididae	*Brachymeria* sp. (Fig. 466)
	Eulophidae	*Aprostocetus procerae* (Risbec) (Fig. 469)
	Ichneumonidae	*Amauromorpha* sp. (Fig. 485)
		Charops sp. (Fig. 474)
		Clatha sp. (Fig. 471)
		Coccygomimus cf. *crocatus* Tosquinet (Fig. 480)
		Ischnojoppa sp. (Fig. 473)
		Isotima sp. (Fig. 483)
		Leptobatopsis sp. (Fig. 477)
		Temelucha sp. (Fig. 489)
		Xanthopimpla flavolineata Cameron (Fig. 478)
		Xiphosomella sp. (Fig. 487)
	Platygasteridae	*Platygaster* sp. (Fig. 470)
	Scoliidae	*Campsomeris* sp. (Fig. 464)
Strepsiptera	Elenchidae	*Elenchus* sp. (Fig. 111)
	Halictophagidae	*Halictophagus* sp. (Fig. 110)

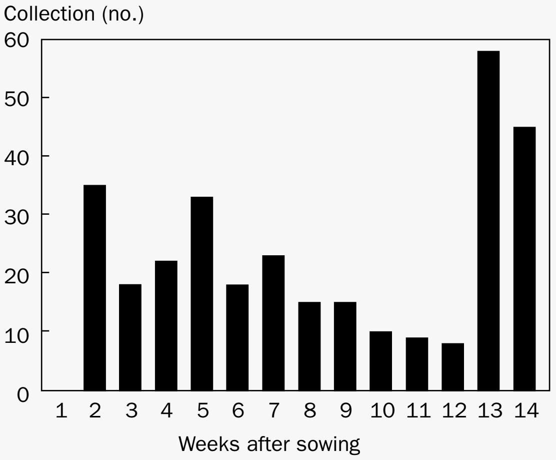


Fig. 77. Activity of ground beetles (Coleoptera: Carabidae) as indicated by the number collected in pitfall traps in upland rice variety IDSA 6 on the continuum toposequence from the upland to the hydromorphic zone (all zones combined) at indicated weeks after sowing. Plots were harvested at 13 WAS. Numbers for each week represent the collection from 24 traps (four continuum toposequence zones and three replications, each replication consisting of two traps = 168 trap d wk^{-1}) (E.A. Heinrichs, WARDA, M'bé, 1996 wet season, unpubl. data).

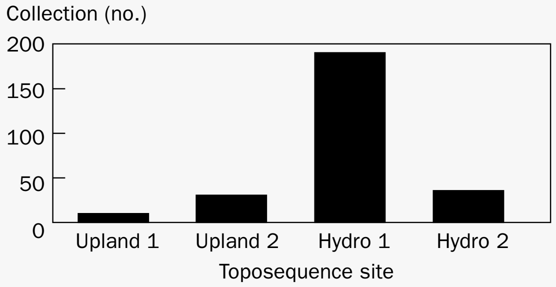


Fig. 78. Activity of ground beetles (Coleoptera: Carabidae) as indicated by the number collected in pitfall traps in upland rice variety IDSA 6 at four zones of the continuum toposequence. Numbers for each toposequence zone represent collections from six traps (three replications each consisting of two traps) over a 14-wk period (= 588 trap d) from sowing to 1 wk after harvest (E.A. Heinrichs, WARDA, M'bé, 1996 wet season, unpubl. data).

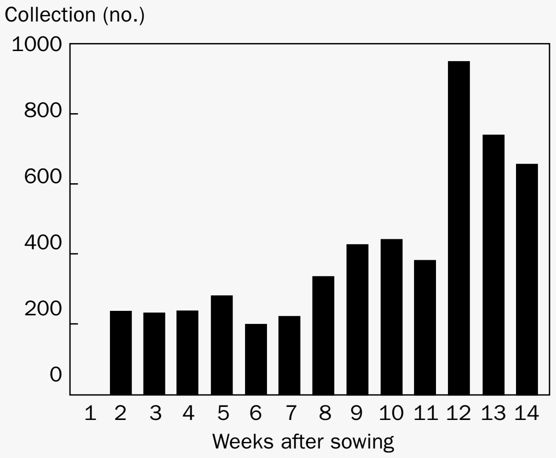


Fig. 79. Activity of ants (Hymenoptera: Formicidae) as indicated by the number collected in pitfall traps in upland rice variety IDSA 6 on the continuum toposequence from the upland to the hydromorphic zone (all zones combined) at indicated weeks after sowing. Plots were harvested at 13 WAS. Numbers for each week represent the collection from 24 traps (four continuum toposequence zones and three replications, each replication consisting of two traps = 168 trap d wk^{-1}) (E.A. Heinrichs, WARDA, M'bé, 1996 wet season, unpubl. data).

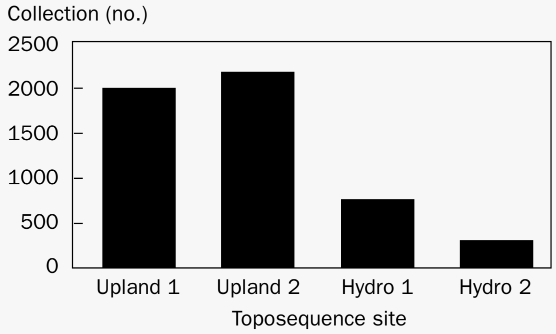


Fig. 80. Activity of ants (Hymenoptera: Formicidae) as indicated by the number collected in pitfall traps in upland rice variety IDSA 6 at four zones of the continuum toposequence. Numbers for each toposequence zone represent collections from six traps (three replications each consisting of two traps) over a 14-week period (= 588 trap d) from sowing to 1 wk after harvest (E.A. Heinrichs, WARDA, M'bé, 1996 wet season, unpubl. data).

(Figs. 468–469), and the platygasterid, *Platygaster diplosisae* Risbec (Fig. 470), are both important parasitoids of the African rice gall midge, *Orseolia oryzivora,* in West Africa. Parasitism of *O. oryzivora* by *P. diplosisae* Risbec ranged from 38 to 60% and parasitism by *T. diplosisae* was 20% in studies conducted in Cameroon (Table 10). Combined parasitism by the two species was 70% in Burkina Faso (Nacro et al 1995).

Several ichneumonids are listed in Table 8. In Asia, an *Amauromorpha* species is a parasitoid of the larvae of yellow stem borer, *Scirpophaga incertulas* (Walker), in irrigated rice (Chandramohan and Chelliah 1990, Shepard et al 1991). A *Charops* species, a *Temelucha* species, and *Xanthopimpla flavolineata* (Cameron) (Fig. 478) parasitize larvae of various stem borer species (Shepard et al 1991).

The strepsipteran families, Elenchidae and Halictophagidae, occur in West African rice ecosystems (Table 8). Strepsipterans feeding within the insect host cause sterility. Members of the genus *Elenchus* (Fig. 111) parasitize leafhoppers and planthoppers (Shepard et al 1991, Ooi and Shepard 1994). *Halictophagus* sp.

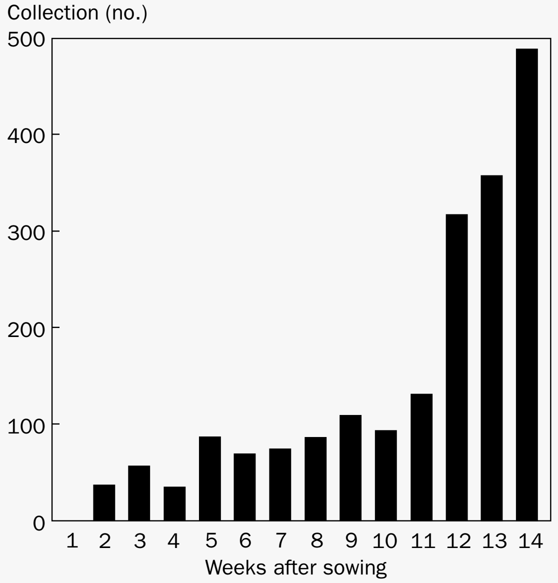


Fig. 81. Activity of the spider *Pardosa injucunda* Roewer (Araneae: Lycosidae) as indicated by the number collected in pitfall traps in upland rice variety IDSA 6 on the continuum toposequence from the upland to the hydromorphic zone (all zones combined) at indicated weeks after sowing. Plots were harvested at 13 WAS. Numbers for each week represent the collection from 24 traps (four continuum toposequence zones and three replications, each replication consisting of two traps = 168 trap d wk^{-1}) (E.A. Heinrichs, WARDA, M'bé, 1996 wet season, unpubl. data).

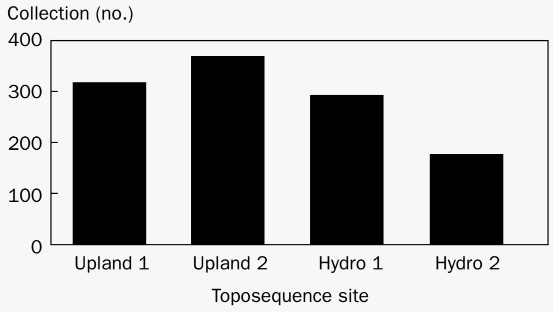


Fig. 82. Activity of the spider *Pardosa injucunda* Roewer (Araneae: Lycosidae) as indicated by the number collected in pitfall traps in upland rice variety IDSA 6 at four zones of the continuum toposequence. Numbers for each toposequence zone represent collections from six traps (three replications each consisting of two traps) over a 14-wk period (= 588 trap d) from sowing to 1 wk after harvest (E.A. Heinrichs, WARDA, M'bé, 1996 wet season, unpubl. data).

Table 9. Frequency of occurrence of the principal spider species in irrigated rice at Bouaké, Côte d'Ivoire (Ly 1978).

Family	Species	Frequency[a]
Lycosidae	Several species	++++
Thomisidae	*Runcinia depressa*	++++
Araneidae	*Argiope trifasciata*	+++
	Gea sp.	+++
	Gea infuscata	+
	Cyrtophora sp.	+
	Araneus rufipalpis	+
	Paraneus cyrtoscapus	+
	Gastercantha semiflava	+
	Ixoxya semiflexa	+
Tetragnathidae	*Leucauge* sp.	+++
	Tetragnatha jaculator	+++
	Eucta isidis	+++
Oxyopidae	*Oxyopes pallidecoloratus*	++
Salticidae	*Bianor* sp.	++
	Hyllus dotatus	++
	Hyllus sp.	++
	Plexippus sp.	++
	Marpissa sp.	++
	Paramodunda aperta	+
	Pachypoessa albimana	+
	Myrmarachne spp.	+
Clubionidae	*Cheiracanthium africanum*	++
Pisauridae	*Thalassius* sp.	++
	Dolomedes sp.	++
Drassidae	*Aphantaulax* sp.	+
Theridiidae	*Theridion* sp.	+++
	Dipoena sp.	++
Linyphiidae	*Erigone* sp.	++
Dictynidae	*Lathys* sp.	++

[a] ++++ = very frequent, +++ = common, ++ = rare, + = very rare.

(Fig. 110) parasitizes the two white leafhopper species in West Africa, *Cofana spectra* and *C. unimaculata.* In a survey conducted in farmers' fields throughout Côte d'Ivoire, *Halictophagus* parasitism of *C. spectra* averaged 21%, while that of *C. unimaculata* averaged 12% (Heinrichs 1994). In a survey conducted in Guinea, strepsipteran parasitism of *Cofana* spp. was 18% (C. Williams and E.A. Heinrichs, WARDA, 1995, unpubl. data).

Importation of foreign parasitoids. Attempts to import foreign parasitoids to control rice insect pests in Africa have been few and these attempts have apparently been unsuccessful. In 1955, the parasitoid, *Cotesia* (=*Apanteles*) *sesamiae* (Cameron), was imported to Madagascar from Mauritius to control the pink stem borer, *Sesamia calamistis*, on rice and sugarcane (Appert et al 1969). Failure was attributed to the low number of individuals released. In 1968, a new strain of the parasitoid was imported into Madagascar from Mauritania and Uganda, but the culture was lost due to rearing problems.

In 1972, the Institut de recherches agronomiques tropicales (IRAT) established a foreign parasitoid introduction program to control stem borers and gall midge in irrigated rice in the Casamance, Senegal (Vercambre 1977). Three hymenopterous species, *Tetrastichus israeli* Mani and Kurian, *Trichospilus diatraeae* Cher. and Margab., and *Itoplectis narangae* (Ashmead) were introduced to control the pupal stage of these pests, which had few naturally occurring parasites. About a half million individuals (mostly *T. israeli*) were introduced in 15 releases at two locations. *Tetrastichus israeli* was found twice on *S. calamistis*

Table 10. Effectiveness of parasites in the control of rice pests in West Africa.

Rice pest (host)	Parasite	Parasitism (%)	References
Orseolia oryzivora	*Aprostocetus procerae*	20	Brenière (1969)
	Platygaster diplosisae	38–60	Brenière (1969)
Maliarpha separatella	*Phanerotoma saussurei*	5–32	Vercambre (1977)
	and *Venturia crossicaput* (combined)	67	Agyen-Sampong (1980)
Chilo zacconius	NM[a]	8–50	Vercambre (1977)
	Coleocentrus sp., *Psilochalcis soudanensis,* and *Tetrastichus soudanensis* (combined)	25	Descamps (1956)
Adelpherupa sp.	*Eurytoma lepidopterae*	25	Descamps (1956)
	Bruchobius sp.	60	Descamps (1956)
Diacrisia scotillum	*Trichogramma aethiopicus*	60	Descamps (1956)
Tettigoniella albida	*Gonatocerus africanus*	60	Descamps (1956)
Pelopidas mathias	*Telenomus* spp. and *Pediobius telenomi*	69–95	Agyen-Sampong (1980)
Hydrellia prosternalis	*Opius* sp., gen. nr. *Peckelachertus* and gen. nr. *Cirrospilus* (combined)	77	Deeming (1977)

[a] NM = species of parasite not mentioned in the literature.

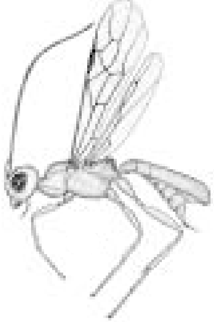
pupae at the end of 1972 near a release site. Further information on the results of these releases is not available.

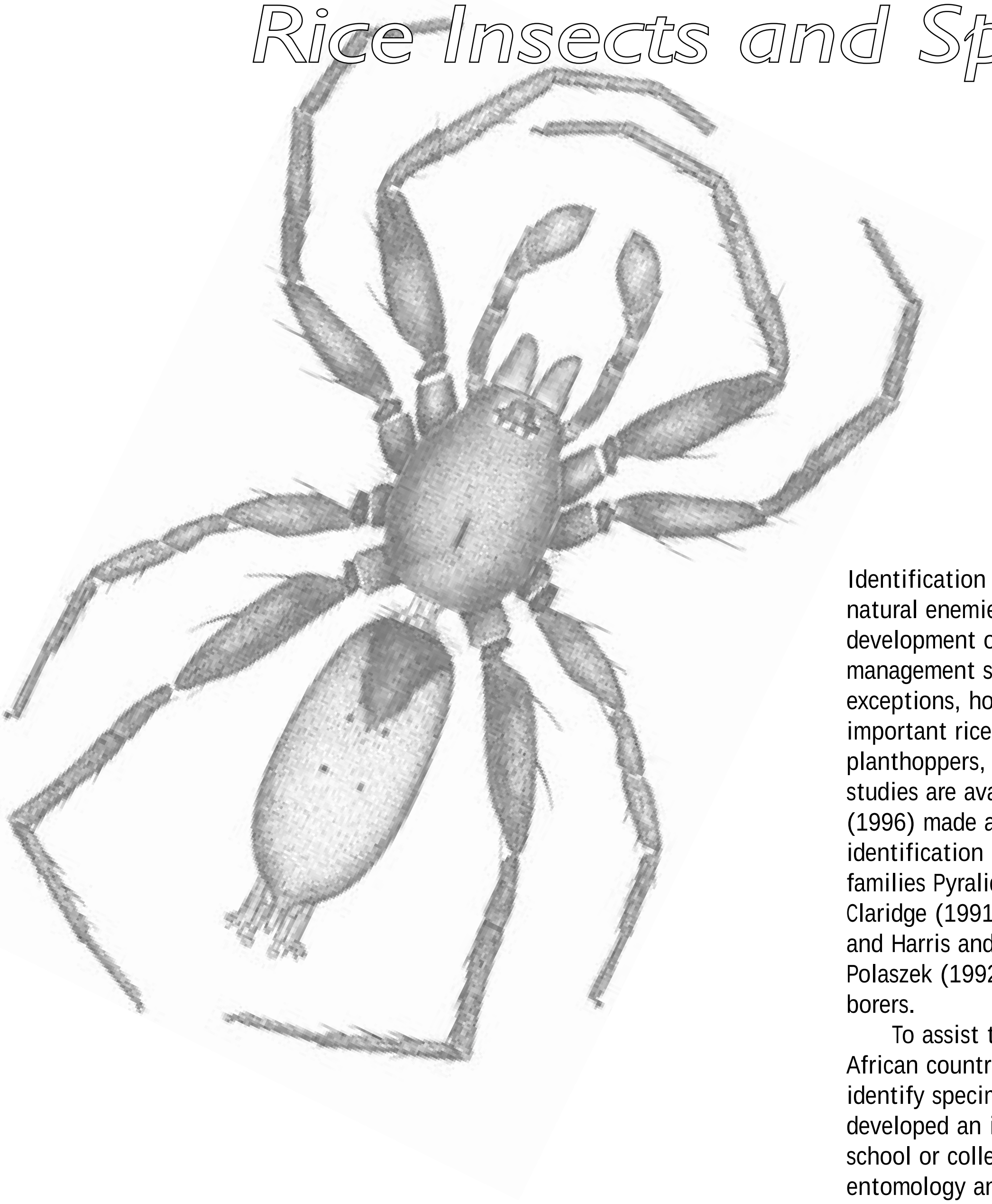
Pediobius furvus Gahan (Hymenoptera: Eulophidae) is a parasitoid of *Sesamia calamistis* in West Africa and is endemic throughout intertropical Africa. In 1968, *P. furvus* parasitoids from Uganda were released to control rice and maize stem borers in Madagascar (Appert et al 1969). The parasitoids were recaptured at a distance of 4 km from the release point, indicating that dispersal had been achieved. Further information on the establishment of this parasitoid has not been found.

Telenomus spp. are parasitoids having many characteristics that make them particularly suitable biological control agents (Polaszek and Kimani 1990). However, for classical biological control of African pyralids, the single documented case of the exportation of *T. applanatus* Bin and Johnson from Côte d'Ivoire to South Africa for control of the stem borer *Eldana saccharina* (Walker) appears to have been a failure despite the release of a million parasitoids over 2.5 yr (Carnegie et al 1985).

There are examples, other than for rice pests, for which classical biological control programs have been highly successful (Polaszek and Kimani 1990). Despite the apparent lack of success in Africa, it may be that, given proper emphasis, this approach could be successful for control of some rice insect pests.

An Illustrated Key to the Identification of Selected West African Rice Insects and Spiders





Identification of rice insect pests and their associated natural enemies is often a limiting factor in the development of a comprehensive insect pest management strategy in West Africa. Notable exceptions, however, are three groups of economically important rice pests—stem borers, leafhoppers and planthoppers, and gall midges for which full taxonomic studies are available to date. Meijerman and Ulenberg (1996) made an excellent contribution to the identification of African stem borer larvae from the families Pyralidae and Noctuidae, while Wilson and Claridge (1991) dealt on leafhoppers and planthoppers, and Harris and Gagne (1982) studied gall midges. Polaszek (1992) treated the parasitoids of cereal stem borers.

To assist the national research systems of 17 West African countries that are collaborating with WARDA to identify specimens in their own collections, we have developed an illustrated key for parataxonomists (high school or college graduates without formal training in entomology and taxonomy). This key provides illustrations for 275 species of insects (Section II) and 69 species of spiders (Section III), which are associated with the rice agroecosystems. Although we tried to be comprehensive, the lack of good specimens, especially for the flies, thrips, chalcidoids, scelionids, and spiders, on which to base the illustrations has limited our coverage of the wide diversity of insects and spiders that abound in the rice agroecosystems. This illustrated key was based solely on a general collection brought to IRRI by Dr. E.A. Heinrichs and Mr. Traore Abdoul Kassoum Aboubakar in 1994 and 1995, respectively. Some common and dominant species of insect pests and beneficial species not represented in the general collection were not included. Nevertheless, we still hope the key will be useful in identifying and understanding the components of the arthropod community in West Africa's rice agroecosystems.

Section I: Orders based on adults

1 Body with 3 pairs of legs, 3 body segments (head, thorax , and abdomen) and 2 pairs of wings [Insects] 2

1' Body with 4 pairs of legs, 2 body segments (cephalothorax and petiolate abdomen) and wingless [Spiders] .... **Araneae**

2 Wings, body, and legs covered with scales .... **Lepidoptera**

2' Wings, body and legs without scales 3

3 Fore wings and hind wings subsequently elongated, membranous and multiveined, each wing with a node and a pterostigma; eyes large, occupying most of the transverse head; antennae small and bristle-like .... **Odonata**

3' Fore wings and hind wings without nodes and pterostigma; eyes and antennae not as above 4

4 Cerci present 5

4' Cerci absent 7

5 Cerci forcep-like, unsegmented and sclerotized, dorsoventrally flattened insects with telescopic and mobile abdomen .... **Dermaptera**

5' Cerci not forcep-like, segmented and not sclerotized; not dorsoventrally flattened insects; abdomen not telescopic 6

6 Front legs normal; hind legs saltatorial with enlarged femora; tarsi 3–4 segmented .... **Orthoptera**

6' Front legs raptorial; hind legs normal, slender and adapted for walking; tarsi 5-segmented .... **Mantodea**

7 Fore wings reduced to knob-like structures; flabellate antennae 4–7 segmented .... **Strepsiptera**

7' Fore wings not knob-like; antennae not flabellate 8

8 Hind wings reduced to knob-like structures (halteres); one pair of membranous fore wings present .... **Diptera**

8' Hind wings not knob-like 9

9 Fore wings modified into hardened and rigid elytra covering the membranous hind wings; antennae 11-segmented or less .... **Coleoptera**

9' Fore wings not forming a rigid elytra; antennal segments variable 10

10 Mouthparts piercing-sucking type forming a segmented beak; wings without hamuli; fore wings either membranous or thickened and leathery with membranous apical portion .... **Hemiptera**

10’ Mouthparts mandibulate; wings with hamuli and reduced venation .... **Hymenoptera**

Section II: Insects

Order Lepidoptera

Skipper butterflies, noctuid and pyralid moths

1 Antennae widely separated at base, flagellum thickens distally forming a club and hooked tips; ocelli absent; haustellum naked; maxillary palpi absent; retinaculum and frenulum absent; fore wings each with 10 transparent or white spots, none in hind wings **(Fig. 83)**; medium-sized butterflies with dull brown body and wings; larvae defoliators [Family **Hesperiidae**] .... *Parnara* sp.

1’ Antennae near each other basally, distal end not clubbed and hooked at tips; ocelli may be present or absent; haustellum very reduced, well developed or scaly; maxillary palpi 1–4 segmented; retinaculum and frenulum present; fore wings pattern variable; larvae stem borers and defoliators 2

2(1’) Heavy-bodied pink stem borer moths with a thick tuft of hairs on thoracic dorsum **(Figs. 84, 85)**; narrowed fore wings yellowish red with slight dusky suffusion, fringe ochreous white and pale infuscate medially and distally, postmedial mark brownish gray; hind wings broadened, vein M1 rudimentary; proboscis strong, maxillary palpi 1-segmented; labial palps not strongly porrect; tibiae II and III spineless; larvae stem borers (note: wing markings easily lost in old specimens) [Family **Noctuidae**] .... *Sesamia calamistis* Hampson

2’ Moderately small, delicate and slender-built moths without thick hair tuft in thorax; fore wings elongate to subtriangular, markings variable; hind wings usually broad; proboscis very reduced to scaly, maxillary palpi 4-segmented; labial palps strongly porrect, beak-like; tibiae II and III usually with spines; larvae stem borers and defoliators [Family **Pyralidae**] 3

3(2’) White moths with or without brown spots on both wings 4

3’ Yellowish brown or straw-colored moths 5

4(3) Wings immaculate to bright white with light yellowish brown and dark brown spots and tuft weakly developed; all legs dull white; commonly known as rice caseworm .... *Nymphula depunctalis* (Guenée) **[Fig. 86]**

4’ Both wings immaculate white except light gray costal area ventrally; anal hair tuft thick and shiny yellowish white; all legs yellowish white; white stem borer .... *Scirpophaga* sp. **[Fig. 87]**

5(3’) Fore wings with a dark brown to reddish brown longitudinal band parallel to the costal margin; tornus rounded upwards; fore and hind wings without vein M3, median nervure with only three veins; whitish hind wings with metallic luster and long fringed hairs; proboscis poorly developed; rice stem borer .... *Maliarpha separatella* Ragonot **[Fig. 88]**

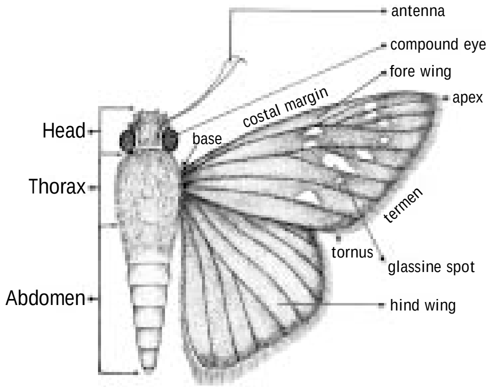
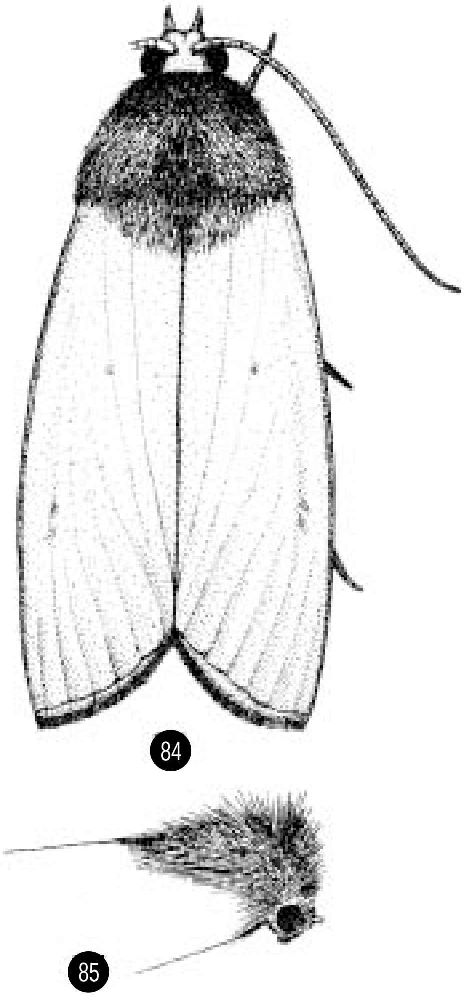


Fig. 83. ***Parnara* sp., dorsal view (2.6X).**



Figs. 84–85. ***Sesamia calamistis* Hampson, dorsal (84; 4.5X), and lateral views of head and thorax (85; 5.3X).**

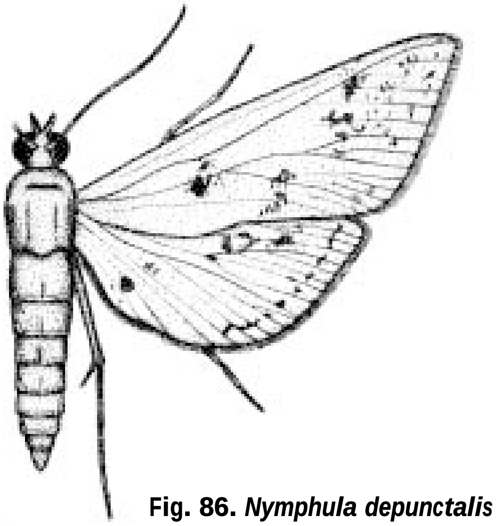


Fig. 86. ***Nymphula depunctalis* (Guenée), dorsal view (7.6X).**

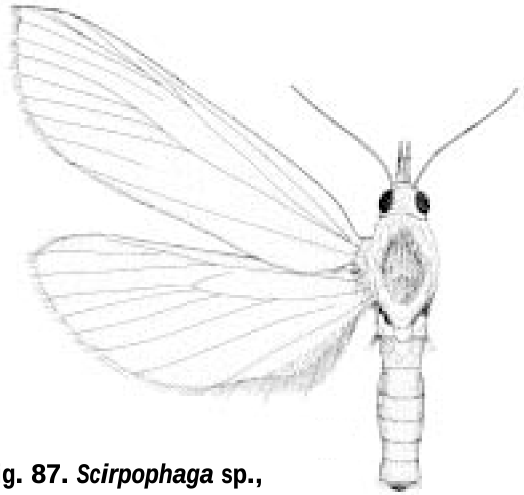


Fig. 87. ***Scirpophaga* sp., dorsal view (2.4X).**

Fig. 88. ***Maliarpha separatella* Ragonot, dorsal view (3.4X).**

5’ Fore wings with different color and markings 6

6(5’) Fore wings and hind wings brownish yellow becoming darker towards the apical margins; fore wings with two short subbasal bands not reaching the costal margin, a short and two complete medians and two subterminal dark brown narrow bands; hind wings with three bands only; larva folds leaves, rice leaffolder .... *Marasmia trapezalis* (Guenée) **[Fig. 89]**

6’ Ochreous yellow moths without transverse bands; larva bores rice stems producing deadhearts and whiteheads on the plant 7

7(6’) Face conical with a distinct point; labial palps 3–3.5 times as long as diameter of eye; fore wings yellow brown with a dull brown spot and dusted with fuscous scales; subterminal line light brown; vein M1 of hind wings arises from Rs before the angle of cell; harpe with a strong median tooth in the costal margin and juxta bell-shaped with two basal notches in the male genitalia .... *Chilo partellus* (Swinhoe**) [Figs. 90, 91]**

7’ Face rounded without a corneous point 8

8(7’) Fore wings ochreous yellow, length 10–14 mm and wing span 20–24 mm; ocelli small yet distinct; vein R1 of front wings runs together with Sc; subterminal line indistinct in both sexes; hind wings dull ochreous yellow; aedeagus without ventral arm; juxta without tooth; harpe tapers apically .... *Chilo zacconius* Bleszynski **[Fig. 92]**

8’ Fore wings orange yellow to dirty yellow, length 8–13 mm, and wing span 16–26 mm; ocelli well developed; vein R1 of front wings free; subterminal line distinct in male, reduced in female; hind wings grayish cream to silky white with luster; aedeagus curved basally with a short ventral arm; arms of juxta bear a subapical tooth; harpe widely blunt apically .... *Chilo diffusilineus* (J. de Joannis) **[Figs. 93, 94]**

Order Diptera

African rice gall midge and stalk-eyed flies

1 Eyes not on a stalk; fore wings with very few longitudinal veins reaching wing margin; costa running around wing margin with reduced venation, longitudinal vein Rs unbranched, discal cell absent; antennae more than 10 segments with bead-like joints; maxillary palpi 3-segmented; anterior margins of abdominal tergites VII and VIII with narrow irregular pigmented bands; hypoproct slightly notched in apical end; gonostyle slightly tapered in apical one-third [Family **Cecidomyiidae**] .... *Orseolia oryzivora* Harris and Gagne **[Figs. 95–97]**

1’ Eyes on a stalk, widely separated from each other [Family **Diopsidae**] 2

2(1’) Apex of fore wings uniformly transparent without any spot; scutellum and spines brownish yellow; wing span 14–15 mm .... *Diopsis longicornis* Macquart **[Fig. 98]**

2’ Apex of fore wings with a large black spot; scutellum blackish brown and scutellar spines brown except black apical one-half; wing span 8–12 mm .... *Diopsis apicalis* Dalman **[Fig. 99]**

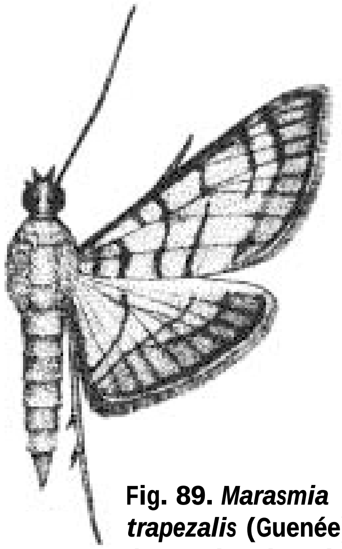
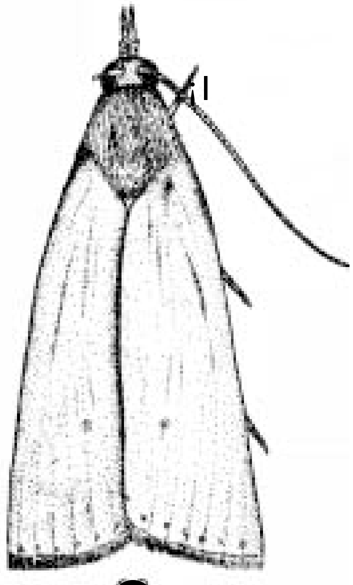


Fig. 89. ***Marasmia trapezalis*** **(Guenée), dorsal view (5.9X).**



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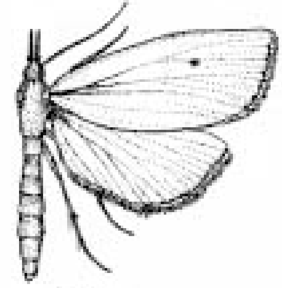

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Figs. 90–91. ***Chilo partellus*** **(Swinhoe), dorsal view at rest position (90; 5.8X) and right wings spread (91; 3.4X).**

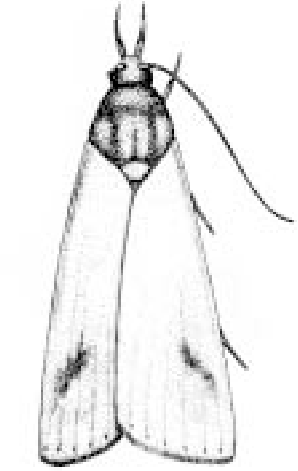
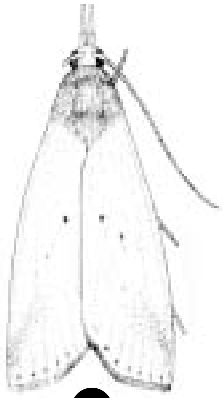


Fig. 92. ***Chilo zacconius*** **Bleszynski, dorsal view (4.7X).**



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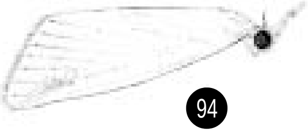

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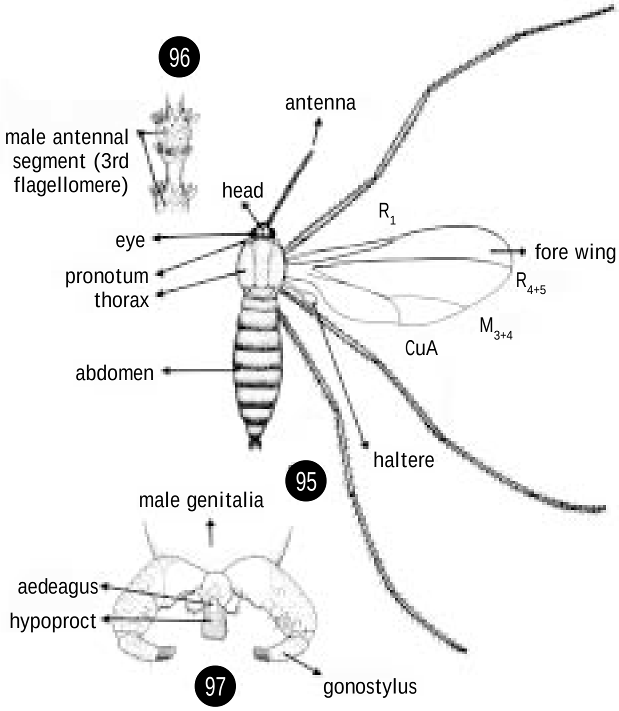
Figs. 93–94. ***Chilo diffusilineus*** **(J. de Joannis), dorsal (93; 4.8X), and lateral (94; 3.8X) views.**



Figs. 95–97. ***Orseolia oryzivora*** **Harris and Gagne, dorsal view of adult (95; 7.25X), male antennal segment (96; 6.6X), and male genitalia (97; 32X).**

Order Odonata

Dragon- and damselflies

1 Wings held horizontally at rest, unstalked basally; hind wings widened towards base, more triangular than fore wings; both pairs of wings yellow with longitudinal black bands not reaching distal ends, lower ends of bands indented medially; discoidal cell triangular; antenodal cross veins (Ax) more than two; thickened antenodal cross vein absent; eye without lateral projection; terminal abdominal segment with one pair of upper and a single lower appendages above anus; small libellulids with a wing span of 40–45 mm; dragonflies [Family **Libellulidae**] .... *Palpopleura* sp. **[Fig. 100]**

1’ Wings held closed or half open at rest, stalked basally; fore and hind wings equally long, similar in shape without longitudinal black bands; discoidal cell with unequal sides; only 2 antenodal cross veins present; terminal abdominal segment with two pairs of appendages above anus 2

2(1’) Wings divergent above body when at rest; long pterostigma elongate brown to rectangular, 2 or more cells long; postnodal cross veins about 11; third radius (R3) arises from R2 below third postnodal cross vein (Px3); intermediate radial veins 3 and 4 closer to arculus than nodus; upper terminal abdominal appendages forcep-like; spread-winged damselflies [Family **Lestidae**] .... *Lestes* sp. **[Fig. 101]**

2’ Wings held close together above body at rest; pterostigma short, rhomboidal, approximately one cell long; postnodal cross veins 10 or less; R3 arises from R2 below middle of postnodal cross vein Px4 and Px5; intermediate radial veins 3 and 4 closer to nodus than arculus; upper terminal abdominal appendages not forcep-like; narrow-winged damselflies [Family **Coenagrionidae**] 3

3(2’) Arculus located at a point nearly midway between the first antenodal (Ax1) and nodus; vein M2 arises below postnodal cross vein 3 (Px3); Fore wings with 7 postnodal nodes each; pterostigma obliquely rectangular in both wings; posterior lobe of prothorax without a pair of porrect spines; 8th abdominal sternite without median spine in female; labrum broadly rounded; anteclypeus convex medially .... *Agriocnemis* sp. **[Figs. 102–104]**

3’ Arculus only slightly nearer to the level of first antenodal (Ax1); vein M2 arises approximately below postnodal cross vein 7 (Px7); fore wing with 14 postnodal nodes each; pterostigma narrowly subquadrate; similar in size and shape in both wings; female prothorax with a pair of small porrect spines in the posterodorsal lobe; labrum strongly convex; anteclypeus straight .... *Pseudagrion* sp. **[Figs. 105–107]**

Order Dermaptera

Earwigs

1 Antennae with 16 segments; head, thorax, and abdomen black; pronotum wider behind than in front, slightly indented at lateral midhalf; forceps close basally, short and stout, apically curved overlapping each other and inner sides with little serrations; terminal abdominal segment not serrated posteriorly [Family **Labiduridae**] .... *Euborellia annulipes* (Lucas) **[Fig. 108]**

1’ Antennae with about 22 segments; thorax and abdomen yellow and brown; pronotum and elytra yellow with parallel sides and a pair of dark brown longitudinal bands; forceps long and slender, widely separated basally, inner half with a small tooth; terminal abdominal segment with about 4 teeth posteriorly [Family **Labiduridae**] .... *Labidura riparia* Pallas **[Fig. 109]**

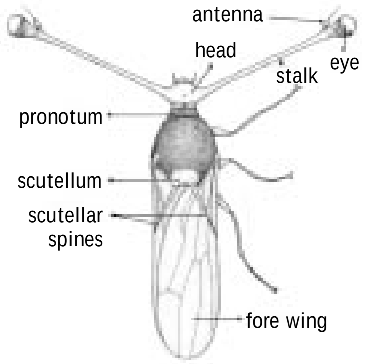


Fig. 98. ***Diopsis longicornis*** **Macquart, dorsal view (4.5X).**

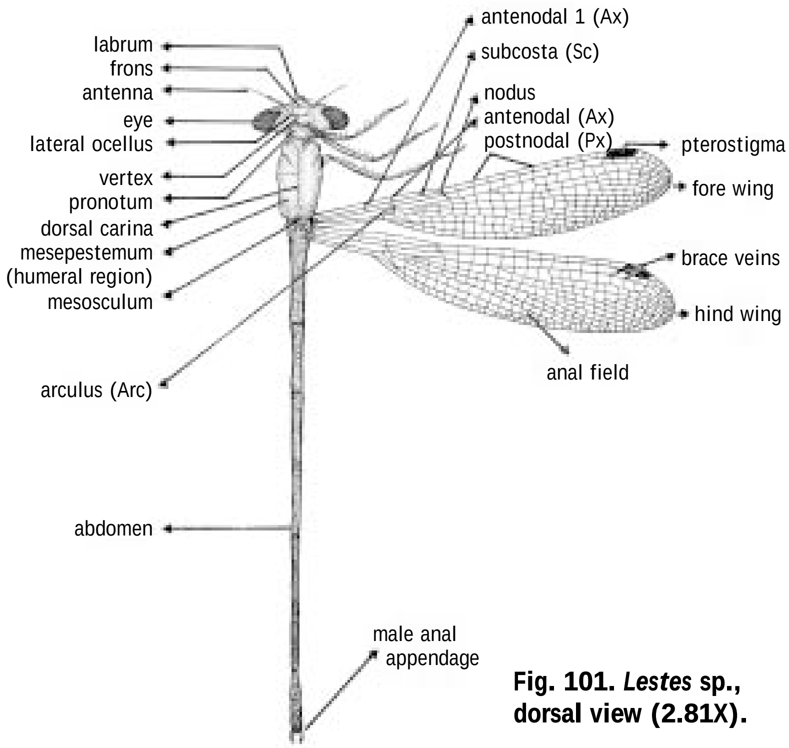


Fig. 101. ***Lestes*** **sp., dorsal view (2.81X).**

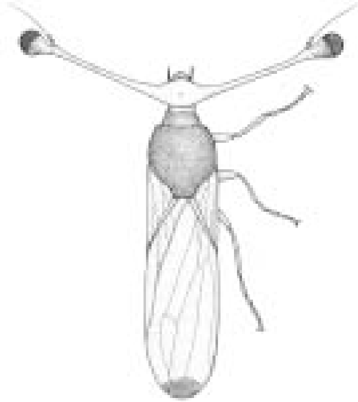
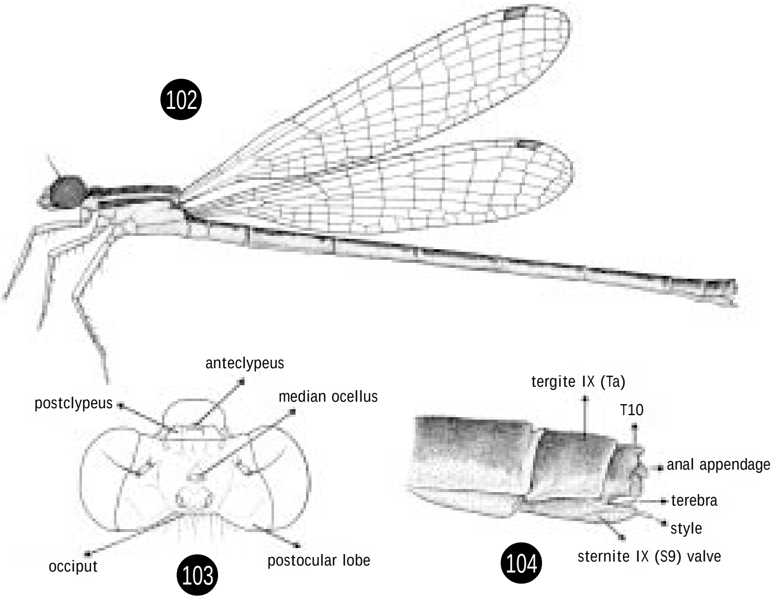


Fig. 99. ***Diopsis apicalis*** **Dalman, dorsal view (6.14X).**



Figs. 102–104. ***Agriocnemis*** **sp., lateral view (102; 4.25X), dorsal view of head (103; 13.75X), and lateral view of abdominal tip (104; 14X).**

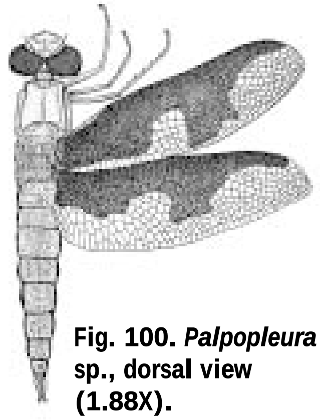
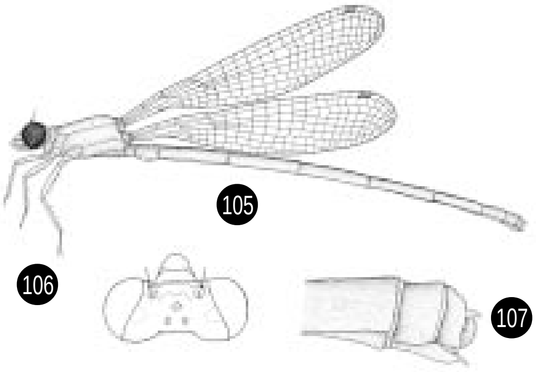


Fig. 100. ***Palpopleura*** **sp., dorsal view (1.88X).**



Figs. 105–107. ***Pseudagrion*** **sp., lateral view (105; 2X), dorsal view of head (106; 5.0X), and lateral view of abdominal tip (107; 6.7X).**

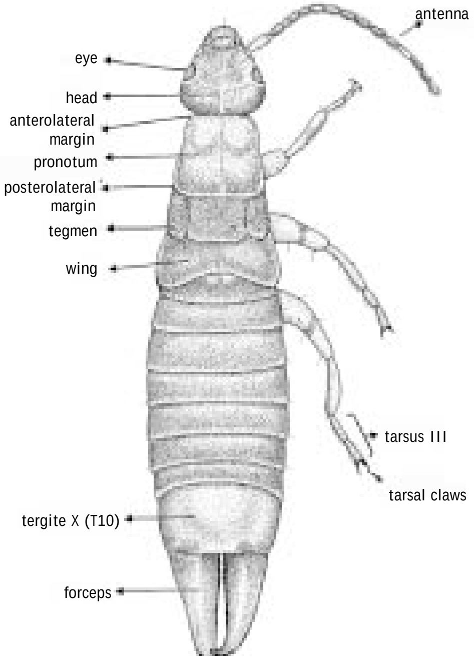


Fig. 108. ***Euborellia annulipes*** **(Lucas), dorsal view (9X).**

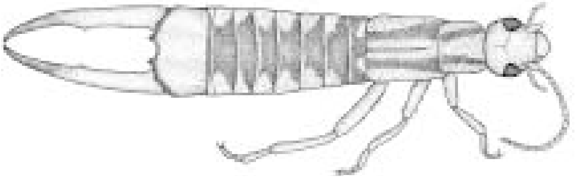


Fig. 109. ***Labidura riparia*** **Pallas, dorsal view (6.2X).**

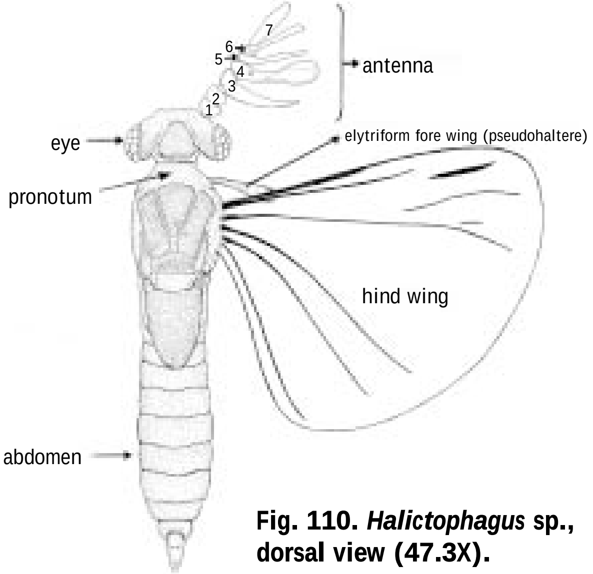


Fig. 110. ***Halictophagus*** **sp., dorsal view (47.3X).**

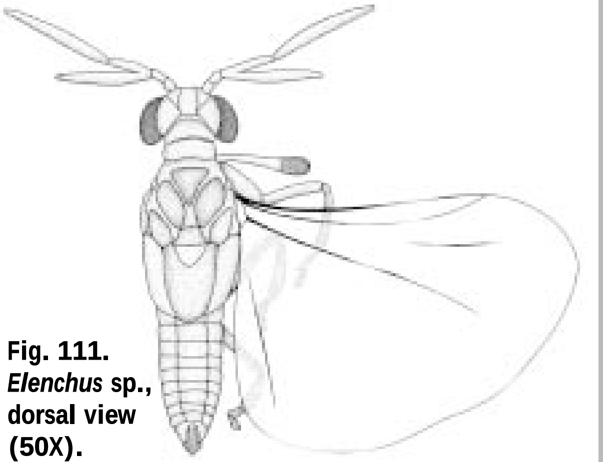


Fig. 111. ***Elenchus*** **sp., dorsal view (50X).**

Order Strepsiptera

Twisted-winged flies

1 Tarsi 3-segmented; antennae 7-segmented with segments III–VI flabellate and segment IV robust; veins MA2, CuA1, and CuA2 very prominent; parasitic on leafhoppers [Family **Halictophagidae**] .... *Halictophagus* sp. **[Fig. 110]**

1’ Tarsi 2-segmented; antennae 4-segmented with flabellate third segment; veins MA2 and CuA1 absent, only CuA2 present in the bottom half of the hind wing; parasitic on planthoppers [Family **Elenchidae**] ....*Elenchus* sp. **[Fig. 111]**

Order Orthoptera

Grasshoppers, locusts, and crickets

1 Antenna very long, more than 30 segments, extended well beyond tip of abdomen; tarsus 3- or 4-segmented; foreleg fossorial or for walking 2

1’ Antenna short, less than 30 segments, never reaches tip of abdomen; tarsi 3-segmented or tarsi I and II 2-segmented and tarsus III 3-segmented 8

2(1) Tarsus 4-segmented; fore wing tough and leathery; venter of tibiae I and II without articulated spines [Family **Tettigoniidae**] 3

2’ Tarsus 3-segmented 6

3(2) Anterior of head without a protruding process extended to at least two-thirds of scape; fore wing green, not reaching the hind knee, one-third shorter than hind wing; Fore wing length/hind femur length ratio less than 1.1; lateral pronotal lobe as long as deep; femur III without ventral spines; tibia III with 41 external dorsal spines; female ovipositor broad and upwardly curved, serrated dorsally except basal one-third; body length 25 mm .... *Phaneroptera nana sparsa* Stål **[Figs. 112–115]**

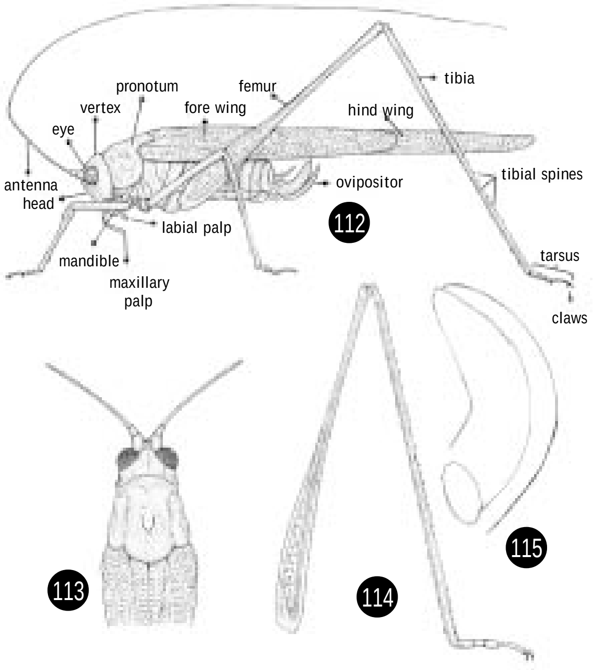
3’ Anterior tip of head snout-like; fore wings extended beyond the hind knee; tibia III and femur III with ventral spines 4

4(3’) Snout-like process on tip of head blunt, as long as wide and extending beyond scape; eyes ovoid as seen dorsally; pronotum flat dorsally behind the transverse groove in the anterior one-third; posterior margin strongly concave, lateral side of pronotum much longer than deep and rounded along ventral margin; fore wings as long as hind wings; femur III as long as ovipositor; tibia III with at least 21 dorsal and 10 ventral external spines; body length 42 mm ....*Ruspolia differens* Audinet-Serville **[Figs. 116–118]**

4’ Snout-like process constricted at midhalf and knob-like at tip 5

5(4’) Dorsum of head and pronotum with a reddish-brown longitudinal band, broad posteriorly and narrows anteriorly; snout-like process moderately constricted at midhalf; basal segments of antenna with reddish brown mottles; fore wings brownish basally; femur and tibia with reddish brown dots; body length 21 mm .... *Conocephalus maculatus* Le Guillou **[Fig. 119]**

5’ Dorsum of head and pronotum green (yellow brown in alcohol-preserved specimens) without a reddish longitudinal band; snout-like process distinctly constricted at midhalf; basal antennal segments without reddish brown mottles; fore wing uniformly green; femur and tibia uniformly yellowish brown; body length 27 mm ..... *Conocephalus conocephalus* Linnaeus **[Figs. 120–122]**



Figs. 112–115. *Phaneroptera nana sparsa* Stål, lateral view of adult (112; 2.3X), dorsal view of head and pronotum (113; 3.9X), lateral view of leg III (114; 3.4X), and cercus (115; 10X).

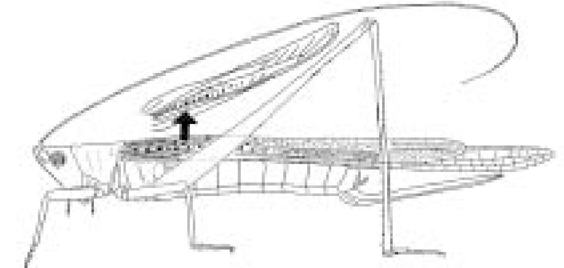
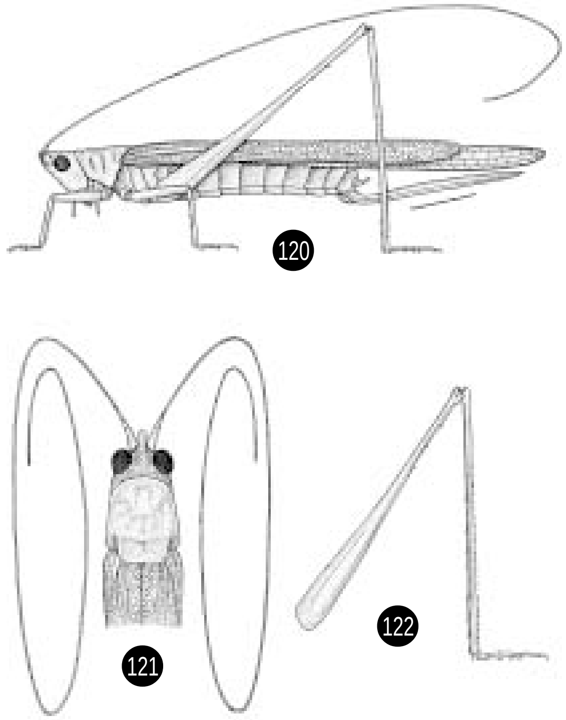
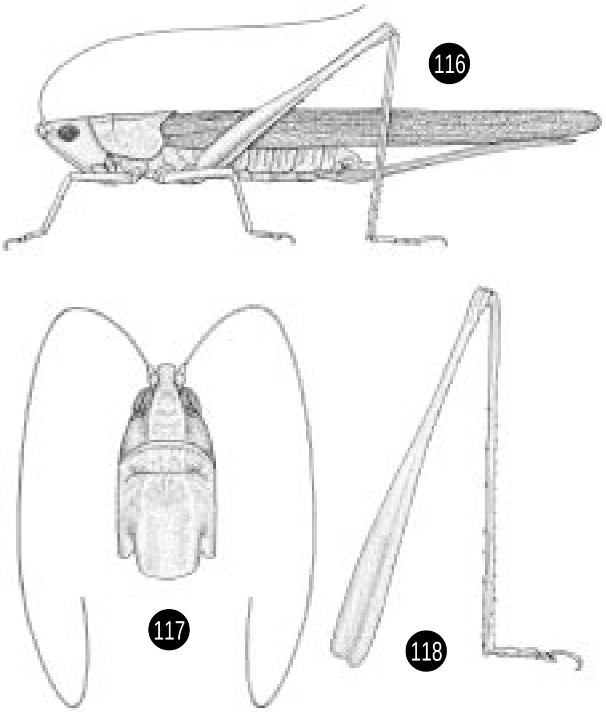


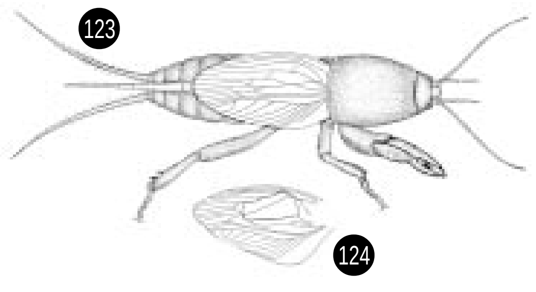
Fig. 119. *Conocephalus maculatus* (Le Guillou), lateral view (3.1X).



Figs. 120–122. *Conocephalus conocephalus* Linnaeus, lateral view of adult (120; 2.30X), dorsal view of head and pronotum (121; 4.3X), and lateral view of leg III (122; 2.84X).



Figs. 116–118. *Ruspolia differens* Audinet-Serville, lateral view of adult (116; 1.66X), dorsal view of head and pronotum (117; 2.9X), and lateral view of leg III (118; 2.52X).



Figs. 123–124. *Gryllotalpa africana* Palisot de Beauvois, dorsal view (123; 1.7X) and male fore wing (124; 1.85X).

6(2’) Foreleg modified for digging (fossorial type); femur and tibia of leg I flat; femur I with a basal spur; fore tibia with 4 large teeth; tarsus I with 2 fan-like teeth; veins R1 and Rs distally separated; harpe of male fore wing almost rectangular; genitalia very large, ventral processes long; generally pale brown; body length 28.4 mm [Family **Gryllotalpidae**] ....*Gryllotalpa africana* Palisot de Beauvois **[Figs. 123, 124]**

6’ Foreleg normal, adapted for walking 7

7(6’) Small black cricket, 4.5–7.0 mm long; head somewhat triangular from vertex to anterior tip, without a transverse ridge connecting eyes anteriorly, subquadrate plate between antennal base; pronotum as long as wide, lateral margin straight; antenna yellow except black scape and pedicel; fore wing longer than hind wing with a pointed apicoinner tip, veins mostly longitudinal and parallel to each other; cercus yellow with long hairs and clubbed setae in inner basal one-third; leg black with an apicoventral spine in tibia I; ovipositor very short .... *Metioche* sp. **[Fig. 125]**

7’ Slender brownish yellow to dark brown cricket, 18 mm long; head somewhat transverse with three broad longitudinal bands, a transverse ridge connects two eyes anteriorly; vertex subquadrate, blunt anteriorly and as low as mid-eye level; pronotum with a broad dark brown median longitudinal band extended to fore wing faded brown; propleuron with a thin pale brown longitudinal band extended to temple, lower margin broader in anterior one-half; antenna pale yellow brown with dark brown venter of scape and pedicel; fore wing much shorter than the hind wing, squarish cells brownish, apical margin rounded; cercus yellow and hairy; leg yellowish with 10–11 external and 12 internal long dorsal spines in tibia III .... *Euscyrtus bivittatus* (Guerin-Meneville) **[Figs. 126–128]**

8(1’) All tarsi 3-segmented 9

8’ Tarsi I and II 2-segmented, tarsus III 3-segmented 19

9(8) Fastigium of vertex lacks a midlongitudinal sulcus anteriorly [Family **Acrididae**] 10

9’ Fastigium of vertex with a mediolongitudinal sulcus extended posteriorly for a short distance from its anterior extremity [Family **Pyrgomorphidae**] 16

10(9) Dense stridulatory veinlets in radial area of tegmen parallel and regular; fastigium of vertex wider than long, shallow cavity in front of a bow-shaped transverse furrow, apex moderately rounded to angular; antenna with 27–28 segments; pronotum with three transverse furrows dorsally, anterior not extended to the laterals unlike 2nd and 3rd furrows; posterior one-third of propleuron densely punctated similar to meso- and metapleuron; prosternal process conical; tegmina and wings extended beyond abdominal tip; femur III moderately robust with 12–13 laterally concave or widely V-shaped striae present ; upper external femoral lobe black extended to base of yellow lower lobe of knee; tibia III with 10 spines each in inner and outer rows; cerci downcurved at tip laterally and incurved dorsally; body length 27 mm ....*Hieroglyphus africanus* Uvarov **[Figs. 129, 130]**

10’ Elytron without stridulatory veins from the radial area 11

11(10’) Prosternal process absent 12

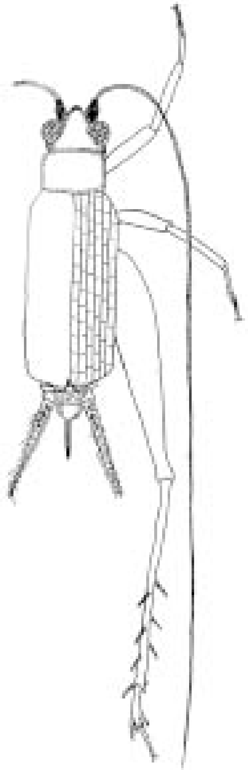
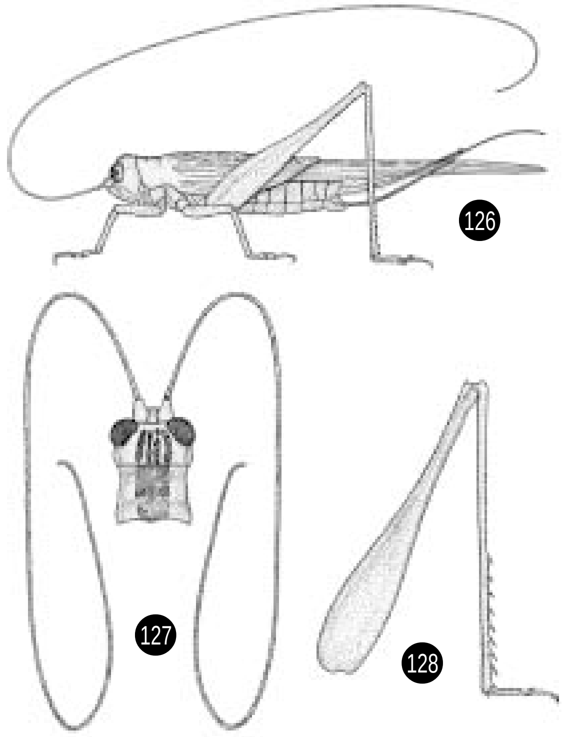


Fig. 125. *Metioche* sp., dorsal view (8X).



Figs. 126–128. *Euscyrtus bivittatus* (Guerin-Meneville), lateral view (126; 3X), head and pronotum (127; 5.2X), and leg III (128; 4.5X).

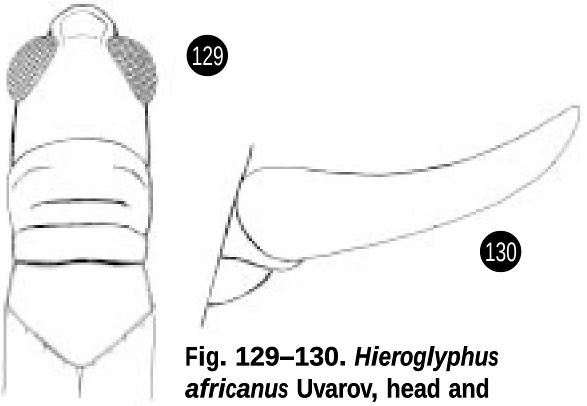


Fig. 129–130. *Hieroglyphus africanus* Uvarov, head and pronotum (129; 4.6X) and cercus (130; 17.3X).

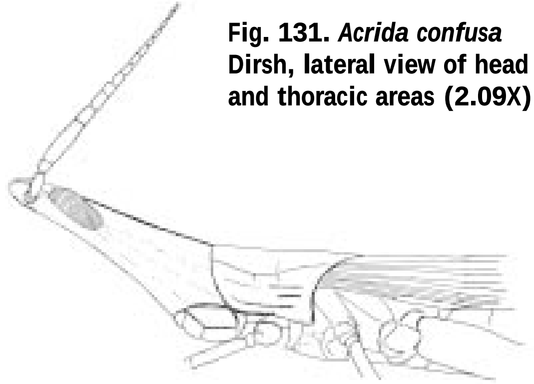


Fig. 131. *Acrida confusa* Dirsh, lateral view of head and thoracic areas (2.09X).

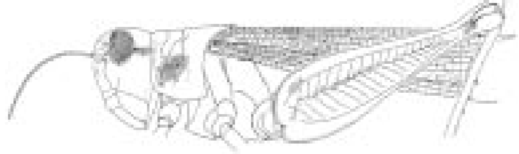
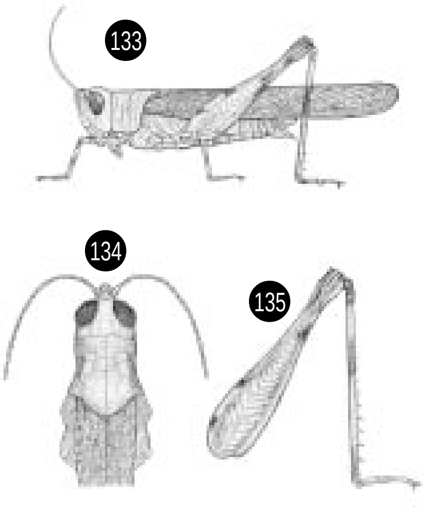


Fig. 132. *Heteropternis* sp., lateral view of head and thoracic areas (2.75X).



Figs. 133–135. *Ailopus simulatrix simulatrix* (Walker), lateral view (133; 1.59X), dorsal view of head and pronotum (134; 2.57X), and leg III (135; 2.4X).

11’ Prosternal process present 15

12(11) Head oblique in front viewed laterally; fastigium concave medially, slightly longer than eye length; antenna with at least 16 segments, flat in segments III–VIII, segment III longest; transverse furrow of pronotum situated a little to the rear of midlength; tibia III with 35 spines in the outer row; body length 74 mm .... *Acrida confusa* Dirsh **[Fig. 131]**

12’ Head not oblique viewed laterally; antenna without flattened segments; tibia III with less than 35 spines 13

13(12’) Midtegmen with a dense row of parallel thickened veinlets; anterior of transverse pronotal furrow with 3 slightly oblique grooves not reaching mid-longitudinal carina; femur III with black and brown spots; tibia III with 10 spines in the outer row; body length 23 mm .... *Heteropternis* sp. **[Fig. 132]**

13’ Midtegmen without dense row of thickened parallel veinlets 14

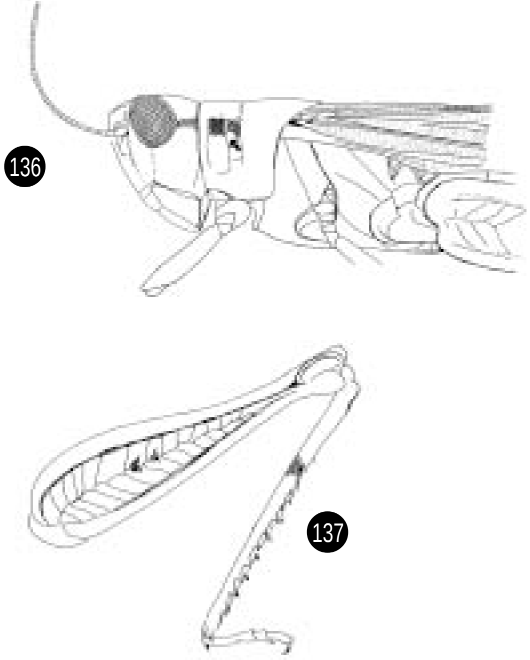
14(13’) Hind femur distinctly broad with an anterior and posterior black band in the swollen area; tibia III with 10 inner spines, black basally with submedian and apical brown bands; apical tarsal segment yellow except brown both ends; transverse furrow of brown pronotum located anterior of midlength, elevated medially with two slightly concave frontal furrows interrupted before the median carina; fore wing extended beyond the knee by one-fourth femoral length; body length 26 mm .... *Aiolopus simulatrix simulatrix* (Walker) **[Figs. 133–135]**

14’ Hind femur slightly broad with light brown dorsal band (sometimes reduced to 4 dorsal bands including apex); tibia III light brown to grayish brown with subbasal whitish yellow band, inner row with 11 spines; apical tarsal segment brown with yellow mottles; transverse pronotal furrow almost at midlength, convex medially with two transverse furrows in front extended to the black laterals; fore wing at rest brown dorsally and black laterally, extended beyond the knee by one-sixth femoral length; body length 18 mm .... *Aiolopus thalassinus thalassinus* (Fabricius) **[Figs. 136, 137]**

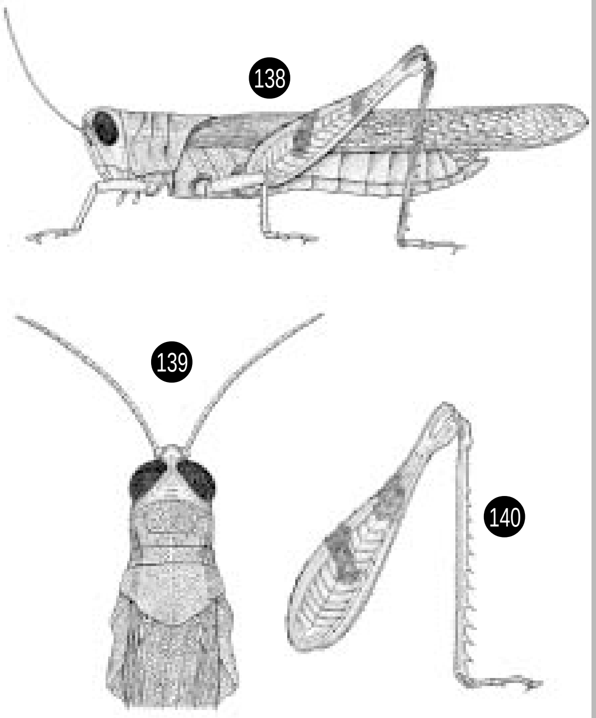
15(11’) Prosternal process smoothly rounded and shiny apically, penis-like; base of fastigium with an inverted V-furrow in the converging point of eyes; lower external lobe of femur III apically rounded, without spine; tibia III with 10 spines each in the outer and inner rows; fore wing brown with blackish to dark brown mottles, extended beyond the knee by about one-third femoral length; body length 32 mm ....*Catantops spissus adustus* (Walker) **[Fig. 138–140]**

15’ Prosternal process pointed apically; base of fastigium with a distinct groove, femur III yellowish brown with black knee and a spine in the lower external lobe; tibia III with 8 spines in the outer row and 9 in the inner row; fore wing greenish but reddish in basal half, extending slightly beyond the knee; body length 21 mm .... *Oxya hyla* Stål **[Figs. 141, 142]**

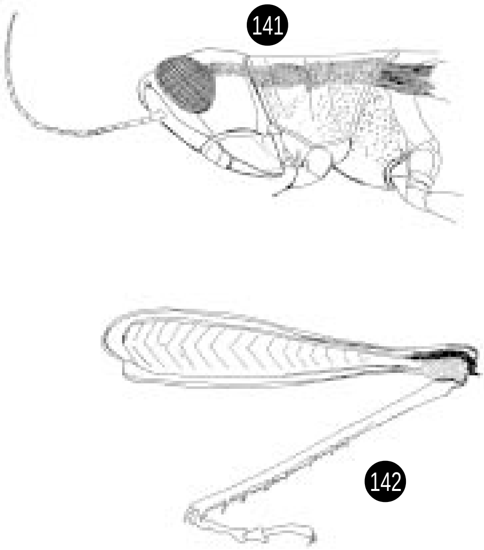
16(9’) Head vertical, numerous black patches present dorsally, frontally and laterally; front and cheek each with a pair of square-like black bands containing a circular median yellow spot; clypeus black in dorsal half with six yellow spots and yellow ventral half; labrum with a w-black band and 2 yellow spots in the middle; antenna 20-segmented, black except yellow segments XII and XVI, and yellowish brown apical two segments; pronotum yellowish green, anteriorly expanded collar-like partially covering back of head; fore wing yellowish green with black base, rounded apex as long as tip of abdomen and knee of femur



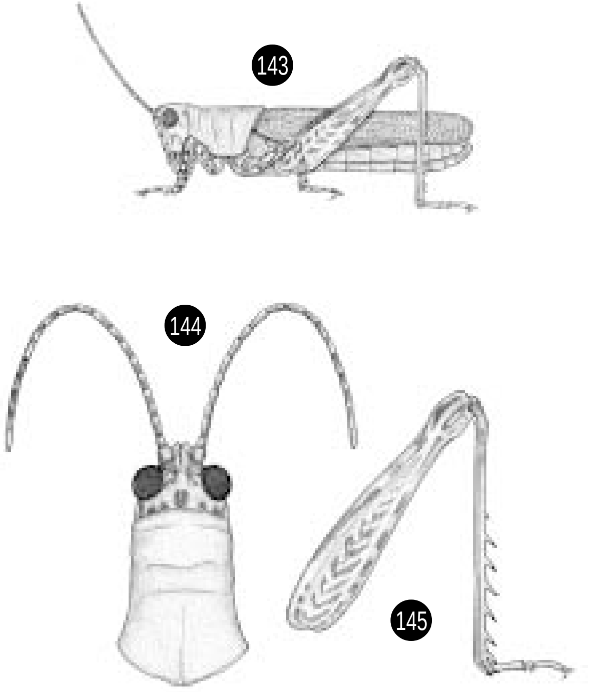
Figs. 136–137. *Ailopus thalassinus thalassinus* (Fabricius), lateral view of head and thoracic areas (136; 6.7X) and leg III (137; 4.5X).



Figs. 138–140. *Catantops spissus adustus* (Walker), lateral view (138; 1.94X), dorsal view of head and pronotum (139; 3.2X), and leg III (140; 2.3X).



Figs. 141–142. *Oxya hyla* Stål, lateral view of head, propleuron and mesopleuron (141; 4X) and leg III (142; 2.9X).



Figs. 143–145. *Zonocerus variegatus* (Linnaeus), lateral view (143; 1.1X), dorsal view of head and pronotum (144; 2.6X), and leg III (145; 1.95X).

III; broad median, narrow basal and apical black bands in femur III; tibia III with 6 outer and 8 inner row spines excluding those at apex; body length 35 mm .... *Zonocerus variegatus* (Linnaeus) **[Figs. 143–145]**

16’ Head oblique 17

17(16’) Eyes elongate; sides of head and lower lateral side of pronotum lined with wart-like tubercles, serrated-like; antennae arise in front of ocelli; fore wing greenish, pointed at apex and extending beyond the tip of abdomen and knee; body length 34 mm .... *Atractomorpha acutipennis gerstaeckeri* I. Bolivar **[Figs. 146–148]**

17’ Eyes spherical and bulging; head and pronotum rough; tibia III with 8 spines in the outer row 18

18(17’) Fore wing red, not reaching abdominal tip or knee of femur III; pronotum and head reddish lined with numerous warts; posterior pronotum behind second transverse furrow heavily punctated; legs reddish except yellow apices of tibia I, basal tarsal segments of legs I and II; body length 20.5 mm .... *Pyrgomorpha vignaudii* Guerin-Meneville **[Fig. 149]**

18’ Fore wing extending well beyond tip of abdomen in the female, but up to knee only in the male; pronotum and head yellowish brown with less but larger warts; posterior pronotum behind second transverse furrow deeply and heavily punctated almost similar to wing base; legs uniformly yellowish brown except blackish venter of tibia III; body length 21 mm .... *Pyrgomorpha cognata* Krauss **[Figs. 150–152]**

19(8’) Head and pronotum finely punctated, smooth and shiny, strongly convex and subcylindrical viewed dorsally; pronotum covers the thorax only, posterior margin prominently concave; femur III flat and broad; tibia III with thin leaf-like ‘spines’ in anterior one-third [Family **Tridactylidae**] 20

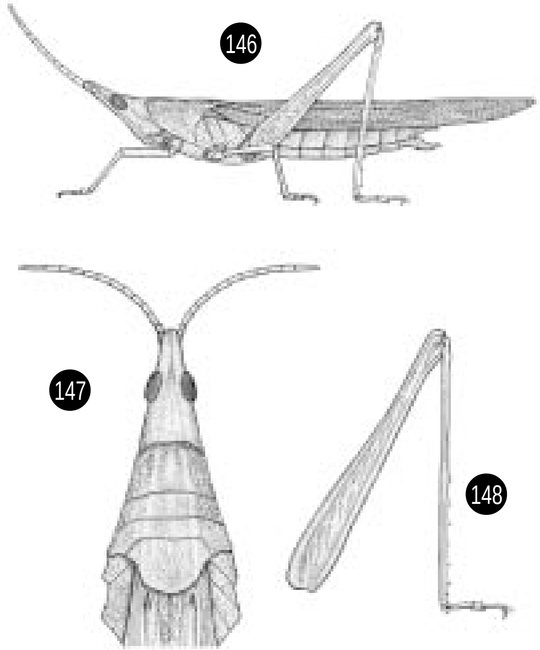
19’ Pronotum extended posteriorly covering abdomen [Family **Tetrigidae**] 21

20(19) Prominently black except whitish yellow eye margins, yellow brown leg I, blackish brown leg II, black femur III and whitish yellow tibia III; leg III with 5 long leaf-like outer and 4 inner spines in tibia; body length 5 mm .... *Tridactylus* sp. A **[Fig. 153]**

20’ Dark brown with whitish yellow or white areas in the body, wings and legs; head with a diamond-like dark brown band in ocellar region, vertex with 7–8 short dark brown bands; pronotum anteriorly and posterolaterally yellow; femur I pale whitish brown, II whitish with dark brown bands dorsally, III dark brown with a submedian and a subanterior transverse white bands; tibia with 4 pairs of short leaf-like spines; body length 8 mm ... *Tridactylus* sp. B **[Fig. 154]**

21(19’) Entire body coarsely covered with serrated outgrowths; pronotum expanded laterally with serrated edges; femora I–III leaf-like with dorsal, lateral, and ventral outgrowths; tibia with 6 spines in the outer row and 5 in the inner row, serrations in between spines; antenna 15-segmented; body length 10 mm .... *Hancockia* sp. **[Figs. 155–157]**

21’ Entire body without serrated outgrowths; body length 10 mm or more 22



Figs. 146–148. ***Atractomorpha acutipennis gerstaeckeri*** **I. Bolivar, lateral view (146; 1.53X), dorsal view of head and pronotum (147; 3.0X), and leg III (148; 3.02X).**

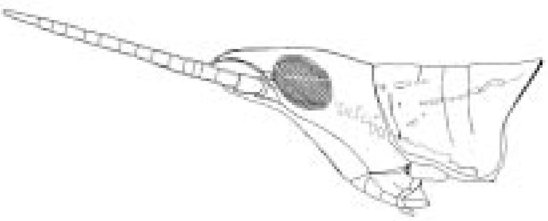
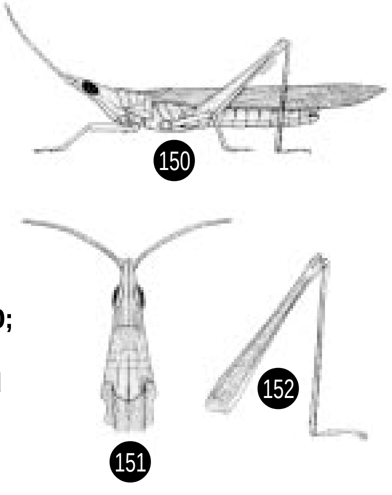


Fig. 149. ***Pyrgomorpha vignaudii*** **Guerin-Meneville, lateral view of head and pronotum (5.93X).**



Figs. 150–152. ***Pyrgomorpha cognata*** **Krauss, lateral view (150; 1.71X), dorsal view of head and pronotum (151; 2.34X), leg III (152; 2.67X).**

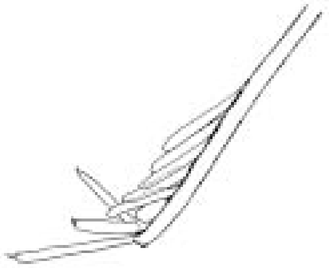
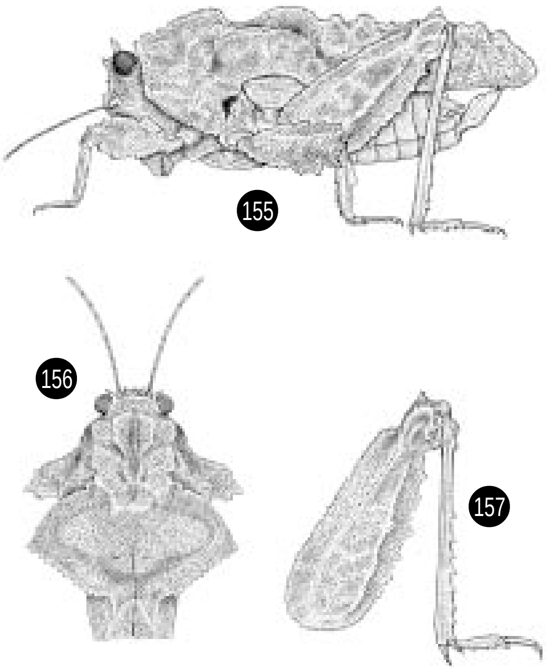


Fig. 153. ***Tridactylus*** **sp. A, lateral view of tibia III (15.6X).**

Fig. 154. ***Tridactylus*** **sp. B, lateral view of tibia III (12.76X).**



Figs. 155–157. ***Hancockia*** **sp., lateral view (155; 5.3X), dorsal view of head and pronotum (156; 6.2X), and leg III (157; 7.9X).**

22(21') Pronotum brown dorsally and black laterally, not surpassing the tip of cerci and the knee, transverse groove not distinct, lateral side (pleuron) roughened by short and rounded pebble-like warts and bears three transverse furrows, posterolateral angle moderately rounded; paired ocelli relatively larger; antenna 16-segmented, scape and pedicel with small grayish brown warts similar to those in frontal ridge and femora; femur III with 10 spines in the outer row; body length 10 mm ....*Coptotettix* sp**. [Figs. 158–160]**

22' Pronotum not as above; antennal segments less than 16 segments; body length more than 13 mm 23

23(22') Dull light brown with a black tinge between the shoulder; median pronotal ridge elevated on a small hump along the transverse furrow; propleuron with pale gray brown shades below the transverse furrows; posterolateral lobe long, rounded at apex, prominently projected to coxa II; mesopleuron and metapleuron black to gray similar to femora I and II; femur III with 5 oblique ridges; knee reaches tip of abdomen; tibia III with 7 spines in the outer row; body length 13 mm ....*Paratettix scaber* (Thunberg) **[Figs. 161–163]**

23' Black species with a broad transverse white band between the shoulder; median pronotal ridge elevated on a large hump along the transverse furrow; propleuron black with white small tubercles, mottles and spots as in the head, thorax, legs and posterior segments of abdomen; posterolateral lobe short and slightly projected to coxa II; femur III with 5–7 oblique rows of ridges with peg-like spines; knee prominently beyond tip of abdomen; tibia III with 8 spines in outer row; body length 14.5 mm .... *Paratettix dorsifer* (Walker) **[Figs. 164–166]**

Order Mantodea

[Family **Hymenopodidae**] *(represented by a single genus)*

Pseudocreobotra sp. **[Fig. 167]**

Foreleg raptorial with very large movable coxa, femur and tibia spinous; apices of femora II and III enlarged; tarsus 5-segmented; head with a process on vertex; pronotum laterally expanded; fore wing green with a large circular or eye-ring pattern; abdomen laterally exposed, uncovered by wings at rest.

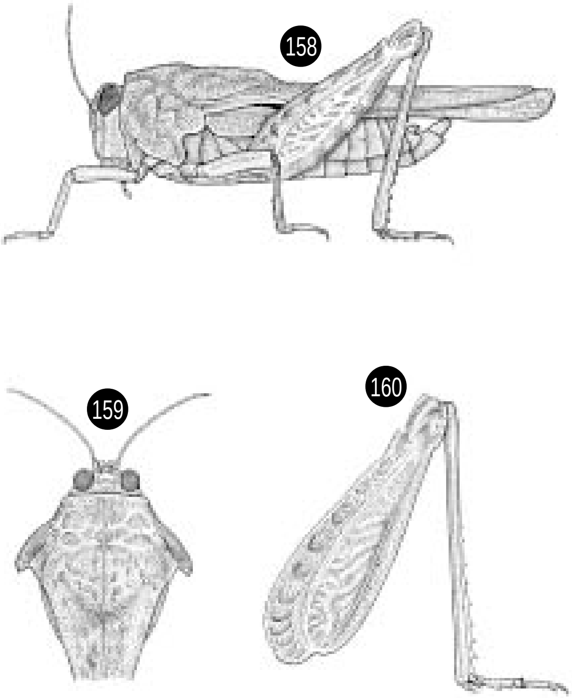
Order Coleoptera

Beetles

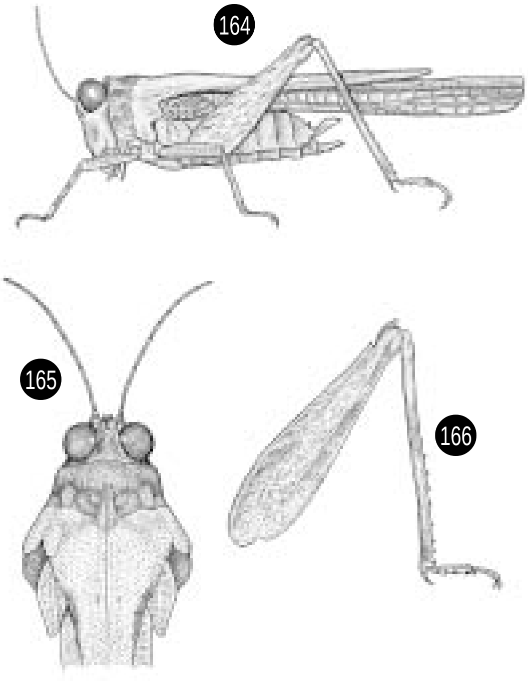
1 Coxa III fused to the metasternum dividing the basal visible abdominal sternite into two lateral portions; hypomeron narrow, notopleural sutures and lateral margins of prothorax present; metasternum with a transverse suture anterior of coxa III; antenna 11-segmented, filiform and inserted between the eyes and mandible; fore tibia with a tibial comb or cleaning organ [Family **Carabidae**] 2

1' Coxa III movable, separated from metasternum and not dividing the basal visible abdominal sternite into 2 lateral portions; notopleural suture absent; hypomeron broad; antenna dorsal, not inserted between the eyes and mandibles 20

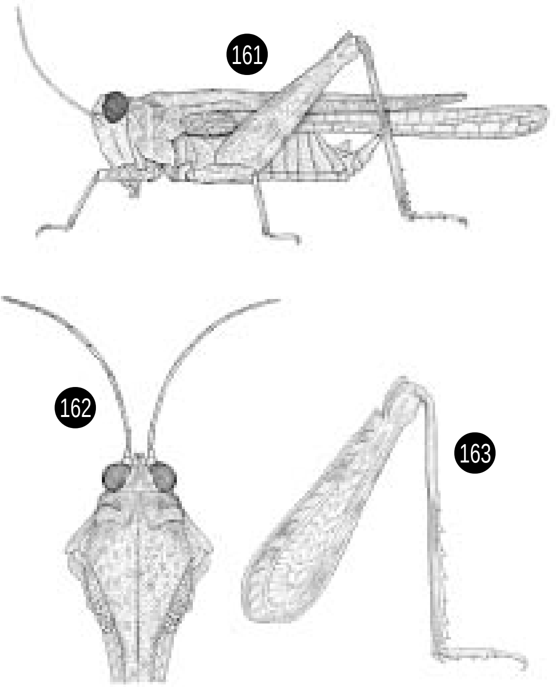
2(1) Elytra black except yellow margins, truncate anteriorly with at least 8 longitudinal ridges and a yellow median zigzag transverse spot; two abdominal segments exposed posteriorly; pronotum brown, as long as wide with a long bristle on each midlateral side; head brown except silvery white eyes, smooth similar to pronotum; labrum more or less truncate with 6 hairs arranged in a



Figs. 158–160. ***Coptotettix*** **sp., lateral view (158; 5.6X), dorsal view of head and pronotum (159; 7.25X), and leg III (160; 6.9X)**



Figs. 164–166. ***Paratettix dorsifer*** **(Walker), lateral view (164; 4.3X), dorsal view of head and pronotum (165; 6X), and leg III (166; 5.7X).**



Figs. 161–163. ***Paratettix scaber*** **(Thunberg), lateral view (161; 4X), dorsal view of head and pronotum (162; 7X), and leg III (163; 7X).**

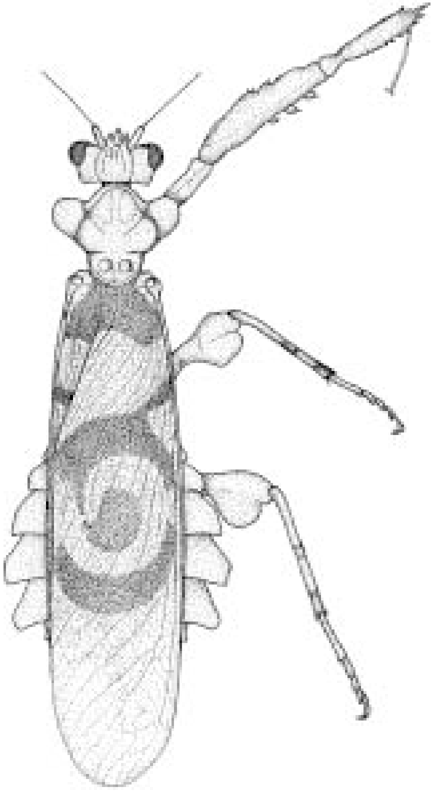


Fig. 167. ***Pseudocreobotra*** **sp., dorsal view (2.3X).**

transverse row; antenna brown similar to the legs, posteroventral tip of femora I–III with a black spot; body length 20 mm .... *Pheropsophus cincticollis* Ferte-Senectere **[Fig. 168]**

2’ Elytral coloration and pattern variable 3

3(2’) Labrum toothed or anteriorly serrate; mandible covered by labrum or exposed, usually with two long inner teeth; legs, abdominal venter, propleuron and lateral margins of pronotum with white hairs 4

3’ Labrum often truncate, not serrated anteriorly; mandibles without long inner teeth; body without white hairs 9

4(3) Labrum with 7 teeth and 4 long setae arranged in a transverse line, yellow along median; head and prothorax metallic blue and shiny; elytra coarsely punctured, dull bluish black; body length 12 mm .... *Prothyma* cf. *versicolor* Dejean **[Fig. 169]**

4’ Labrum with 1–5 teeth and 4–10 long setae; elytra with yellow markings 5

5(4’) Labrum with 5 teeth and 5–6 setae 6

5’ Labrum with 1–3 teeth and 4–10 long setae 7

6(5) Labrum sharply pointed midanteriorly with 6 setae almost covering entire mandibles; antennal segments I–IV not metallic; elytra bluish green with two black spots in the middle and in the posterior one-third, margins covered by a distinctly broad yellow longitudinal band with 3 inner branches resembling the letter E; body length 12.5 mm .... *Cicindela* (*Lophyra*) *luxeri* Dejean **[Figs. 170, 171]**

6’ Labrum convex and serrated anteriorly with 5 setae; dull black with metallic blue luster in the antennal segments I–IV, beneath the eye and lateral margins of elytra; black elytra with a distinctly long yellow marginal band not reaching apical spines, two small yellow spots present in the midbasal one-fifth and at midlength; body length 18–20 mm .... *Cicindela* sp. **[Figs. 172, 173]**

7(5’) Labrum with 5–7 setae and 3 teeth; mandibles yellow except blackish brown teeth; elytra dull black with brownish yellow tinge, margins yellow forming loops outside and inside of the humeral area, inside loop inverted J-like, succeeding marginal yellow band form two oblique letter Es on top of each other, suture with a lanceolate yellow band .... *Cincidela* (*Lophyra*) nr. *catena* Fabricius **[Fig. 174]**

7’ Labrum with 4 or 10 long setae and 1–3 teeth along anterior margin 8

8(7’) Labrum with 4 setae and 3 teeth along anterior margins; mandibles black exposing 2 long inner teeth; elytra black with fine and even punctures, each elytron bears 2 yellow spots above and below midlength, margins yellow with 5 inward branches, second and fourth the longest reaching midelytron; body length 9–10 mm .... *Cicindela* (*Lophyra*) sp. **[Figs. 175, 176]**

8’ Labrum with 10 white long setae and an anterior median tooth; elytra with 2 rounded yellow spots in anterior one-third and below midlength, lateral margins with a C-band along the shoulder, r-band in the middle and an r- or c-band towards tip; body length 8.5 mm .... *Cicindela* (*Ifasina*) sp**. [Fig. 177]**

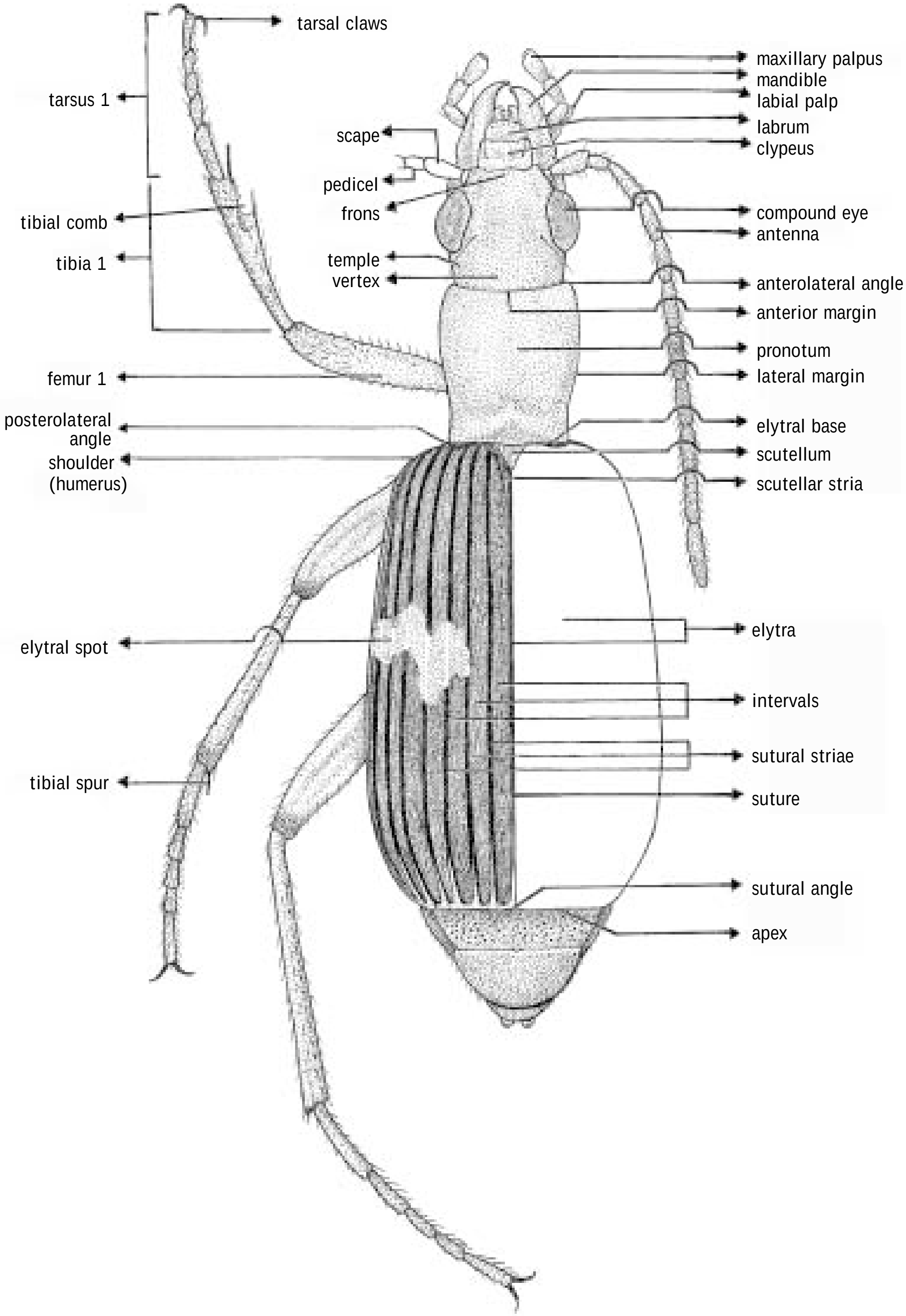


Fig. 168. ***Pheropsophus cincticollis*** **Ferte-Senectere, dorsal view (6.31X).**

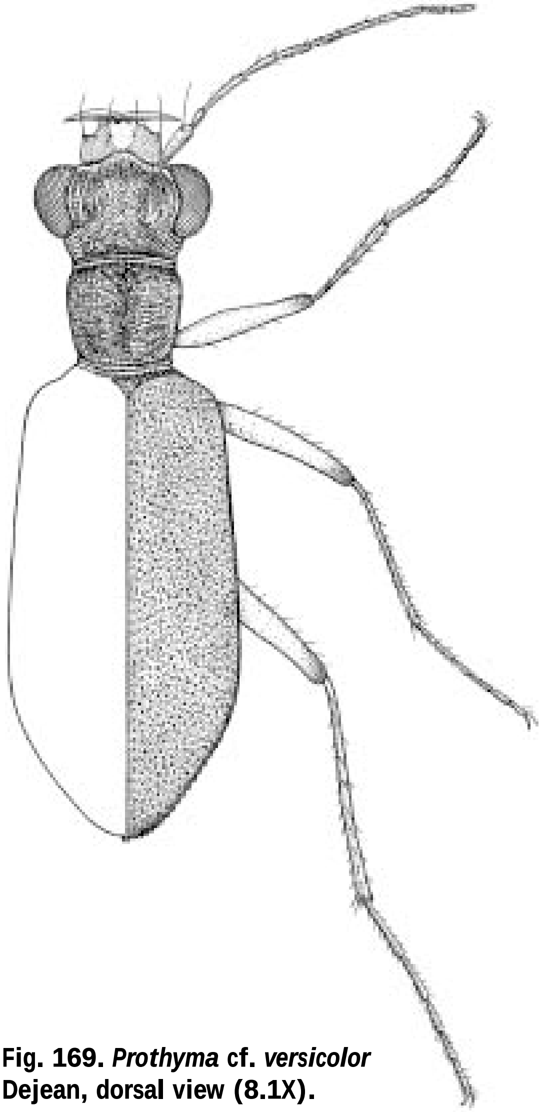


Fig. 169. ***Prothyma*** **cf.** ***versicolor*** **Dejean, dorsal view (8.1X).**

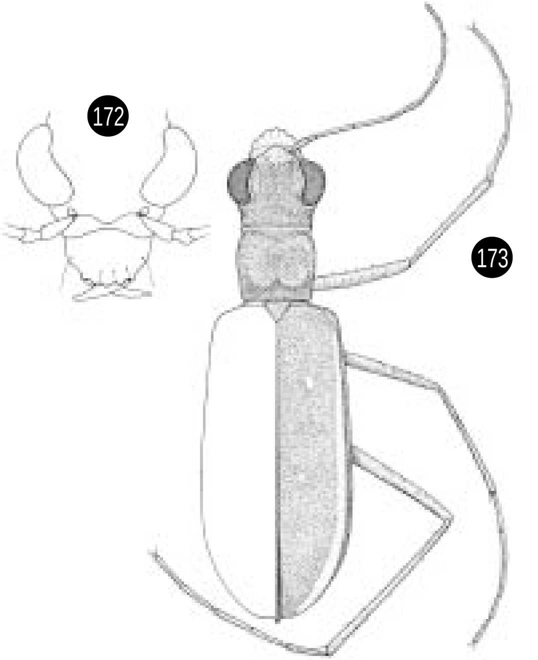
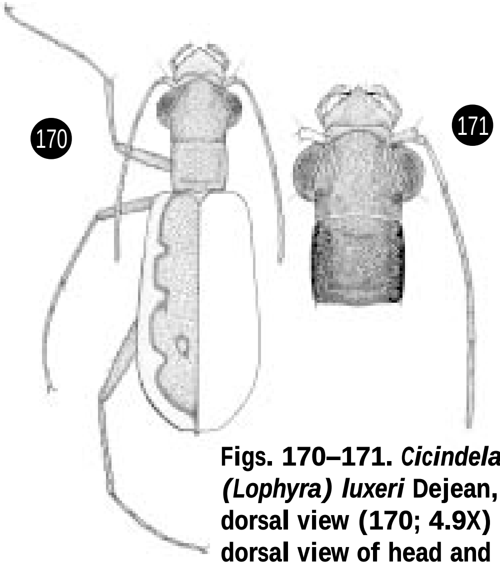


Fig. 172–173. ***Cicindela*** **sp., dorsal view (172; 6X) and frontal view of head (173; 3.6X).**



Figs. 170–171. ***Cicindela (Lophyra) luxeri*** **Dejean, dorsal view (170; 4.9X) and dorsal view of head and pronotum (171; 6.75).**

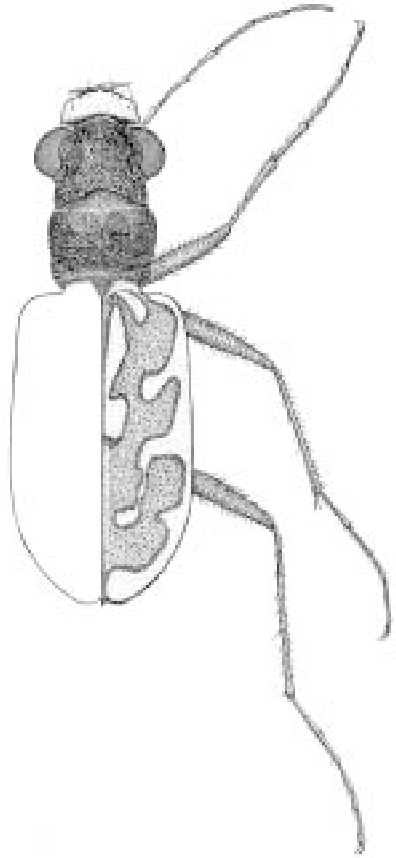
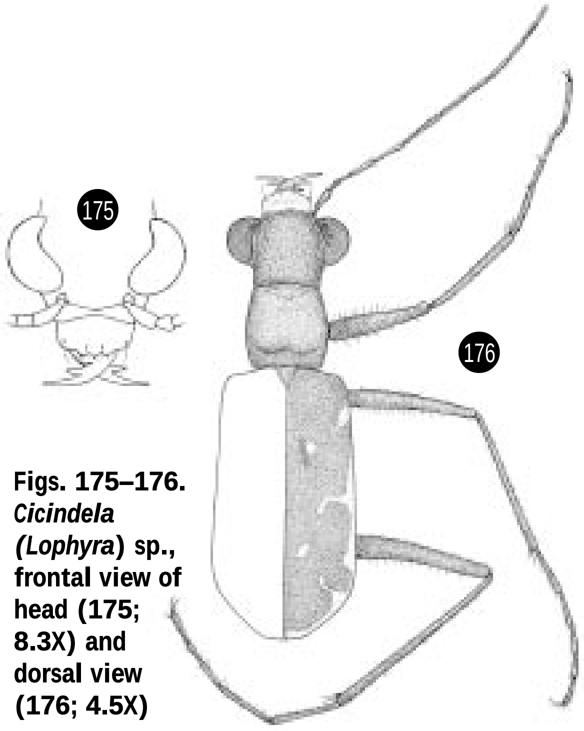


Fig. 174. ***Cicindela (Lophyra)*** **nr.** ***catena*** **Fabricius, dorsal view (5.9X).**



Figs. 175–176. *Cicindela (Lophyra)* sp., frontal view of head (175; 8.3X) and dorsal view (176; 4.5X)

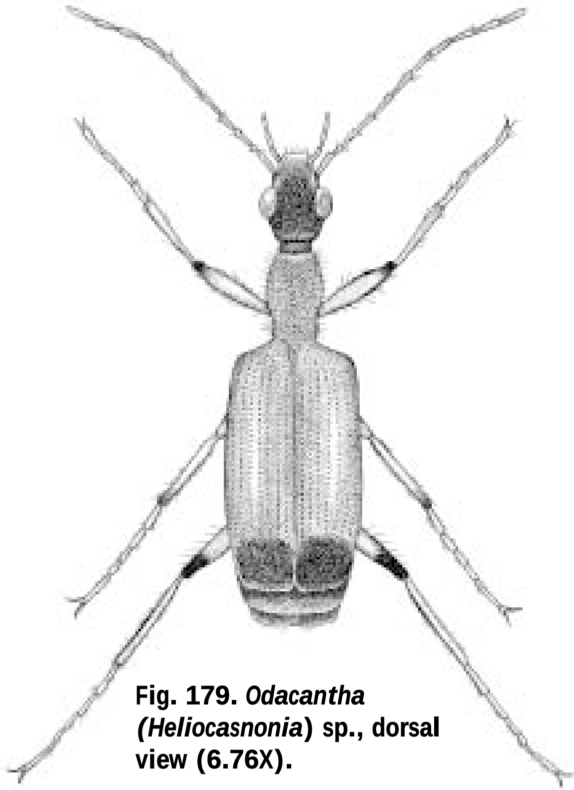


Fig. 179. *Odacantha (Heliocasnonia)* sp., dorsal view (6.76X).

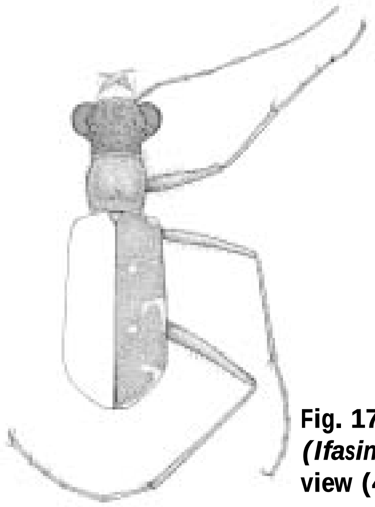


Fig. 177. *Cicindela (Ifasina)* sp., dorsal view (4.0X).

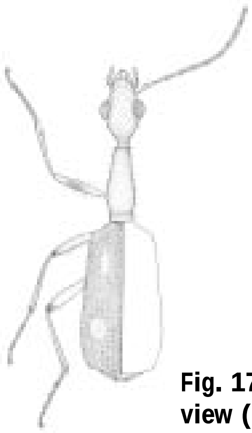
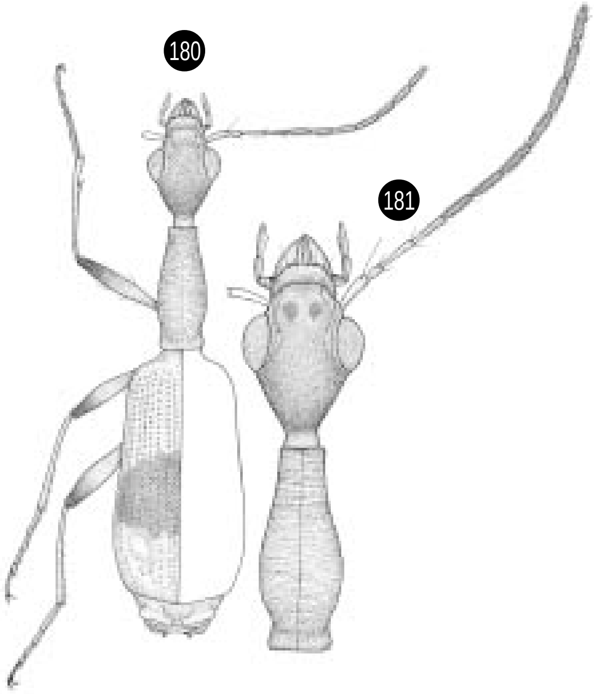


Fig. 178. *Odacantha* sp., dorsal view (4.44X).



Figs. 180–181. *Archicolliuris* cf. *dimidiata* Chaudoir, dorsal view (18; 6.75X) and dorsal view of head and pronotum (181; 17X).

9(3’) Pronotum prominently longer than wide, usually cylindrical 10

9’ Pronotum not cylindrical, often as wide as long to wider than long 15

10(9) Pronotum with a lateral groove 11

10’ Pronotum without lateral groove 12

11(10) Pronotum reddish brown, barrel-shaped with transverse striae, lateral groove with 10 setae each; head black with two pairs of supraorbital setae; labrum truncate; elytra black to reddish brown with erect hairs, a pair of brown spots anteriorly and a pair of white spots posteriorly; legs hairy particularly the femora; general coloration black; body length 7.2 mm .... *Odacantha* sp. **[Fig. 178]**

11’ Pronotum black with dense fine punctations, widest at midlength, lateral grooves distinctly parallel to each other and lined with more than 10 setae in each row; black head with 7 supraorbital setae; labrum slightly emarginate; brown elytra with a posterior black spot each; legs brown with black apices of all femora; body length 7.4 mm .... *Odacantha* (*Heliocasnonia*) sp. **[Fig. 179]**

12(10’) Pronotum orange red with transverse striae dorsally and ventrally without hairs; head black smooth and shiny with 2 supraorbital setae; elytra orange red with a broad transverse black band almost at midhalf and a pair of white spots posterior of band; body length 8 mm .... *Archicolliuris* cf. *dimidiata* Chaudoir **[Figs. 180, 181]**

12’ Pronotum orange, without transverse striae; elytra usually metallic to dull blue 13

13(12’) Antennal segment I very long, as long as head width across eyes; labrum trilobed with 6 setae; shiny blue head and orange pronotum coarsely punctated and moderately hairy; elytra blue without spots and hairy; body length 9 mm .... *Drypta* sp. **[Figs. 182, 183]**

13’ Antennal segment I short, less than half of head width across eyes; labrum truncate with less than 6 setae; elytra not hairy 14

14(13’) Pronotum and head densely punctated; black head coarsely punctured dorsally, laterally and ventrally, posterior lateral margin behind the eye relatively straight and oblique; antennal segments dark brown except yellow brown scape; elytra slightly lustrous blue; apical one-half of femora dark brown; body length 7.3 mm .... *Eucolliuris* sp. A **[Figs. 184, 185]**

14’ Pronotum and head sparsely punctured; shiny black head with fine punctations dorsally and ventrally, unpunctated laterally; lateral side of head behind the eyes smooth and rounded; antenna dark reddish brown with yellow segments I, II, basal two-thirds of III, and basal one-half of IV; elytra metallic lustrous blue; apices of femora black; body length 7. 5 mm .... *Eucolliuris* sp. B **[Figs. 186, 187]**

15(9’) Pronotum orange red with lateral constriction subposteriorly; head coarsely punctured and slightly flat; neck reddish brown 16

15’ Pronotum black to metallic blue 17

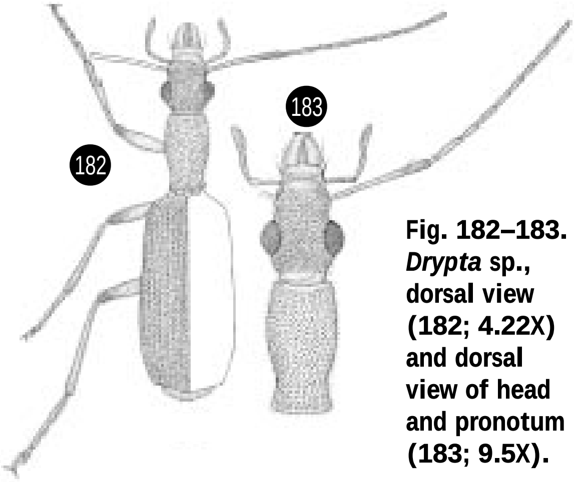
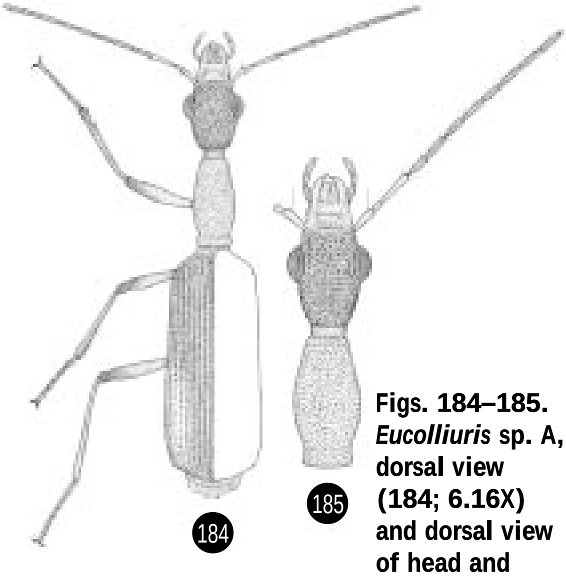
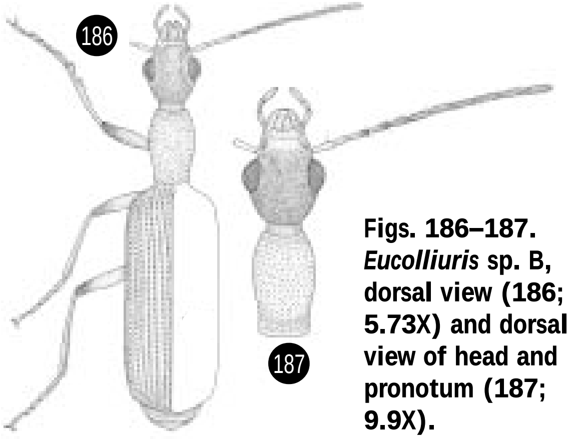


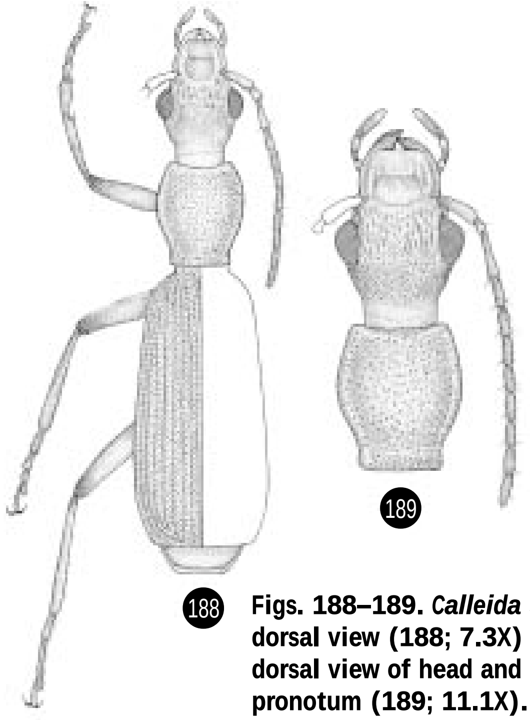
Fig. 182–183. *Drypta* sp., dorsal view (182; 4.22X) and dorsal view of head and pronotum (183; 9.5X).



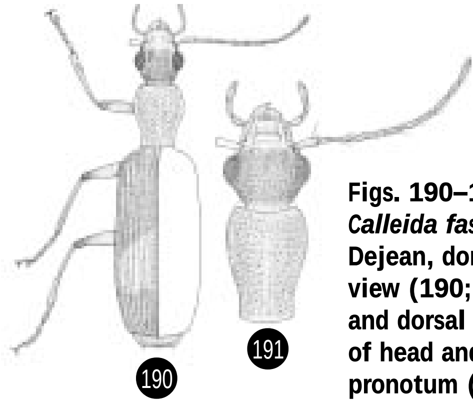
Figs. 184–185. *Eucolliuris* sp. A, dorsal view (184; 6.16X) and dorsal view of head and pronotum (185; 13.4X).



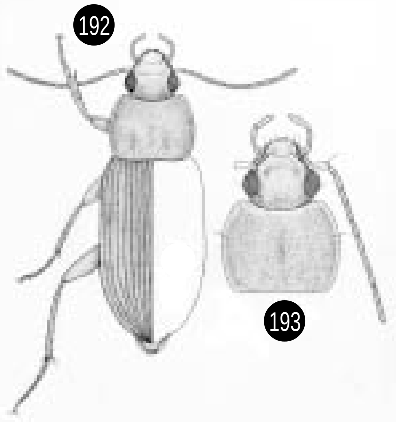
Figs. 186–187. *Eucolliuris* sp. B, dorsal view (186; 5.73X) and dorsal view of head and pronotum (187; 9.9X).



Figs. 188–189. *Calleida* sp., dorsal view (188; 7.3X) and dorsal view of head and pronotum (189; 11.1X).



Figs. 190–191. *Calleida fasciata* Dejean, dorsal view (190; 4.8X) and dorsal view of head and pronotum (191; 7.7X).



Figs. 192–193. *Hyrparpalus holosericeus* Dejean, dorsal view (192; 3X), and dorsal view of head and pronotum (193; 4.5X).

16(15) Elytra uniformly metallic blue green; antennae reddish brown except black tips and dark reddish brown segments III and IV; labrum notched midanteriorly ....*Calleida* sp. **[Figs. 188, 189]**

16' Elytra blue green with a broad transverse yellow brown band in the middle; antenna uniformly brown; labrum truncate anteriorly .... *Calleida fasciata* Dejean **[Figs. 190, 191]**

17(15') Elytra dull black without spots or marks, margins brown, posterior tip obliquely truncate exposing last abdominal segment; pronotum black with brown margins, anteriorly concave, posteriorly truncate and evenly convex laterally; labrum with 6 setae; body length 11.5 mm.. .... *Hyrparpalus holosericeus* Dejean **[Figs. 192, 193]**

17' Elytra with markings 18

18(17') Elytra with a pair of subglobular yellow spots in posterior one-third; head and pronotum metallic blue; pronotum more densely punctated than head; antenna brown except black reddish brown segments IV–VI; margins of labrum with 6 setae; body length 11 mm ....*Ocybatus discicollis* Ferte-Senectere **[Figs. 194, 195]**

18' Elytra with different markings; pronotum smooth 19

19(18') Both head and pronotum smooth and metallic blue; elytra black with fine white hairs and an inverted J- or C-shaped yellow band posteriorly; body length 13.5 mm .... *Pachydinodes conformis* Dejean **[Figs. 196, 197]**

19' Head black except brown labrum, anterior clypeus and mandibles; pronotum brown marginally with black to dark brown areas medially; elytra yellow brown in outer one-half, dark brown in the other half towards the suture; body length 8 mm .... *Aulacoryssus* sp. **[Figs. 198, 199]**

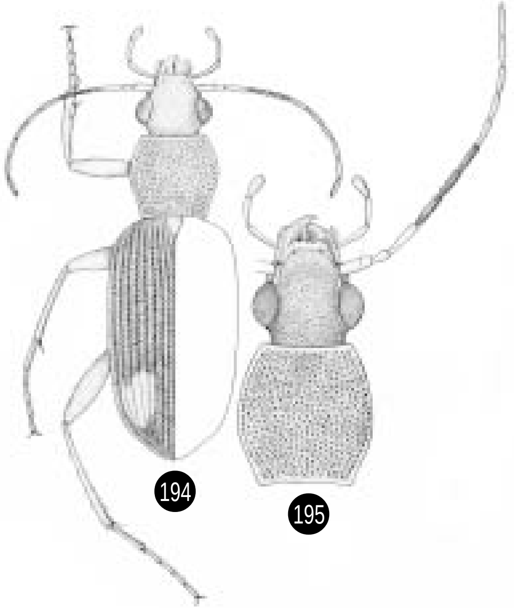
20(1') Abdomen with 6 or 7 visible sternites and 5 exposed tergites; labial palp 3-segmented; prothorax smooth, orange red with a longitudinal row of hairs on each side, shortly elongate and subcylindrical; head moderately flat and uniformly black except labrum yellow and antenna yellowish brown dorsally and ventrally with long brown hairs; short and bluish elytra punctated, covered with fine silvery hair; abdomen orange red similar to pronotum except black terminal segment; leg I yellow brown, II blackish brown except yellow basal three-fourths of femur and III almost black with basal half of femur yellow; tarsi with 2 equal claws [Family **Staphylinidae**].. .... *Paederus fuscipes* Curtis **[Figs. 200, 201]**

20' Not as above 21

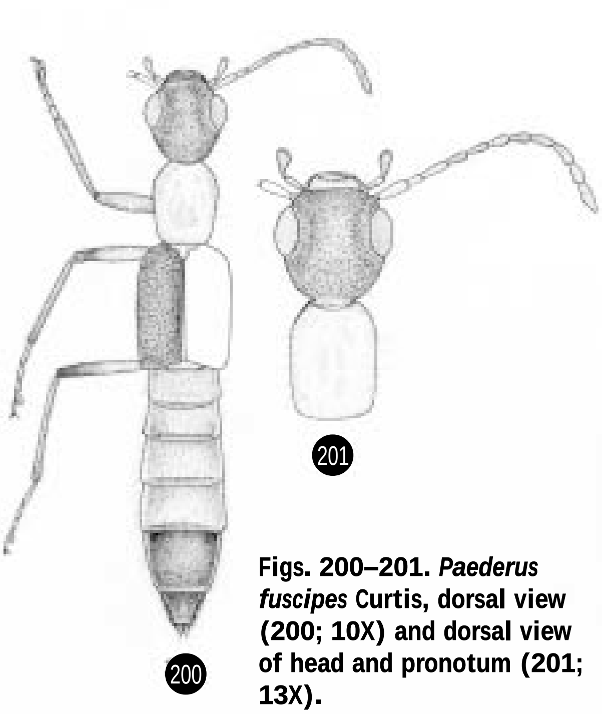
21(20') Elongate bodied beetles with 'clicking' mechanism made by the long prosternal process and by an anteriorly open mesosternal cavity; posterolateral area of pronotum elongated, pointed and spine-like; antennae usually serrate; tarsi simple or bilobed segments 3 and 4 [Family **Elateridae**] 22

21' Beetles without "clicking mechanism", long posternal process absent......... 24

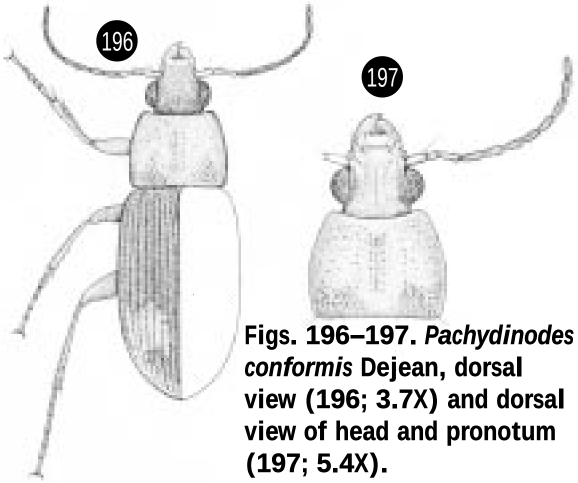
22(21) Entire body including scape, femur and tibia uniformly covered by clubbed setae; head with a laterally expanded frons partly covering the eyes; pronotum strongly convex along anterior three-fourths and flat posteriorly; dark brown to grayish brown; body 9 mm long .... *Agrypnus* sp. **[Figs. 202, 203]**



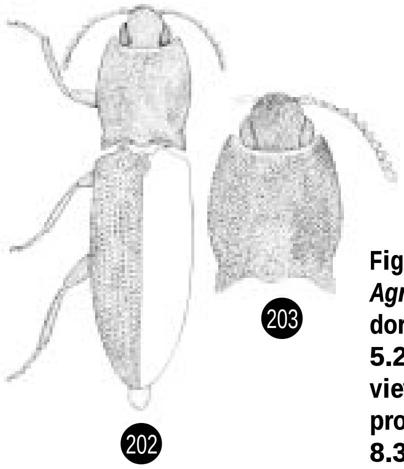
Figs. 194–195. *Ocybatus discicollis* Ferte-Senectere, dorsal view (194; 3.95X) and dorsal view of head and pronotum (195; 7.8X).



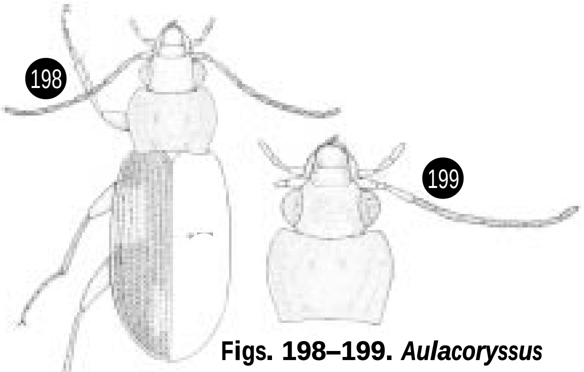
Figs. 200–201. *Paederus fuscipes* Curtis, dorsal view (200; 10X) and dorsal view of head and pronotum (201; 13X).



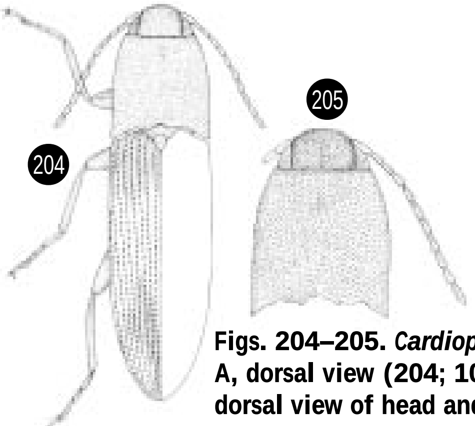
Figs. 196–197. *Pachydinodes conformis* Dejean, dorsal view (196; 3.7X) and dorsal view of head and pronotum (197; 5.4X).



Figs. 202–203. *Agrypnus* sp., dorsal view (202; 5.2X) and dorsal view of head and pronotum (203; 8.3X).



Figs. 198–199. *Aulacoryssus* sp., dorsal view (198; 4.5X) and dorsal view of head and pronotum (199; 10.9X).



Figs. 204–205. *Cardiophorus* sp. A, dorsal view (204; 10.6X) and dorsal view of head and pronotum (205; 12.2X).

22’ Body covered with fine white hairs; smaller species 3.8-5.0 mm long 23

23(22’) Head and pronotum brown except basal half of pronotum yellow; elytra as wide as pronotum anteriorly, narrows posteriorly, dull yellow with pale brown anterior and a broad transverse black band below midlength; venter yellow except lateral edge of abdomen brown, legs yellow; body 3.8 mm long .... *Cardiophorus* sp. A **[Figs. 204, 205]**

23’ Head black; pronotum brown with a small black longitudinal band anteriorly; elytra brownish yellow with an inverted w-black band anteriorly and a V-black band posteriorly; venter brown with black spots on the lateral edges of abdomen; body 5 mm long..................... *Cardiophorus* sp. B **[Figs. 206, 207]**

24(21’) Head produced into a snout or rostrum; antenna elbowed with a short 1 or 3-segmented club and a long scape; prothorax without defined lateral margins; tarsi with 4th segment hidden in deeply bilobed 3rd segment 25

24’ Without the combination of above characters 32

25(24) Pronotum narrower than the strongly dome-shaped elytra; long rostrum uniformly curved downwards; trochanter moderately elongated, if not, antennal club very long [Family **Apionidae**] 26

25’ Not as above 29

26(25) Black snout beetle, body less than 5 mm long; pronotum with a ring-like constriction at anterior one-third; antennal club short, multisegmented; elytra strongly convex with prominent striae; trochanter moderately elongate; abdomen ovate or subglobular... 27

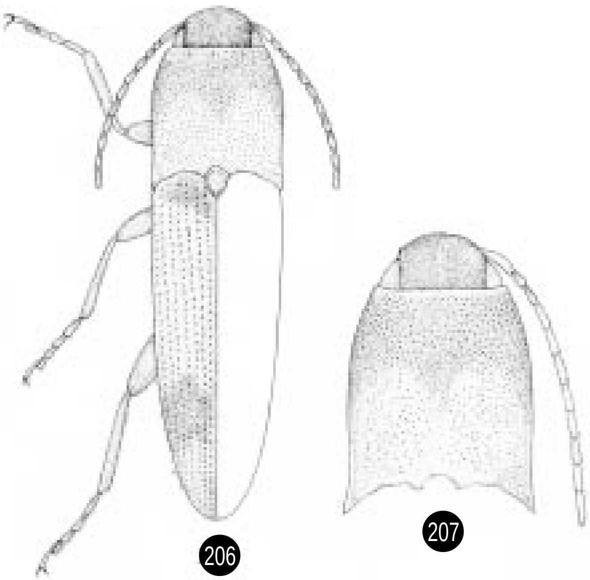
26’ Black to dark brownish red, more than 6 mm long; club of antenna single, very long; pronotum constricted in posterior one-third; elytra mostly smooth without deep longitudinal striae; trochanter short and oblique 28

27(26) Rostrum gently curved downwards with two shallow longitudinal grooves in front of eye and antenna arising behind midlength; head finely punctate with three low parallel ridges between eyes forming two shallow grooves; temple shallowly punctate; pronotum punctured similar to the head, nearly parallel-sided with two depressions laterally and anterolateral angle not bulged; metapleuron, abdominal venter and femora I–III all finely punctured; black, 2.6 mm long.. *Apion* sp. **[Figs. 208, 209]**

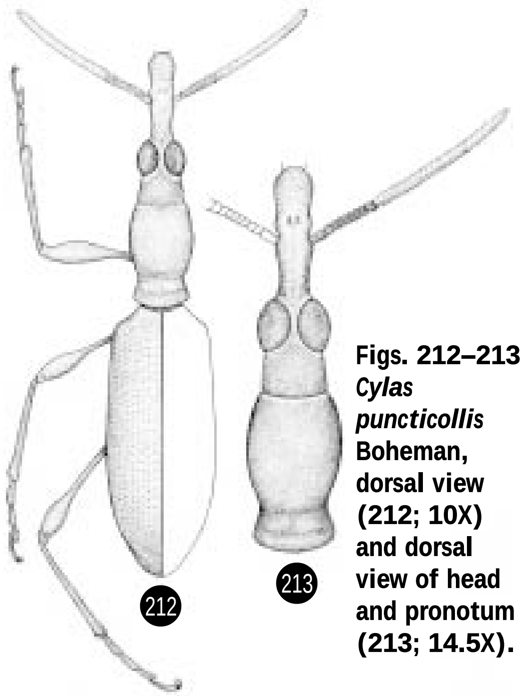
27’ Rostrum strongly curved downwards with two deep longitudinal punctated grooves in front of eyes; head coarsely punctured including temple and ridges close to the eyes prominent with a deep groove in between; pronotum deeply punctured, widest posteriorly and constricted along anterior one-third, terminating at a deep lateral pit, anterolateral angle strongly rounded forming a conical anterior pronotal margin; metapleuron, abdominal venter, femora and tibiae coarsely punctured; uniformly black, 4.8 mm long .... *Canopion* sp. **[Figs. 210, 211]**

28(26’) Vertex, temple and pronotum uniformly black and smooth; elytra, venter of metathorax and abdomen very finely punctured; legs black .... *Cylas puncticollis puncticollis* Boheman **[Figs. 212, 213]**

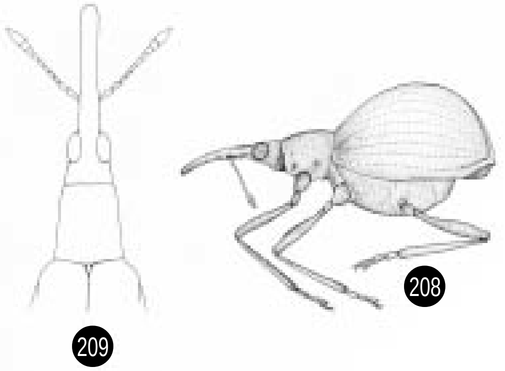
28’ Vertex, temple and midpronotum dark reddish brown, slightly punctured; elytra, abdominal and metathoracic venter and lateral sides of pronotum coarsely punctured; legs reddish brown................. *Cylas* sp. **[Figs. 214, 215]**



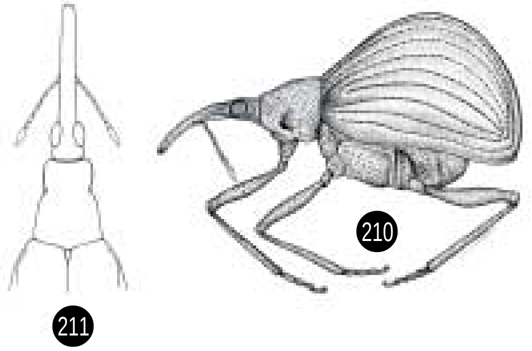
Figs. 206–207. ***Cardiophorus*** **sp. B, dorsal view (206; 16.8X) and dorsal view of head and pronotum (207; 24.6X).**



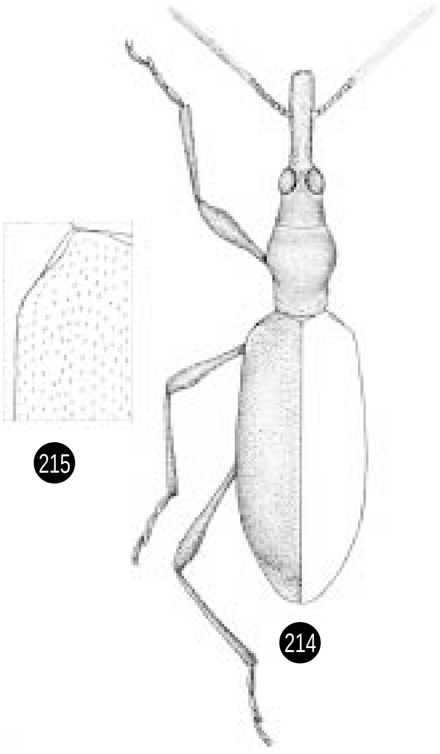
Figs. 212–213. ***Cylas puncticollis*** **Boheman, dorsal view (212; 10X) and dorsal view of head and pronotum (213; 14.5X).**



Figs. 208–209. ***Apion*** **sp., lateral view (208; 10.4X) and dorsal view of head, pronotum, and part of elytra (209; 14.8X).**



Figs. 210–211. ***Canopion*** **sp., lateral view (210; 20.5X) and dorsal view of head, prothorax, and part of elytra (211; 25.3X).**



Figs. 214–215. ***Cylas*** **sp., dorsal view (214; 10.3X) and close-up of elytral punctures (215; 25X).**

29(25') Antenna straight, scape short, club 3-segmented; eyes before or at midlength of head; rostrum apically expanded; vertex and temple smooth, well-rounded and extended behind the eyes; smooth pronotum narrowed anteriorly and broad posteriorly with a strongly concave midanterior margin and two transverse grooves anterior and posterior of the convex middorsum; elytra subrectangular with squarish punctures; uniformly brownish except dark brown antennae; body 6 mm long [Family **Attelabidae**] .... *Parapoderus fuscicornis* Fabricius **[Fig. 216]**

29' Antennae elbowed, scape very long; club 1–3 segmented; eyes close to posterior portion of head; rostrum usually not expanded at apex; vertex and temple coarse or moderately smooth; pronotal shape variable; elytra without subrectangular punctures; color variable; body small to moderately large [Family **Curculionidae**] 30

30(29') Antenna with very long scape, arises close to anterior head margin; head widest at eye area, midapical margin deeply notched, posterior end with 5–7 fine transverse ridges; pronotum and scape with club setae; distal half of femur enlarged; abdomen ovoid to subglobular; uniformly black; body length 6 mm .... *Mitophorus acerbus* Faust **[Figs. 217, 218]**

30' Antenna with short scape, arises close to eyes or at midlength of head; abdomen usually elongate 31

31(30') Pronotum as wide and almost as long as elytra with exposed abdominal tip, densely covered with rounded network of punctures; antenna 8-segmented with F1 shorter than F2 and F3 and short ovoid club smooth and 1-segmented; elytra coarsely punctured, intervals much narrower than strial punctures, often with 4 reddish spots; scutellar apex rounded; dark reddish brown; body less than 5 mm long .... *Sitophilus zeamais* Motschulsky **[Figs. 219, 220]**

31' Pronotum narrow, about one-third length of elytra that covers entire abdomen, without rounded network of punctures; antennae 11-segmented, elongated F1 a little longer than combined length of F2 and F3, all funicular segments blackish red, wider than long except F1, club 3-segmented with a tapered tip; elytra deep evenly spaced punctures covered with short, white fine hairs, scutellar apex with or without a tubercle; uniformly black; body length 14 mm .... *Gasteroclisus* spp. **[Figs. 221–224]**

32(24') Head large, abruptly narrowed posteriorly forming a narrow neck, eye oblique in side view; prominently indented opposite base of antenna; pronotum narrower than the head or elytra; elytra soft and entire; fore coxal cavities merged and open behind; coxae I and II elongate; tarsi 5-5-4 segmented; claws cleft or dentate; abdomen with 5 or 6 free sternites [Family **Meloidae**] 33

32' Head usually small; elytra always hard 39

33(32) Antennae long with slender segments, apical segments not club-like; body slender and elongate, grayish to black covered with very short and fine pubescence; ovoid eyes strongly oblique viewed laterally; head black; elytra without any spot and clothed with white short and fine hairs 34

33' Antennae moderately short with segments about as long as wide 37

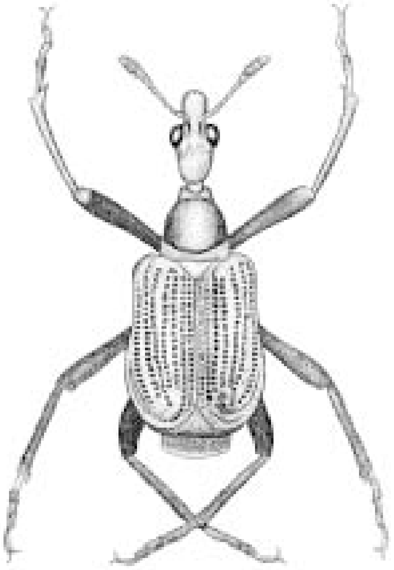
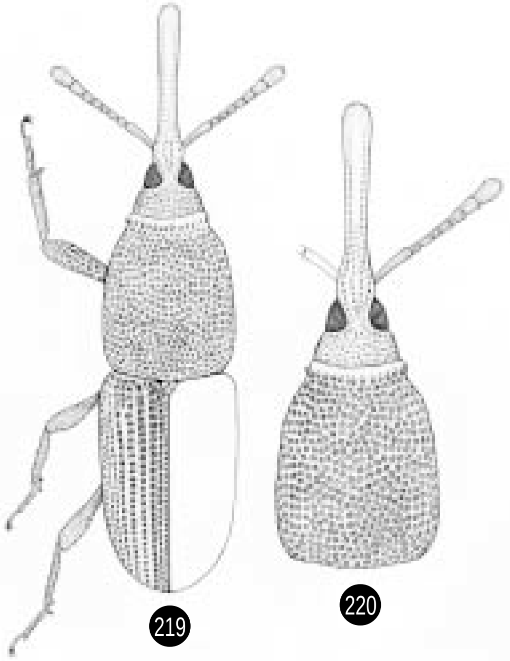
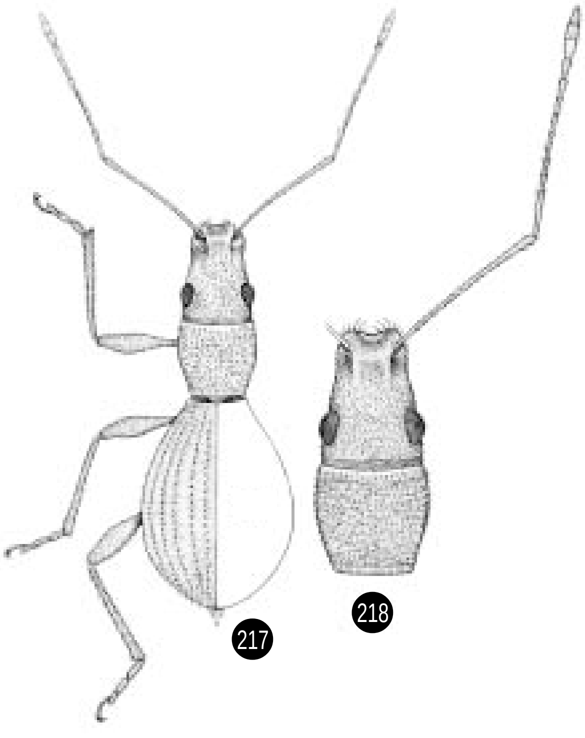


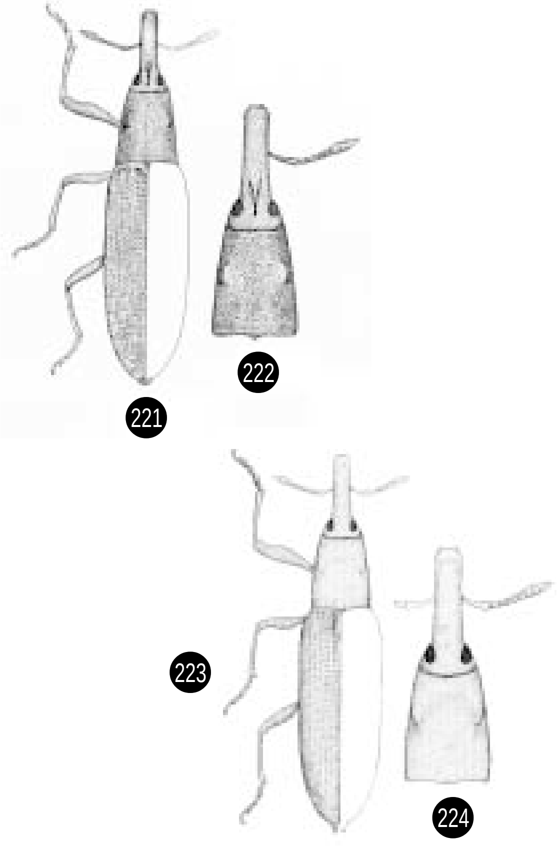
Fig. 216. *Parapoderus fuscicornis* Fabricius, dorsal view (7.2X).



Figs. 219–220. *Sitophilus zeamais* Motschulsky, dorsal view (219; 17.4X) and dorsal view of head and pronotum (220; 25X).



Figs. 217–218. *Mitophorus acerbus* Faust, dorsal view (217; 8.8X) and dorsal view of head and pronotum (218; 13X).



Figs. 221–224. *Gasteroclisus* spp., dorsal views (221, 5X; 223, 5X) and dorsal views of head and pronotum (222, 5.4X; 224, 5.4X).

34(33) Temple orange-yellow, lower portion with fine white hairs; head coarsely punctated; labrum with a yellow median notch; antennae black with reddish brown tinge, segment III (F1) as long as combined length of IV and V, V–XI flat and almost wider than long; entire body clothed with fine white hairs .... *Epicauta* sp. **[Fig. 225]**

34' Not as above 35

35(34') Uniformly black head, thorax and abdomen; legs black except reddish brown claws; tibia I–III with a pair of apicoventral spines; tip of the outer spine broad and somewhat hollow inside; antennae black except brownish yellow scape and pedicel, scape as long as or slightly shorter than the longest segment III; combined length of pedicel and funicular segment I as long as distance between eyes in frontal view; body length 18 mm .... *Cylindrothorax* sp. **[Fig. 226]**

35' Not as above, prothorax usually orange red 36

36(35') Body long and slender, approximately 20 mm long; clypeus and labrum not clearly differentiated into two rectangular plates separated by a deep transverse groove; femora I–III each with an outer longitudinal median groove; antennal segments long and slender, segment XI narrowed from midlength to tip producing a sharply pointed process; venter of thorax clothed with long white hairs; temple very high, its height more than one eye diameter viewed laterally........ *Cylindrothorax melanocephala* Fabricius **[Figs. 227, 228]**

36' Smaller, 11–14 mm long; clypeus and labrum prominent, labrum distinctly and transversely rectangular producing a deep transverse groove in between; all femora without longitudinal median groove; antenna long and slender with segment XI uniformly slender; venter of thorax with short fine white hairs; temple narrow, shorter than eye diameter viewed laterally .... *Cylindrothorax spurcaticollis* Fabricius **[Figs. 229–231]**

37(33') Elytra with an anterior pair of large ovoid orange yellow spots, almost converged basally and two broad orange yellow transverse bands in the median and below the median; laterally with a longitudinal orange yellow band below the shoulder; antennae orange-yellow except black scape and pedicel, funicular segments I, II, and III brownish yellow; head black, punctured and clothed with short hairs, vertex hairs projecting forward and frons hairs directed to each other; black, hairy and punctured pronotum with a subapical and posterior transverse groove and a median shallow pit; body length 18 mm .... *Mylabris* cf. *amplectens* Gerstacker **[Figs. 232, 233]**

37' Without the combination of the above characters 38

38(37') Elytra with two transverse yellow zigzag bands posterior of the elongate yellow anterior band, laterally with an elongate yellow L-band below humeri connected to the base of the anterior band; elytron with moderately long whitish yellow and black erect hairs; head coarsely punctured, frons with long yellow hairs, clypeus and labrum with long yellow hairs and a few much longer black hairs along margins, vertex with more black hairs than yellow hairs; pronotum prominently punctured similar to head clothed with long yellow hairs, with a shallow posterior groove and gently sloped anterior one-half; antennae black except orange yellow segments VI–IX .... *Mylabris* sp. A **[Figs. 234, 235]**

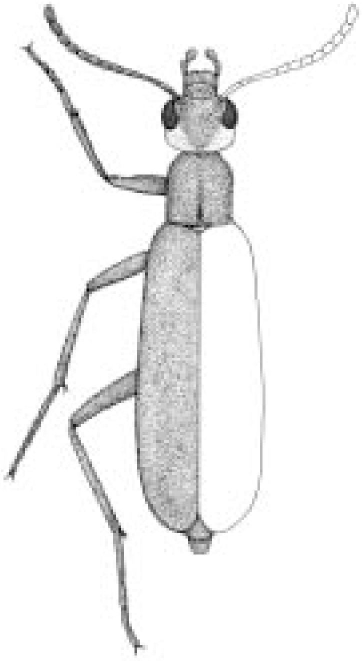
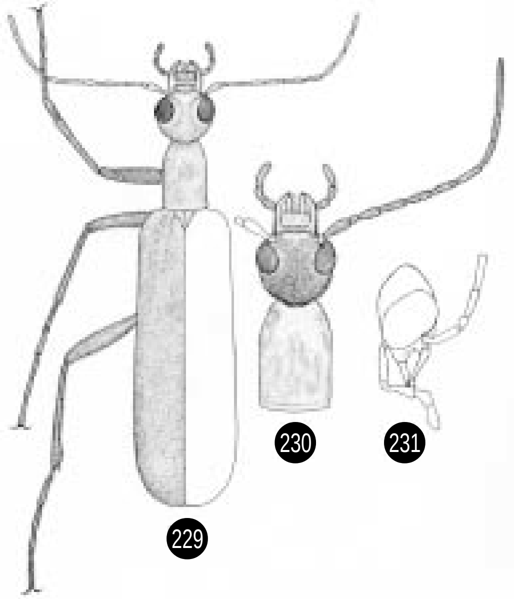


Fig. 225. ***Epicauta*** **sp., dorsal view (7X).**



Figs. 229–231. ***Cylindrothorax spurcaticollis*** **Fabricius, dorsal view (229; 4X), dorsal view of head and pronotum (230; 5.8X) and lateral view of head (231; 6.6X).**

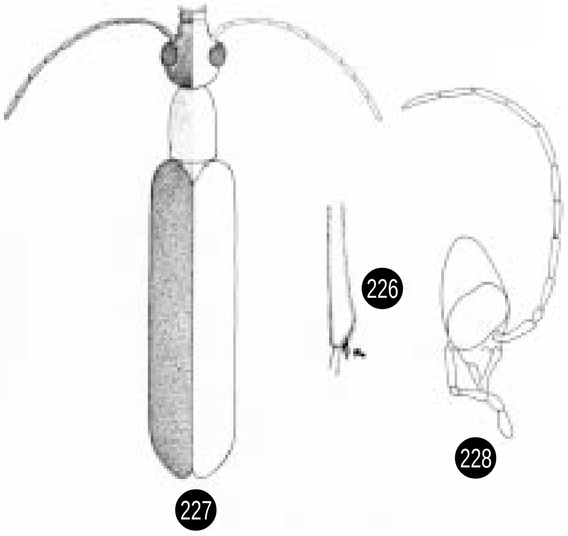
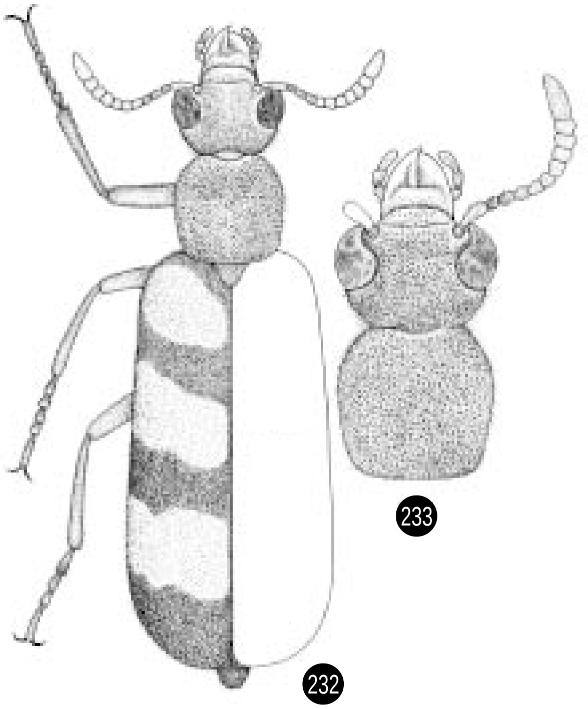


Fig. 226. ***Cylindrothorax*** **sp., lateral view of tibia III with a pair of apicoventral spines (3.3X).**

Figs. 227–228. ***Cylindrothorax melanocephala*** **Fabricius, dorsal view (227; 2.7X) and lateral view of head (228; 4.7X).**



Figs. 232–233. ***Mylabris*** **cf.** ***amplectens*** **Gerstacker, dorsal view (232; 3.7X) and dorsal view of head and pronotum (233; 5.6X).**

38’ Elytra with a broad yellow transverse median band, C-shaped posterior band and an oblongate yellow band anteriorly, all bands connected to each other along lateral margins up to the shoulder and the anteriorly elongated band; elytron clothed with long yellow hairs anteriorly and shorter ones posteriorly; head finely punctured with long silvery white hairs in frons, clypeus and labrum; white hairs on frons converging, vertex with short silvery hairs and long black hairs near the frons; pronotum prominently covered with long silvery white hairs, posteriorly with a median transverse groove; antennae black in segments I–II, brownish in III–IV, and orange red in V–XI .... *Mylabris* sp. B **[Figs. 236, 237]**

39(32’) Ant-like beetles; head strongly deflexed with small eyes; prothorax subcylindridcal, narrowed along posterior one-third; antenna 11-segmented; maxillary palps with a large securiform to pointed apical segment; elytra entire; tarsal segmentation 5-5-4 without epipleura and striae; abdomen with 5 sternites free [Family **Anthicidae**] 40

39’ Not ant-like in appearance; antennal and tarsal segmentation different 43

40(39) Pronotum widest along anterior one-third, finely punctated, moderately convex and narrow posteriorly terminating to a small transverse ring extended obliquely to coxa I; head finely punctated; elytra blackish brown to dark reddish brown with a pair of pale yellow brown spots near humeri, fine punctures without distinct striae; femora II and III less swollen than femur I ....*Anthicus* sp. **[Fig. 238]**

40’ Without the combination of the above characters 41

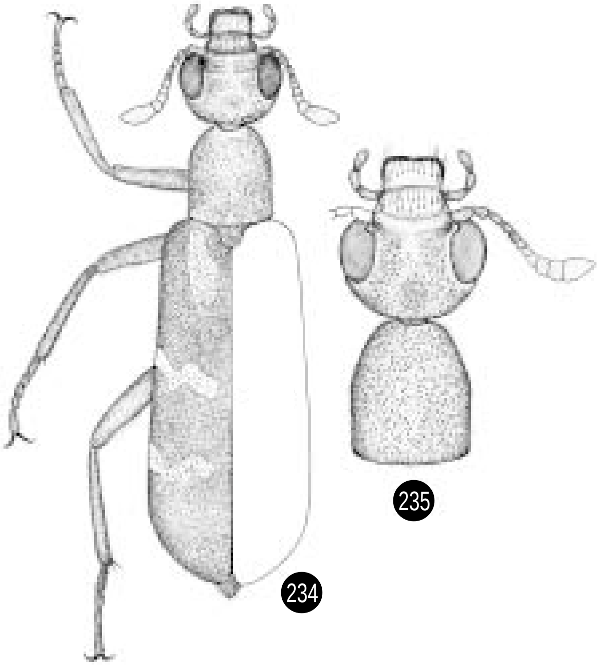
41(40’) Elytra smooth without a transverse white band of hairs, twice as long as pronotum; posterior lobe of pronotum at basal one-third, divided medially by a longitudinal shallow groove forming two small humps; anterior pronotal lobe smooth and subglobose with very fine white hairs, slightly longer than its height; head clothed with creeping light brown hairs; femur III with a black swollen apical half and a slender reddish brown basal half; general color black except dark brown antennae and dark brownish red elytra .... *Formicomus* sp. A **[Fig. 239]**

41’ Elytra with interrupted transverse band of white hairs near the humeri 42

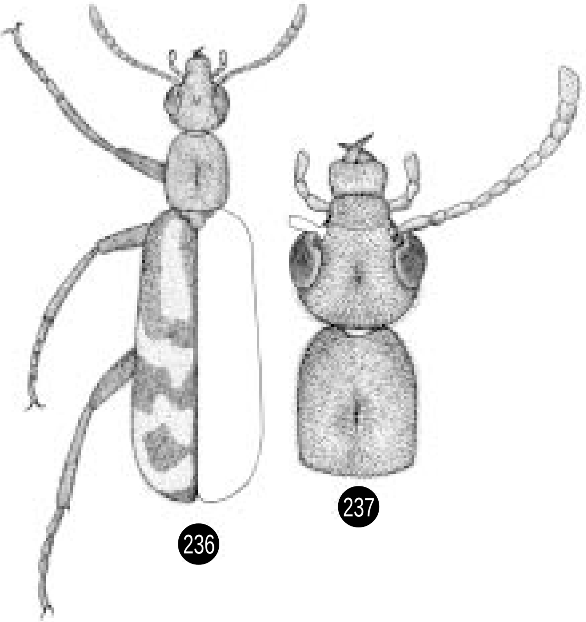
42(41’) Head, prothorax and venter of mesothorax dark brown to brownish red; antenna black except brown scape, pedicel and fumicular segments I–III, midposterior pronotum with hairs, not shiny and plate-like; elytra with a thick transverse white band in anterior one-fourth and a lighter but wider transverse white band in posterior one-fourth; legs black to dark reddish brown with brown basal one-third of femur III .... *Formicomus* sp. B **[Fig. 240]**

42’ Uniformly black except brownish antennal segments I–V; midposterior pronotum smooth, shiny, plate-like and hairless; anterior one-fourth of elytra with a transverse band of sparsely set white hairs; all legs black ....*Formicomus* sp. C **[Fig. 241]**

43(39’) Frons prominently developed over the antennal insertions; eyes deeply emarginate, wider than long pronotum strongly concave anteriorly and extended laterally; tarsus without lobed segment claws simple; abdomen with 5 basal 3 sternite segments fused; elytra covering sides of abdomen [Family **Tenebrionidae**] 44



Figs. 234–235. ***Mylabris*** **sp. A, dorsal view (234; 6.2X) and dorsal view of head and pronotum (235; 8X).**



Figs. 236–237. ***Mylabris*** **sp. B, dorsal view (236; 4.4X) and dorsal view head and pronotum (237; 9.4X).**

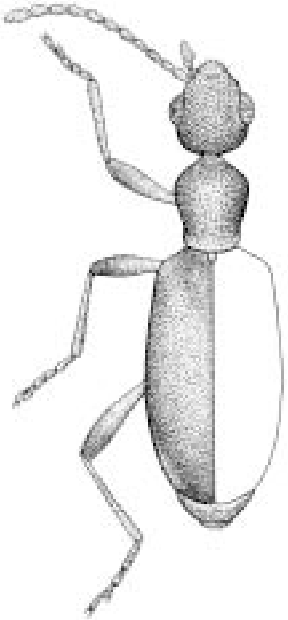


Fig. 238. ***Anthicus*** **sp., dorsal view (24X).**

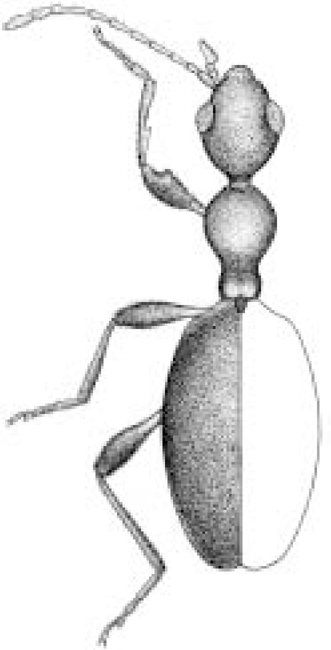


Fig. 239. ***Formicomus*** **sp. A, dorsal view (18X).**

43’ Frons not strongly developed over antennal bases 46

44(43) Lateral margins of pronotum nearly parallel; head, pronotum and elytra coarsely punctured, without hairs; broad midanterior notch present in the head; elytral striae distinct, without clubbed hairs; first funicular segment of antennae almost as long as second .... *Tenebrio* sp. **[Figs. 242, 243]**

44’ Lateral pronotal margins strongly convex, elytra and pronotum covered with appressed clubbed hairs 45

45(44’) Midanterior part of head with a moderate notch; eyes visible from above rounded; apical end of elytra rounded, elytral striae with 1–2 rows of clubbed hairs .... *Gonocephalum* sp. A **[Figs. 244, 245]**

45’ Midanterior part of head with a deep notch; eyes moderately elongate, oblique and converging anteriorly; elytral striae with 3–4 rows of clubbed hairs .... *Gonocephalum* sp. B **[Figs. 246, 247]**

46(43’) Head, pronotum, and elytra uniformly punctured and setose; eyes strongly emarginate; antenna with moderately long terminal segment; pronotum subcylindrical and broadest at midhalf, margins ill-defined; leg strongly hairy with slender tibia without spur; tarsal segmentation 5-5-4 with long basal segment, claws simple, penultimate segment widely lobed underneath apical segment; spongy ventrally; abdomen with 5 visible sternites
[Family **Lagriidae**] 47

46’ Without the full combination of above characters 48

47(46) Elytra black; head, pronotum and elytra coarsely punctured, densely covered with erect white hairs; generally black with bluish luster in the pronotum; antennae black, segments globose except III and XI; clypeus with a wide anterior notch; femur and tibia with long white hairs .... *Lagria villosa* Fabricius **[Fig. 248]**

47’ Elytra lustrous brown; head, pronotum and elytra sparsely covered with erect white hairs, antenna blackish brown, terminal segment elongate and longer than combined length of segments VIII, IX, and X; clypeus with a wide V-shaped notch; femur and tibia with moderately long white hairs .... *Chrysolagria cuprina* Thomson **[Figs. 249, 250]**

48(46’) Body strongly convex or rounded; head deflexed, deeply sunk into the prothorax; lateral edge of pronotum strongly curved; antennae with a 3-segmented club; terminal segment of maxillary palp large and securiform; coxa I close together and transverse; tarsal segmentation 4-4-4, 3rd segment hidden; claws toothed beneath; abdomen with 5 or 6 visible sternites
[Family **Coccinellidae**] 49

48’ Body not strongly convex; head not deflexed; tarsal claws simple 58

49(48) Small, less than 2 mm long; globose black with oblique brown spot running from shoulder to midwidth of elytra; entire body with fine white pubescense ... . *Scymnus* sp. **[Fig. 251]**

49’ Moderately large, more than 2 mm long; elytra with different markings; entire body without white hairs 50

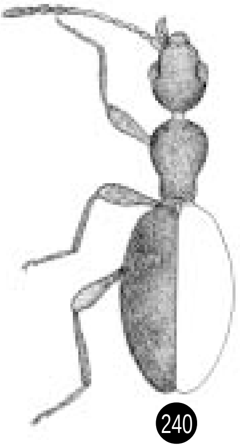
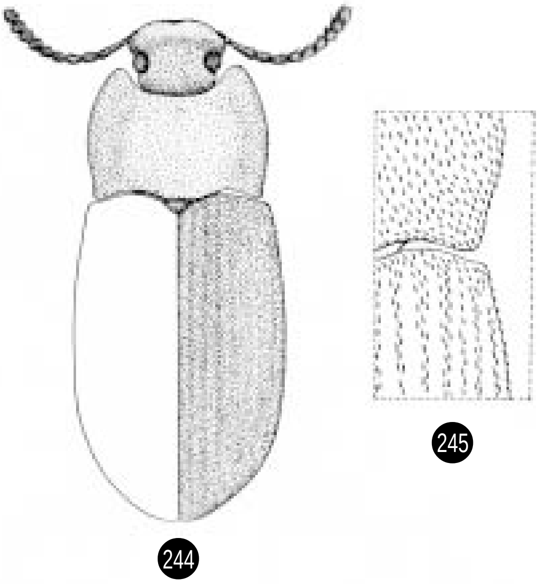
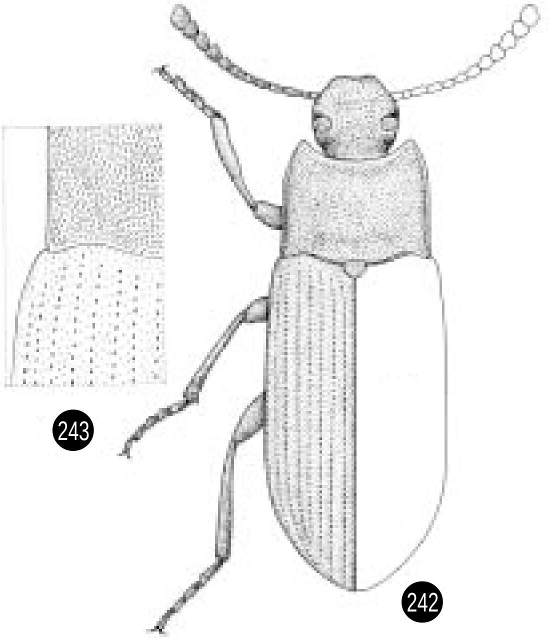


Fig. 240. *Formicomus* sp. B, dorsal view (12.6X).

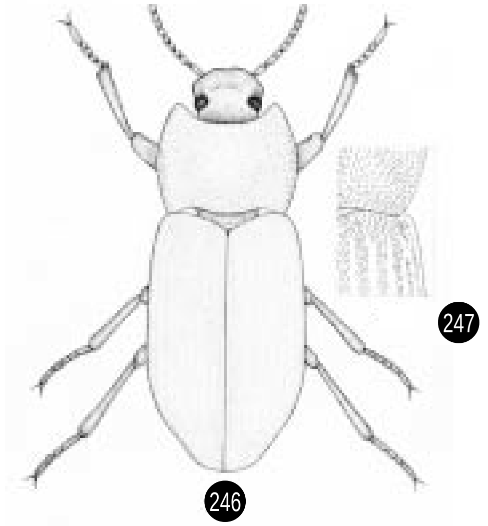
Fig. 241. *Formicomus* sp. C, dorsal view (13.7X).



Figs. 244–245. *Gonocephalum* sp. A, dorsal view (244; 8.8X) and close-up of right lateral part of pronotum and elytron (245; 17X).



Figs. 242–243. *Tenebrio* sp., dorsal view (242; 7X) and close-up of left lateral part of pronotum and elytron (243; 13X).



Figs. 246–247. *Gonocephalum* sp. B, dorsal view (246; 5X) and close-up of right lateral part of pronotum and elytron (247; 9X).

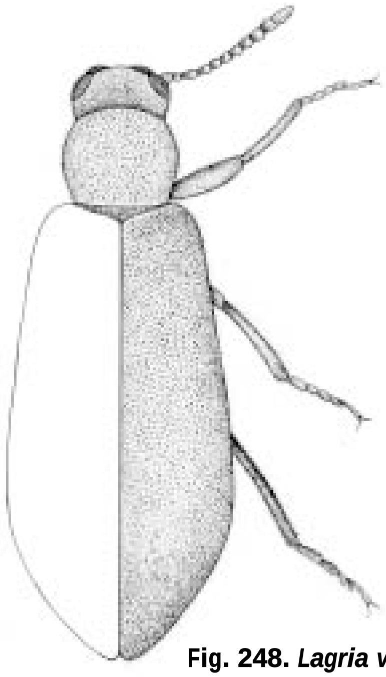


Fig. 248. ***Lagria villosa*** **Fabricius, dorsal view (7.4X).**

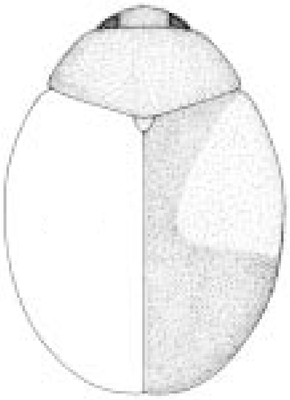
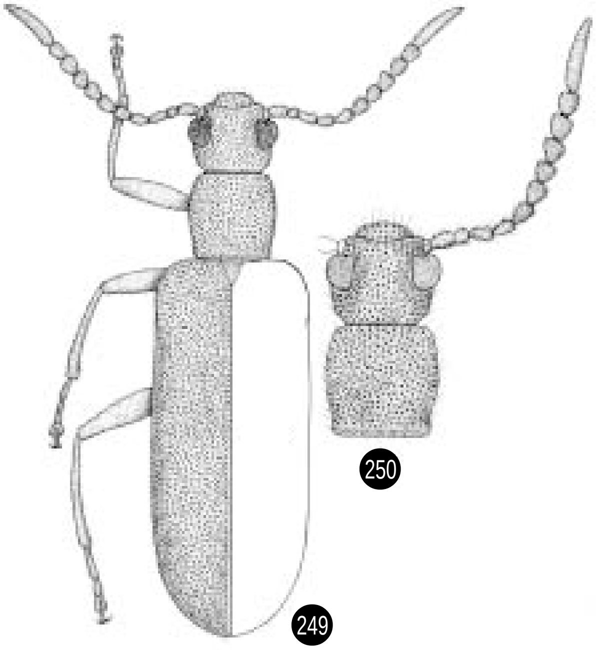
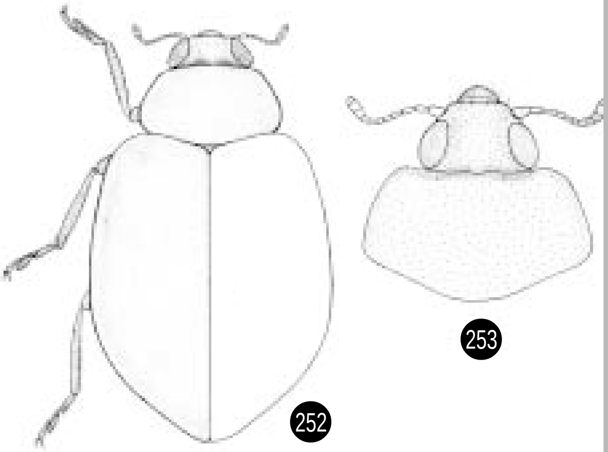


Fig. 251. ***Scymnus*** **sp., dorsal view (24.5X).**



Figs. 249–250. ***Chrysolagria cuprina*** **Thomson, dorsal view (249; 8.9X) and dorsal view of head and pronotum (250; 12.6X).**



Figs. 252–253. ***Micraspis*** **sp., dorsal view (252; 11.1X) and dorsal view of head and pronotum (253; 21.7X).**

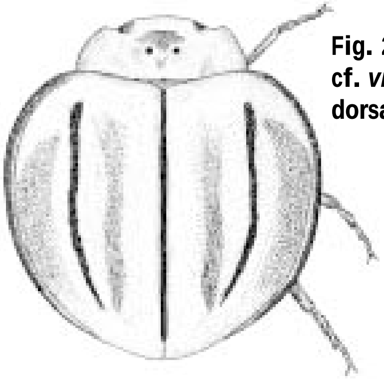


Fig. 254. ***Micraspis*** **cf.** ***vincta*** **(Gorham), dorsal view (8.0X).**

50(49’) Elytra uniformly yellowish brown except black sutural line, rounded laterally in apical one-third and moderately pointed at apex; head gray posteriorly; terminal segment of antenna strongly rounded .... *Micraspis* sp. **[Figs. 252, 253]**

50’ Not as above, elytral color patterns different 51

51(50’) Elytra yellowish cream to orange brown with margins black and a median longitudinal basal band aborted; pronotum with or without paired spots; strongly convex beetle, body length 5 mm .... *Micraspis* cf. *vincta* (Gorham) **[Fig. 254]**

51’ Elytra with different patterns 52

52(51’) Elytra lustrous black with yellow margins; head and pronotum brown; body length 3 mm .... *Chilocorus* sp. **[Fig. 255]**

52’ Not as above 53

53(52’) Pronotum yellow with a quadrate black band on anterior margin; elytra yellowish brown with black sutural line, 2 ovoid black spots in the middle of basal one-half pointed towards each other and a pair of irregularly round black spots diverging apically .... *Xanthadalia effusa* Erichson **[Fig. 256]**

53’ Pronotum without a quadrate black band on anterior margin 54

54(53’) Elytra black with 2 transverse yellow bands or yellow with elongate spots ... 55

54’ Not as above, elytra with many black or yellow spots 56

55(54) Elytra black with transverse yellow brown bands slightly behind middle and an apical tip; pronotum brown and head entirely black; body length 5–5.7 mm .... *Xanthadalia* sp. A **[Figs. 257]**

55’ Elytra yellow with 2 pairs of subanterior and subposterior elongate black spots; yellowish brown pronotum with a light brown transverse band midanteriorly; body length 5.5 mm .... *Xanthadalia* sp. B **[Fig. 258]**

56(54’) Pronotum black and with 3 yellow spots; elytra with 2 pairs of yellow globose spots lining the sutural margins and 2 pairs in a transverse row connected to each other below the midline; humeral and apical lunules or bands broad and C-shaped; body length 6.7 mm .... *Cheilomenes lunata* Fabricius **[Fig. 259]**

56’ Pronotum brownish with or without spots; elytron with 5–6 spots 57

57(56’) Scutellar area without converging spots; elytron with 6 rounded spots in 2 longitudinal rows, paired median spots the largest, a small transverse band between anterior and median spots and a small vertical spot below midlength of elytron; body length 8.2 mm .... *Epilachna reticulata* Olivier **[Fig. 260]**

57’ Scutellar area with converging spots; elytron with 5 black spots, large median spot elongate with median constriction .... *Chnootriba similis* Mulsant **[Fig. 261]**

58(48’) Head covered by explanate anterior margin of pronotum; antenna long with funicular segment I longest; maxillary palpi with 4 segments; ovoid eyes strongly convex; pronotum expanded laterally with prominent ridges; coxa I

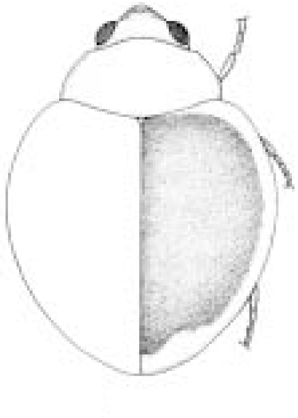


Fig. 255. *Chilocorus* sp., dorsal view (15X).

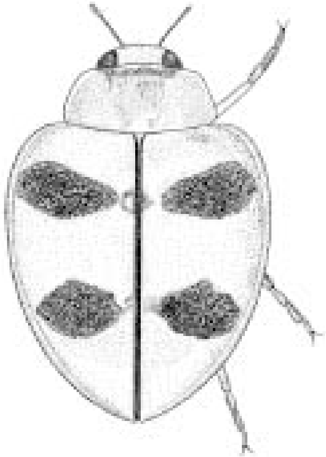


Fig. 258. *Xanthadalia* sp. B, dorsal view (8.73X).

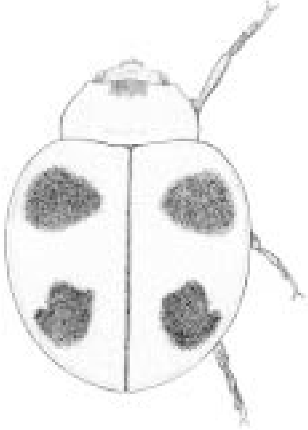


Fig. 256. *Xanthadalia effusa* Erichson, dorsal view (8.6X).

Fig. 259. *Cheilomenes lunata* Fabricius, dorsal view (5.6X).

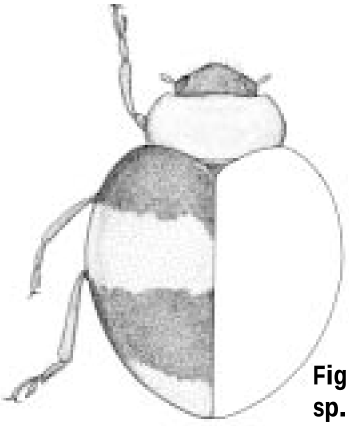


Fig. 257. *Xanthadalia* sp. A, dorsal view (8X).

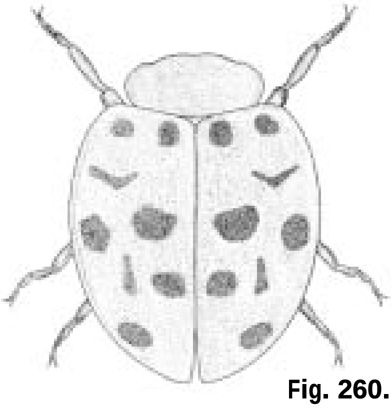


Fig. 260. *Epilachna reticulata* Olivier, dorsal view (5.49X).

globular with a large triangular trochantin; elytra elongate, more than 5 times longer than pronotum, leaf-like with veins and a network of raised lines [Family **Lycidae**] 59

58’ Head not covered by explanate anterior margin of pronotum 61

59(58) Elytra, yellow with a broad brown marginal band running just above midlength to apical one-fourth of wing apex; shoulder high; prothorax wider than long, expanded marginally, concave medially; antenna dark brown except yellowish brown segment III; head dark reddish brown except yellow brown snout; legs brown; body length 14 mm ....*Lycus (Lycus) semiamplexus* Murray **[Fig. 262]**

59’ Not as above, elytra usually with a median dark brown longitudinal band 60

60(59’) Head with a moderately short snout as long as first funicular segment divided medially by a transverse furrow; pronotum bluntly pointed anteriorly and with a transverse furrow posteriorly interrupted in the middle by a longitudinal ridge; elytra narrow and slender, yellow except black apical one-fourth .... *Lycus (Lycostomus) proboscidens* Fabricius **[Fig. 263]**

60’ Head with a long snout slightly longer than the first funicular segment without median furrow; pronotum with a small median notch anteriorly, entire blackened area bell-shaped with punctations around it; elytra almost 4 times longer than wide, midlateral with a black spot and apical one-third black .... *Lycus (Lycostomus)* sp**. [Fig. 264]**

61(58’) Elytra truncate, short and broad, with regular longitudinal striae and clothed with fine and short hairs forming spot patterns, head small, deflexed and produced anteriorly into a short snout covering the prosternum and coxa I; eyes prominently emarginate in front; pronotum narrow anteriorly and subtriangular; large pygidium exposed by truncate elytra; basal segment of tarsus III longer than total length of other segments; fore coxae contiguous; mesepimera not distinct [Family **Bruchidae**] 62

61’ Elytra entire, striae usually absent; head deeply positioned in an often transverse, subquadrate or anteriorly convex pronotum, and not covering prosternum and coxa I viewed underneath; pygidium seldom exposed; basal segment of tarsus III shorter than combined length of other segments; globular or transverse, fore coxae separated; mesepimera distinct, reaching midcoxal cavities; antennae often as long as one-half body length [Family **Chrysomelidae**] 63

62(61) Pronotum reddish brown medially, anteriorly and posterolaterally, black subdorsally; elytra reddish brown with white hairs, base and shoulder black, midlaterally with a black triangular band and apex uniformly black; interval 2 of elytra or with a pair of black spots below scutellum and another pair in apical one-third .... *Callosobruchus chinensis* (Linnaeus) **[Fig. 265]**

62’ Pronotum dull brown with four faint black median spots; reddish brown elytra with white hairs on all intervals except black shoulder, middle and apex of intervals 8 to 10, apices of elytra with faint dark reddish brown spots ....*Callosobruchus* sp. **[Fig. 266]**

63(61’) Femur III enlarged for jumping; pronotum and elytra without spines 64

63’ Femur III not enlarged, if so, all femora similar and enlarged on apical two-thirds; pronotum with or without spines 68

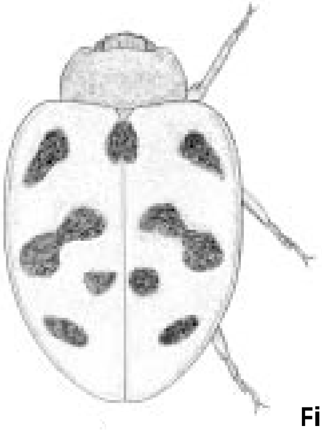


Fig. 261. ***Chnootriba similis*** **(Mulsant), dorsal view (8.85X).**

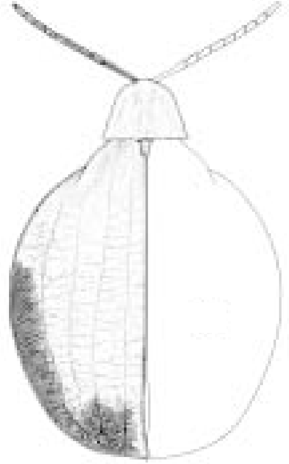


Fig. 262. ***Lycus (Lycostomus) semiamplexus*** **Murray, dorsal view (3.6X).**

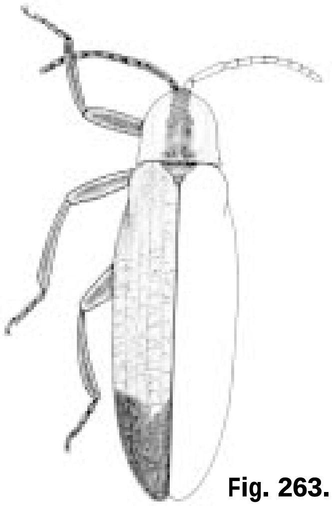


Fig. 263. ***Lycus (Lycostomus) proboscidens*** **Fabricius, dorsal view (3.9X).**

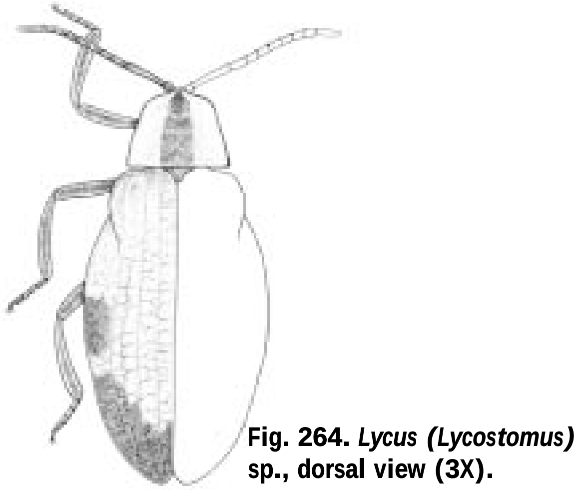


Fig. 264. ***Lycus (Lycostomus)*** **sp., dorsal view (3X).**

Fig. 265. ***Callosobruchus chinensis*** **(Linnaeus), dorsal view of right elytron (7.4X).**

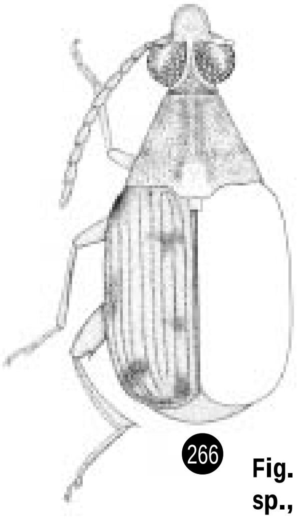
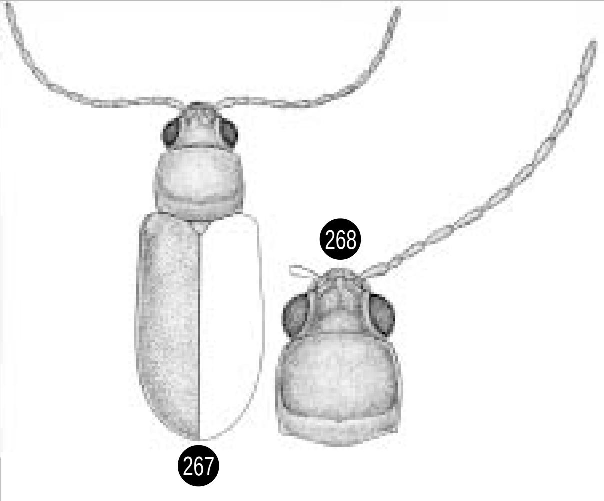


Fig. 266. ***Callosobruchus*** **sp., dorsal view (17.3X).**



Figs. 267–268. ***Altica*** **sp., dorsal view (267; 8X) and dorsal view of head and pronotum (268; 15.7X).**

64(63) Moderately large, at least 5 mm long; head and pronotum smooth, pronotum with a transverse groove in the posterior one-fourth; elytra finely punctated without distinct striae, venter of abdomen, sides of thorax and legs with white fine hairs .... *Altica* sp. **[Figs. 267, 268]**

64’ Small, 1.5–2.4 mm long; head and pronotum smooth to punctured; pronotum not grooved elytra on distinct puncture arranged in lines or striae 65

65(64’) Head and pronotum punctured evenly; elytra without clear rows of sutural puncture adjacent the scutellum; legs I and II reddish brown to black; femur III black; prothorax one-third wider than long, body length 2.40 mm .... *Chaetocnema* cf. *abyssinica* Jacoby **[Figs. 269, 270]**

65’ Head impunctate; pronotum moderately to finely punctured; body length less than 2 mm 66

66(65’) Pronotum finely and evenly punctured; antennal segments yellow except yellowish brown segments VII to XI; legs I and II yellow brown; femur III reddish brown with yellow tibia and tarsus; body length 1.5 mm ....*Chaetocnema pusilla* Laboissiere **[Figs. 271, 272]**

66’ Not as above 67

67(66’) Pronotum smooth except for very fine punctures; elytral puncture more pronounced; apical three segments of antennae brownish red .... *Chaetocnema pulla* Chapuis **[Figs. 273, 274]**

67’ Pronotum sparsely punctured; elytral punctures moderate but distinct, lighter than *C. pulla;* apical 5–6 segments of antennae brownish to brownish red .... *Chaetocnema* spp. **[Figs. 275–280]**

68(63’) Pronotum and elytra with spines 69

68’ Pronotum and elytra without spines 74

69(68) Lateral margins of pronotum each with 4 small spines, anterior 2 spines close to each other, third spine at midlength and the fourth in posterior quarter; elytra with 5 small marginal spines ....*Trichispa sericea* Guerin-Meneville **[Figs. 281, 282]**

69’ Lateral margins of pronotum with strong spines 70

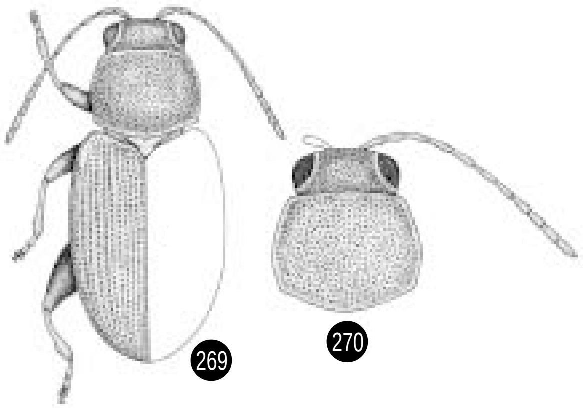
70(69’) Pronotum with anterior trifurcate spine; elytron with at least 11 marginal spines and 4 spines on disc; metallic blue beetle; body length 5.5 mm .... *Dicladispa viridicyanea* (Kraatz) **[Figs. 283–285]**

70’ Pronotum with a pair of midanterior and lateral spines 71

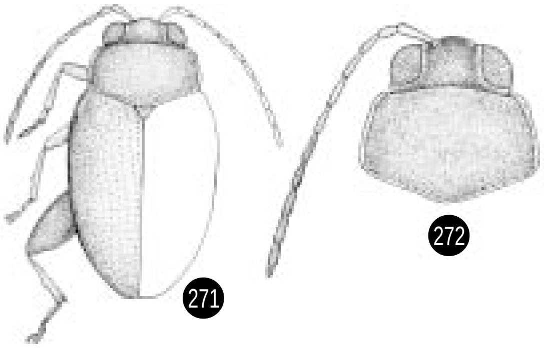
71(70’) Apicolateral and anterior median spines of the pronotum bifurcate; femur I without ventral spines 72

71’ Three lateral spines of pronotum separated; midanterior pronotal spine with a small spine at basal front; femora I–III with ventral spines 73

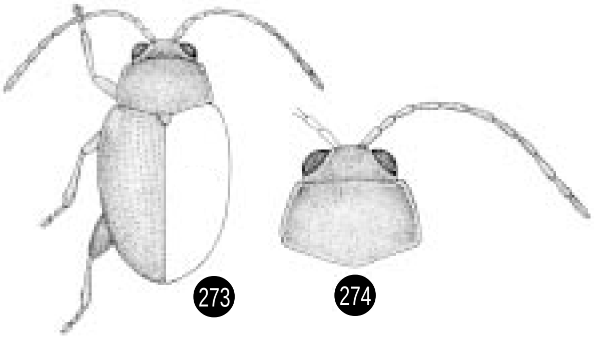
72(71) Brown; lateral margins of each elytron with 18 spines or more, dorsal plate with 13–14 prominent and black spines; antennae and legs uniformly brown; body length 4.2 mm ....*Dactylispa* sp. A **[Figs. 286, 287]**



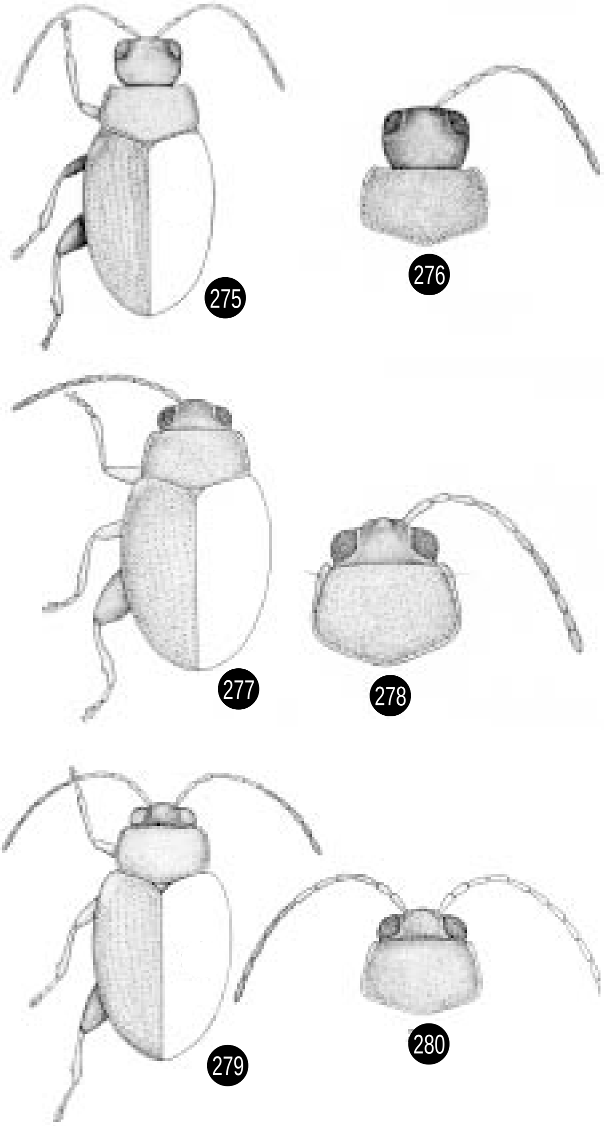
Figs. 269–270. *Chaetocnema* cf. *abyssinica* Jacoby, dorsal view (269; 17.5X) and dorsal view of head and pronotum (270; 25X).



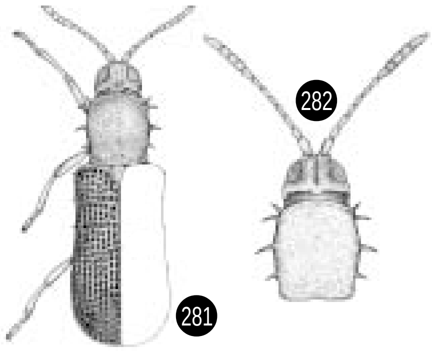
Figs. 271–272. *Chaetocnema pusilla* Laboissiere, dorsal view (271; 22.67X) and dorsal view of head and pronotum (272; 36X).



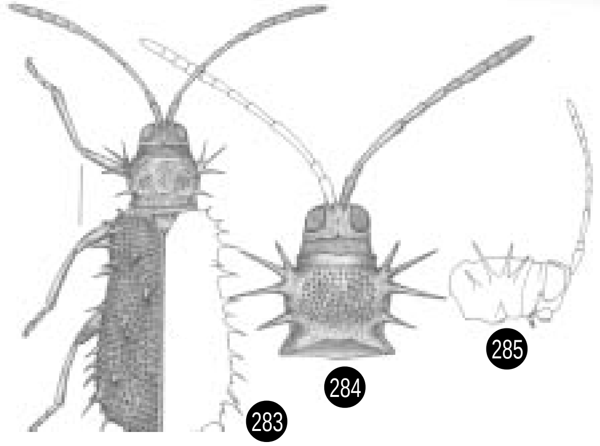
Figs. 273–274. *Chaetocnema pulla* Chapuis, dorsal view (273; 18.4X) and dorsal view of head and pronotum (274; 30X).



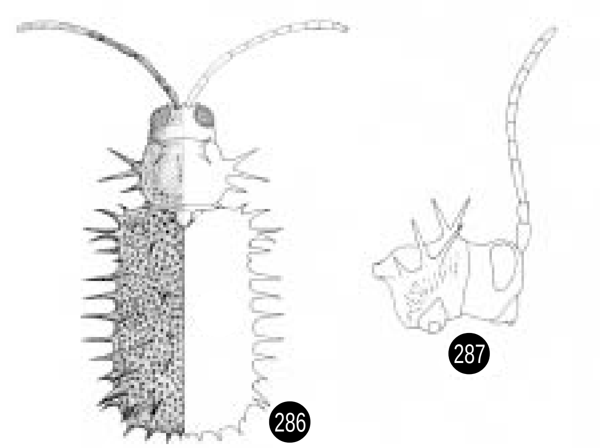
Figs. 275–280. *Chaetocnema* spp., dorsal views (275, 20X; 277, 20X; 279, 20X) and dorsal views of head and pronotum (276, 31X; 278, 31X; 280, 31X).



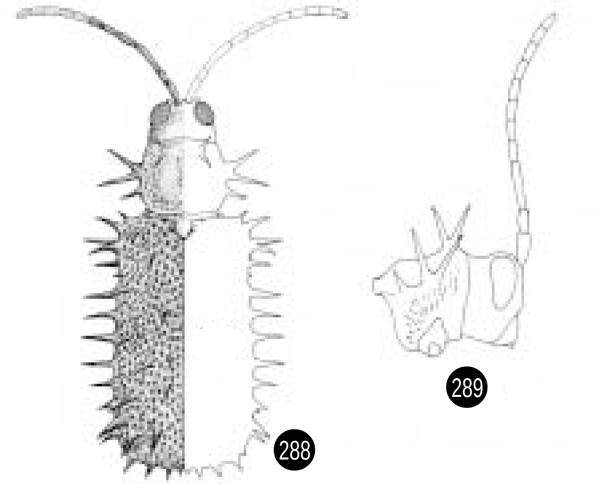
Figs. 281–282. *Trichispa sericea* Guerin-Meneville, dorsal view (281; 9.8X) and dorsal view of head and pronotum (282; 16.7X).



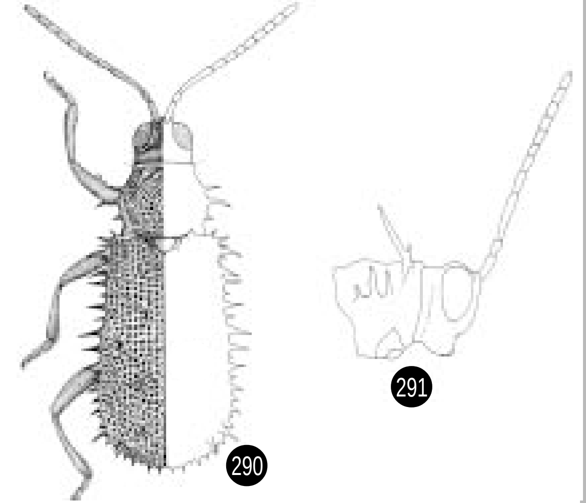
Figs. 283–285. ***Dicladispa viridicyanea*** **(Kraatz), dorsal view (283; 6.9X) and dorsal (284; 12.0X) and lateral (285; 9.1X) views of the head and pronotum.**



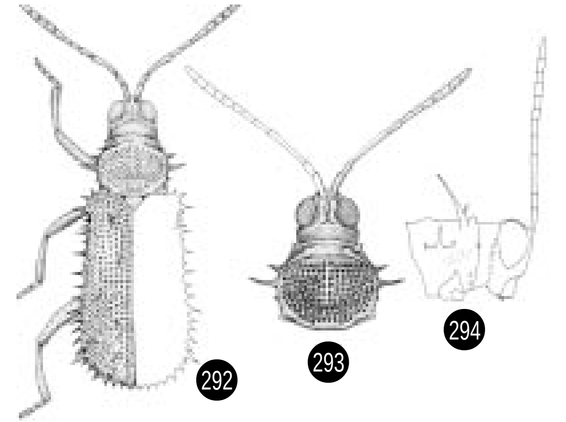
Figs. 286–287. *Dactylispa* sp. A, dorsal view (286; 9.52X) and lateral view of head and pronotum (287; 18.2X).



Figs. 288–289. *Dactylispa* cf. *bayoni* Gestro, dorsal view (288; 12.11X) and lateral view of head and pronotum (289; 18.2X).



Figs. 290–291. *Dactylispa* sp. B, dorsal view (290; 5.12X) and lateral view of head and pronotum (291; 9.5X).



Figs. 292–294. *Dactylispa spinigera* Gyllenhall, dorsal view (292; 4.86X), and dorsal (293; 10.6X), and lateral (294; 9.4X) views of the head and pronotum.

Fig. 295. *Lema* sp. A, dorsal view (8.4X).

72' Black; lateral margins of each elytron with 18 spines, dorsal plate with 12 prominent spines; antennae black except 5 apical brown segments; body length 3.8 mm .... *Dactylispa* cf. *bayoni* Gestro **[Figs. 288, 289]**

73(71') Anterior of pronotum with transverse ridges extended to the slightly elevated plate of anteromedian dorsal spine; midlateral sinuate; venter of femora with at least 5 teeth, 5 in I, 7–8 in II, and 5–6 in III; antenna black with brown apical tip; body length 8.2 mm .... *Dactylispa* sp. B **[Figs. 290, 291]**

73' Anterior of pronotum without transverse ridges; midlateral pronotal spine pointed and strong, posterior lateral spine small; venter of femora with 2 teeth; antennae black except 5 reddish brown apical segments; body length 7 mm .... *Dactylispa spinigera* Gyllenhall **[Figs. 292–294]**

74(68') Prothorax wider than long, sides strongly constricted at or below midlength; eyes indented above antennae; scutellum truncate apically 75

74' Not as above; if eyes emarginated, pronotum not constricted at or below midlength 81

75(74) Head, pronotum and elytra uniformly brown 76

75' Head, pronotum and elytra not colored as above 77

76(75) Body length approximately 5 mm; antennal base, head, pronotum leg I, and elytra uniformly brown; funicular segments of antennae reddish brown; labrum cleft medially; apical half of femora II and III black to reddish brown; venter and sides of thorax and abdomen black except last 2 terminal segments of abdomen .... *Lema* sp. A **[Fig. 295]**

76' Body length 9 mm; vertex of head, pronotum, and elytra brown; frons, antennae, legs, and underneath of entire body black; black labrum truncate anteriorly .... *Lema armata* Fabricius **[Fig. 296]**

77(75') Prothorax brown; elytra uniformly black to dark blue; dorsal surfaces of antennal segments I–VII blackish and brownish ventrally, rest of segments black; head black in front but brown behind the eyes; legs brown except tibia I with inner and outer dark brown longitudinal bands; coxae I & II and trochanter I–III black; tip of tibiae and tarsi reddish brown; body length 5.4 mm .... *Lema rubricollis* Klug **[Figs. 297, 298]**

77' Prothorax black, or if brown then elytra with black spots or longitudinal bands 78

78(77') Prothorax brown; elytra with black spots or bands 79

78' Prothorax black 80

79(78) Elytra with 8 spots arranged in 3 transverse rows of 2, 4 (2 spots on wing edge hidden), and 2 along apical one-half and a transverse band in posterior one-third; legs black to reddish brown with fine silvery white hairs; body length 6.2 mm .... *Lema* sp. C **[Fig. 299]**

79' Elytra with a broad longitudinal black vitta emanating from the humeri and covers sutures 3–6 at midlength and 2–8 subposteriorly; femora yellowish brown except apical half of II and III black to dark reddish brown; tibiae yellowish brown, if yellow, with inner and outer longitudinal bands; body length 4.4 mm .... *Lema* sp. D **[Figs. 300, 301]**

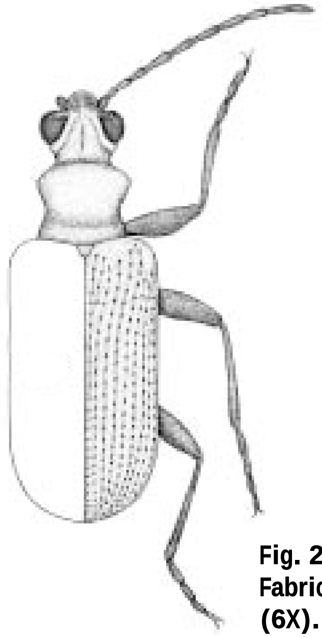
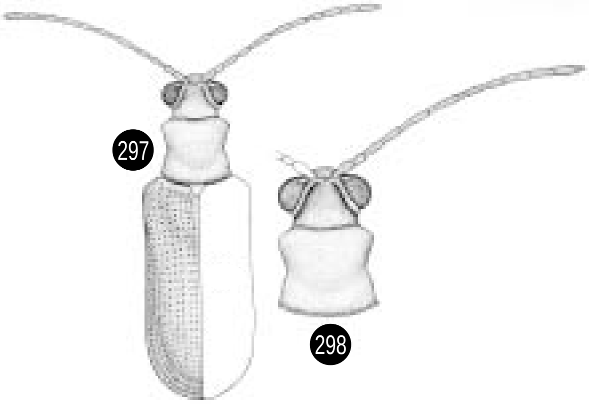


Fig. 296. *Lema armata* Fabricius, dorsal view (6X).



Figs. 297–298. *Lema rubricollis* Klug, dorsal view (297; 6.8X) and dorsal view of head and pronotum (298; 10X).

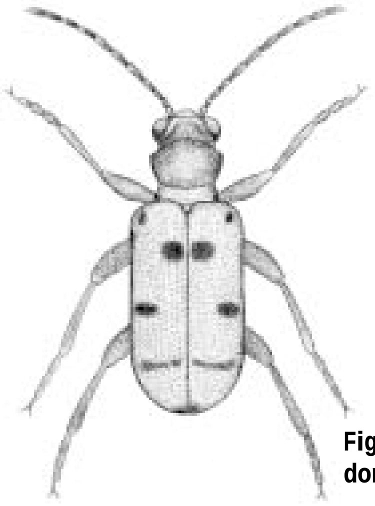
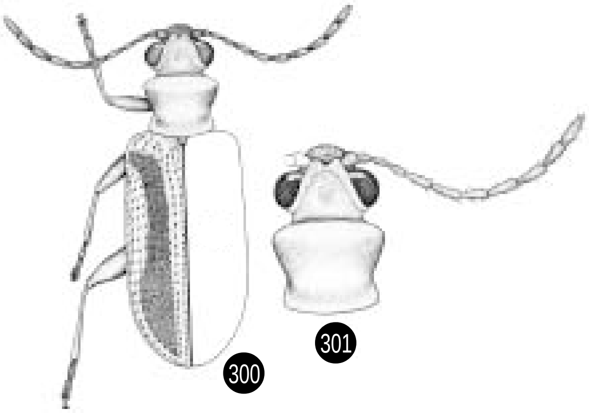


Fig. 299. *Lema* sp. C, dorsal view (6X).



Figs. 300–301. *Lema* sp. D, dorsal view (300; 9.8X) and dorsal view of head and pronotum (301; 15.4X).

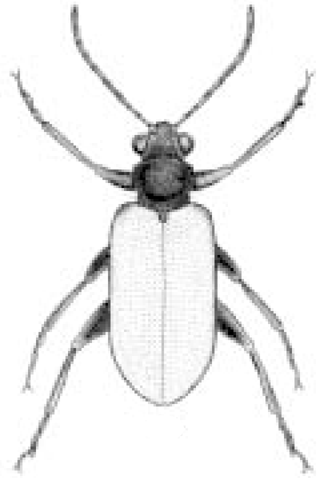


Fig. 302. *Lema* sp. E, dorsal view (6.5X).

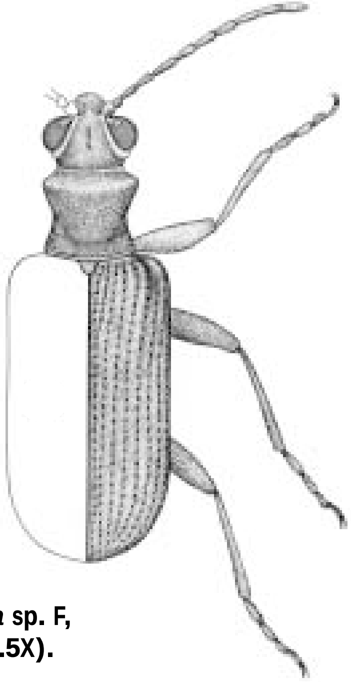


Fig. 303. *Lema* sp. F, dorsal view (8.5X).

80(78’) Pronotum smooth; head, pronotum, legs and venter of body black; antennae brownish yellow in segments I–IV and dark brownish red thereafter; elytra brown; body length 5.2 mm .... *Lema* sp. E **[Fig. 302]**

80’ Pronotum with transverse striae; entirely black except reddish brown eyes; body length 6.6 mm ....*Lema* sp. F **[Fig. 303]**

81(74’) Eyes emarginate near the bases of antennae; head somewhat hidden in dorsal aspect 82

81’ Eyes spherical; head usually visible dorsally... 92

82(81) Antenna with segments V–X wider than long; eyes narrowly notched 83

82’ Antennal segments prominently longer than wide, except subglobose pedicel 84

83(82) Head black, coarsely punctured with a slight transverse groove between the moderately swollen area and apical eye margins and extended down to the base of antennae; elytra yellow punctured with a black ovoid spot in the shoulder and a pair of reddish dark brown spots below midlength; legs and venter of entire body black with fine white hairs...... *Peploptera* sp. **[Fig. 304]**

83’ Head, pronotum, elytra, venter of entire body and legs uniformly yellow to slightly yellowish brown; eyes indented in basal one-fourth; head smooth with a Y-groove between eyes viewed frontally; elytra finely punctated with 3 longitudinal lines; tarsal claws not bifurcate .... *Smaragdina* sp. **[Fig. 305]**

84(82’) Elytra black to bluish black with prominent puncture; red pronotum and head slightly punctured coarser in the head; eyes indented at midlength; antennal scape short and rounded, anterior tip of segments III–VI globose; femora I–III red except black posterior and anterior ends; tibiae and tarsi all black; tarsal claws bifurcate subbasally .... *Syagrus calcaratus* Fabricius **[Fig. 306]**

84’ Elytra yellow, yellowish brown to reddish brown with black bands on spots.... 85

85(84’) Pronotum with a pair of black bands or vittae; elytra bear black C-shaped bands .... *Cryptocephalus* sp. A **[Fig. 307]**

85’ Without the combination of above characters 86

86(85’) Pronotum with a pair of broad lateral bands; elytra with two broad black transverse bands merged along the suture ...... *Cryptocephalus* sp. B **[Fig. 308]**

86’ Entirely not as above 87

87(86’) Pronotum with 4 brown ovoid spots, inner spots larger than outer spots; elytral vittae run from shoulder to posterior two-thirds of striae V–IX............. ....*Cryptocephalus* sp. C **[Fig. 309]**

87’ Pronotum with or without black spots; elytra with 6 spots or broad transverse bands 88

88(87’) Pronotum without spots 89

88’ Pronotum with 2 black spots 90

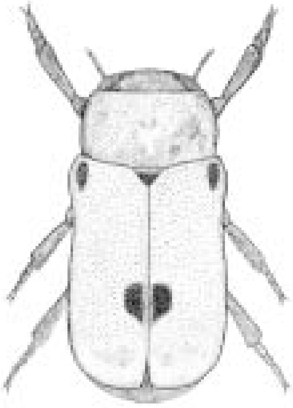


Fig. 304. *Peploptera* sp., dorsal view (5.5X).

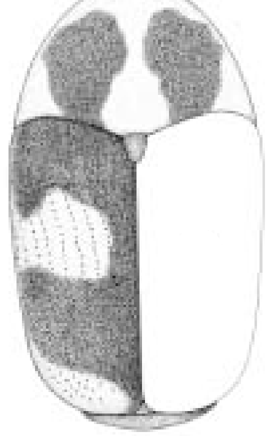


Fig. 307. *Cryptocephalus* sp. A, dorsal view (10X).

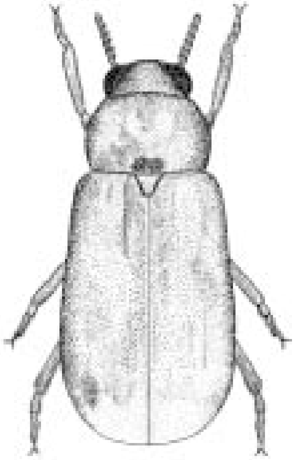


Fig. 305. *Smaragdina* sp., dorsal view (8X).

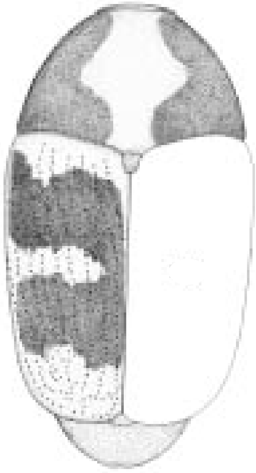


Fig. 308. *Cryptocephalus* sp. B., dorsal view (8X).

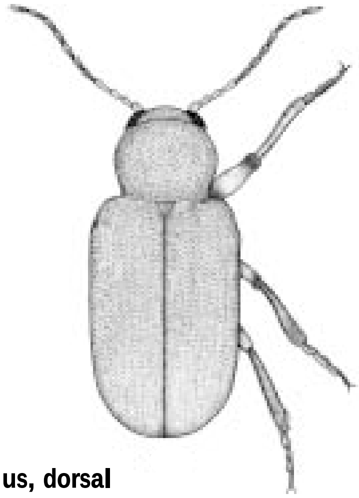


Fig. 306. *Syagrus calcaratus* Fabricius, dorsal view (6.2X).

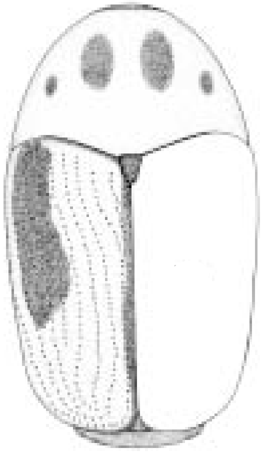


Fig. 309. *Cryptocephalus* sp. C, dorsal view (15.7X).

89(88) Elytra with a broad black transverse band below midlength from suture to stria 10, apical two-thirds of suture black; base of elytra black from shoulder to stria 2; scutellum black with a yellow brown spot subbasally; legs brown with reddish brown longitudinal band in femur II and black femur III except its yellow brown anterior end .... *Cryptocephalus* sp. D **[Fig. 310]**

89' Elytra with 6 black spots, 4 subbasal and 2 midlength; scutellum black to brown; legs all yellowish brown or with a dark brown spot in femur II and reddish brown femur III with brown anterior end .... *Cryptocephalus* sp. E **[Fig. 311]**

90(88') Elytra with a broad black transverse band below midlength and running from humerus to striae 1; scutellum black; femora II and III blackish brown; body venter from mesothorax to abdomen black ...... *Cryptocephalus* sp. F **[Fig. 312]**

90' Not as above 91

91(90') Pronotal spots subspherical slightly shorter in distance as between eyes viewed dorsally; femur III dark reddish brown except brown anterior end .... *Cryptocephalus* sp. G **[Fig. 313]**

91' Pronotal spots very small, barely one-half distance between eyes viewed as dorsally; femur yellowish brown or femur III black with reddish brown apex .... *Cryptocephalus* sp. H **[Fig. 314]**

92(81') Margins of pronotum bordered but not expanded; elytra with or without spots or bands 93

92' Margins of pronotum broadly expanded, covering the head 107

93(92) Elytra without spots or bands 94

93' Elytra with spots or bands 99

94(93) Body length 11 mm; uniformly dark brown and punctured except black scutellum; scutellum punctured and rounded apically; head longitudinal groove; middle of vertex with a black spot; legs and venter of entire body black; tibiae with a dorsomedian ridge and two grooves .... *Bupachytoma* sp. **[Figs. 315, 316]**

94' Smaller species, less than 8 mm long 95

95(94') Pronotum yellow with or without spots; elytra bluish violet to bluish green 96

95' Pronotum and elytra yellow to yellowish brown without spots 97

96(95) Pronotum uniformly yellow, with a transverse groove below midlength; scutellum yellow; elytra finely punctated and dark bluish violet; antennal scape slightly swollen; labial palp swollen and dark brown; venter of entire body yellow; leg dark brownish red with yellow basal one-half of femur .... *Asbecesta cyanipennis* Harold **[Figs. 317, 318]**

96' Pronotum with a median ovate brownish red spot and one each in the mid-lateral area, subanterolateral pit present near the base of lateral spot; scutellum yellow with black apical one-half; elytra bluish green and clothed with white hairs; antenna slender; labial palp slender; venter of body yellow except brown metasternite .... *Apophylia chloroptera* Thomson **[Fig. 319]**

Fig. 310. *Cryptocephalus* sp. D, dorsal view (15X).

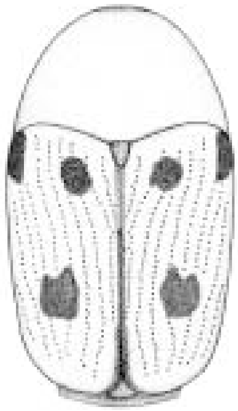


Fig. 311. *Cryptocephalus* sp. E, dorsal view (12.6X).

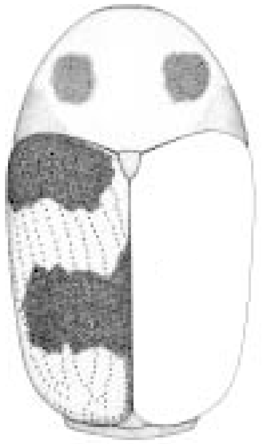


Fig. 312. *Cryptocephalus* sp. F, dorsal view (14.5X).

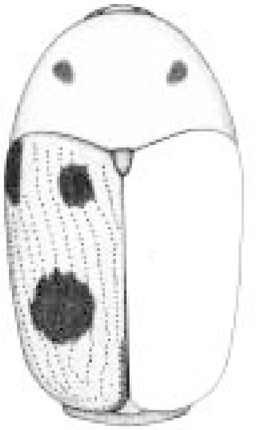
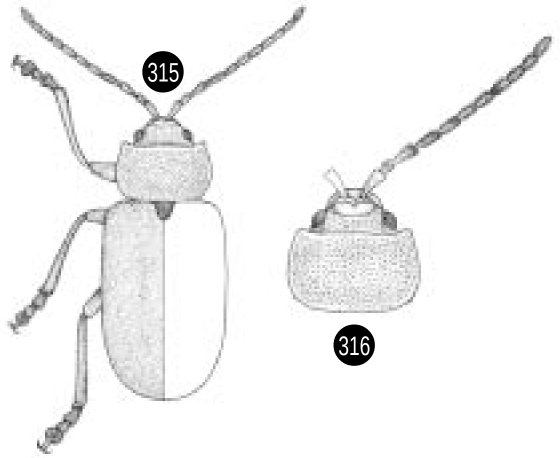


Fig. 313. *Cryptocephalus* sp. G, dorsal view (14X).

Fig. 314. *Cryptocephalus* sp. H, dorsal view (14.8X).



Figs. 315–316. *Bupachytoma* sp., dorsal view (315; 3.2X) and dorsal view of head and pronotum (316; 4.1X).

97(95’) Head with a deep cavity on vertex, center of cavity with an elevated brown subtriangular plate; pronotum with arcuate transverse groove at midlength and densely punctured; antennae yellow with large scape, slender segment III–XI; venter of body yellow brown .... *Lamprocopa occidentalis* Weise **[Fig. 320]**

97’ Not exactly as above 98

98(97’) Prothorax strongly convex, smooth and rounded posteriorly and laterally; head with a transverse groove above and a ridge between antennal base, concealed by the pronotum viewed dorsally; elytra finely punctated; legs yellow except brownish part of tibiae and tarsi; claws with a very small inner teeth .... *Ootheca mutabilis* Sahlberg **[Fig. 321]**

98’ Prothorax subrectangular with a transverse groove at midlength, deep concave cavity present in middle of the groove; head without distinct ridge or groove above and between antennal base, entire head visible dorsally; elytra finely punctured with moderately thick long hairs near the shoulder; legs yellowish brown with bifurcate claws ...... *Aulacophora africana* (Weise) **[Figs. 322, 323]**

99(93’) Elytra with two black transverse bands or 4 yellow globose spots 100

99’ Elytra with two black longitudinal vittae 104

100(99) Head with a dark brown spot on vertex; pronotum with or without two anterolateral and a median dark brown spots but always with a transverse groove below middle; black scutellum with yellow basal one-third; elytra with a broad transverse black band in anterior one-third and posterior one-third; lateral side of thorax with a dark brown band running dorsal of coxae I–III .... *Leptaulaca fissicolis* Thomson **[Fig. 324]**

100’ Head and pronotum without dark brown spots 101

101(100’) Yellow pronotum with a transverse groove at midlength; triangular scutellum yellow; elytra with a broad black transverse band anteriorly and a subcircular or ring black spot posteriorly, inner portion of ring adjacent to the suture with a posteriorly projected spine; entire body, venter and legs yellow; antennal segment III as long as or slightly shorter than segment IV .... *Diacantha albidicornis* Weise **[Fig. 325]**

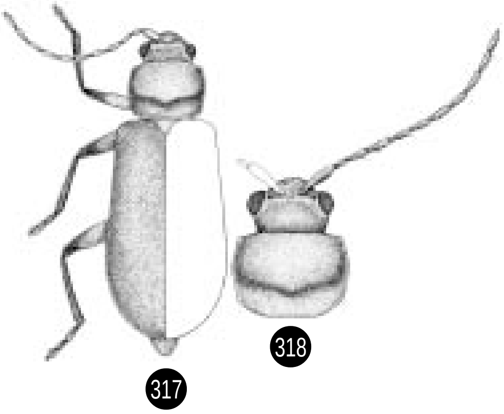
101’ Pronotum without transverse groove; elytra without subposterior spine; antennal segment III clearly shorter than IV; tibial spur of leg III strong 102

102(101’) Pronotum and head uniformly shiny red; elytra black with 4 whitish yellow subglobular spots, 2 each anteriorly and posteriorly; scutellum triangularly red; antenna yellow except brownish apical segments; leg yellowish brown .... *Monolepta elegans* Allard **[Figs. 326, 327]**

102’ Not as above; elytra usually yellow with two black transverse bands 103

103(102’) Elytra with transverse broad black bands anteriorly and submedially, and a brownish black spherical spot posteriorly; segment IV of antenna more than 2 times longer than III .... *Monolepta* sp. A **[Fig. 328]**

103’ Elytra with a transversely broad black band anteriorly and behind midlength, posteriorly without blackish brown spot; segment IV of antenna 1.5x longer than segment III .... *Monolepta* sp. B **[Figs. 329, 330]**



Figs. 317–318. *Asbecesta cyanipennis* Harold, dorsal view (317; 7.6X) and dorsal view of head and pronotum (318; 11X).

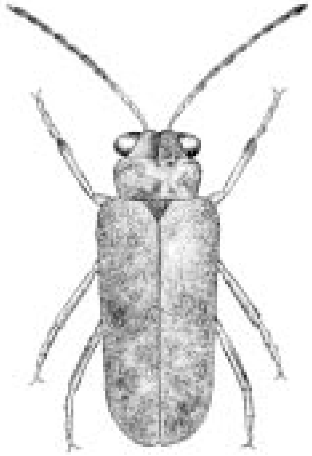


Fig. 319. *Apophylia chloroptera* Thomson, dorsal view (6.3X).

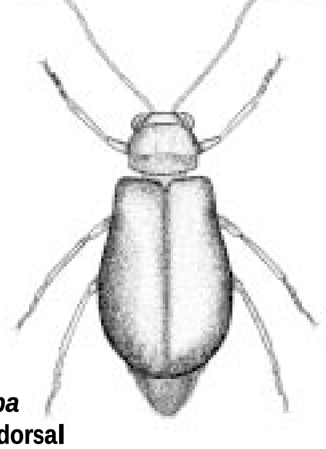


Fig. 320. *Lamprocopa occidentalis* Weise, dorsal view (6.13X).

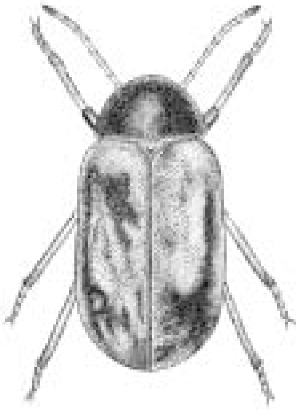
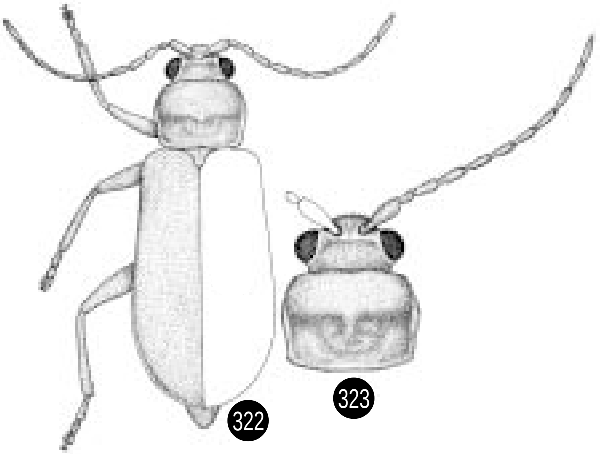


Fig. 321. *Ootheca mutabilis* Sahlberg, dorsal view (5.7X).



Figs. 322–323. *Aulacophora africana* (Weise), dorsal view (322; 6.4X) and dorsal view of head and pronotum (323; 9.3X).

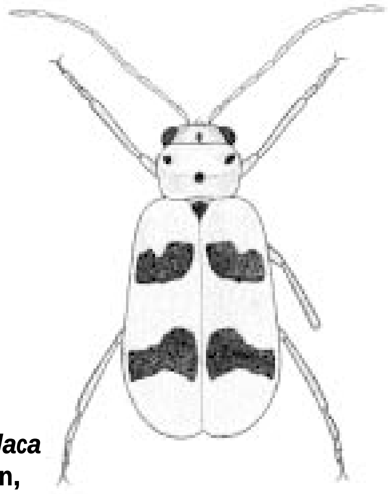


Fig. 324. *Leptaulaca fissicolis* Thomson, dorsal view (6.4X).

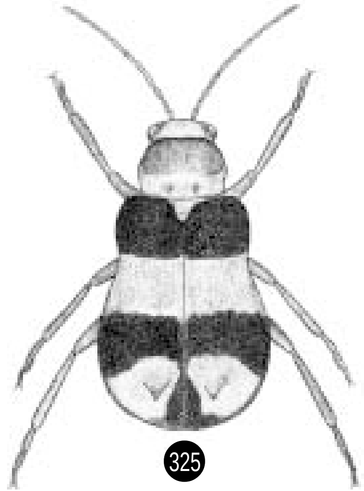
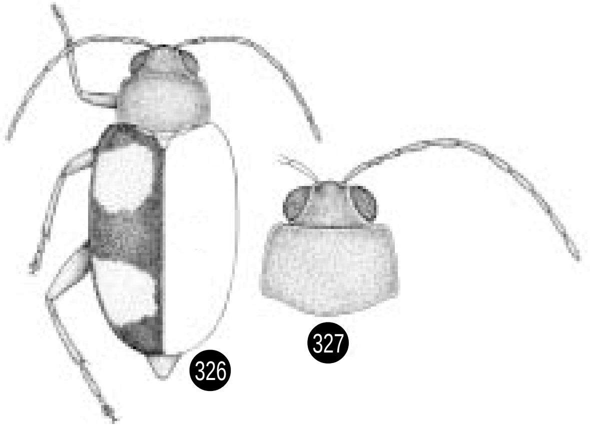


Fig. 325. ***Diacantha albidicornis*** **Weise, dorsal view (6X).**



Figs. 326–327. *Monolepta elegans* Allard, dorsal view (326; 8.8X) and dorsal view of head and pronotum (327; 12.9X).

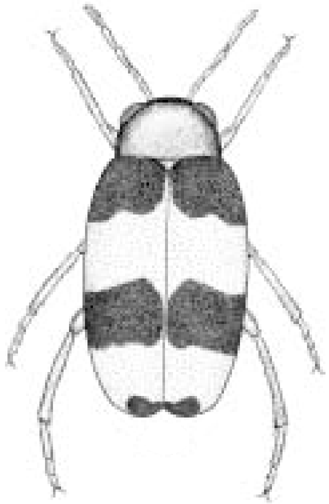
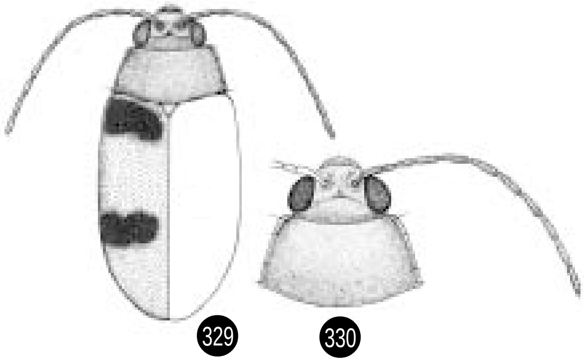
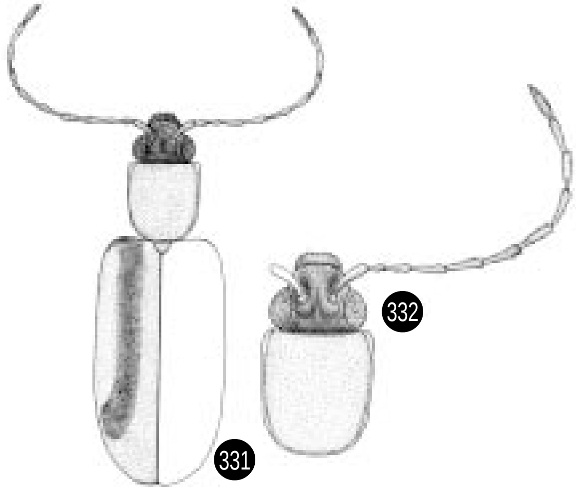


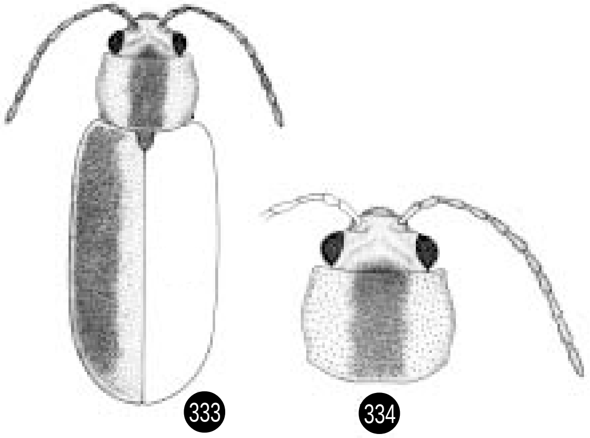
Fig. 328. *Monolepta* sp. A, dorsal view (10X).



Figs. 329–330. *Monolepta* sp. B, dorsal view (329; 10.8X) and dorsal view of head and pronotum (330; 14.3X).



Figs. 331–332. *Medythia* cf. *quaterna* (Fairmaire), dorsal view (331; 12X) and dorsal view head and pronotum (332; 19X).



Figs. 333–334. *Medythia* sp. A, dorsal view (333; 15X) and dorsal view of head and pronotum (334; 24X).

104(99') Pronotum brown, without spots or bands, as long as wide; head black with an elevated process between antennal sockets bissected in the middle by a longitudinal groove; antenna blackish brown except yellow segments IX–X and inner apical one-half of scape; elytra with a lateral and dorsomedian longitudinal black band connected to each other in the shoulder; leg blackish brown to dark reddish brown except yellow basal one-half of femora I–III .... *Medythia* cf. *quaterna* (Fairmaire) **[Figs. 331, 332]**

104' Pronotum with a median dark brown to black band extended on to vertex of head and wider than long 105

105(104') Median vitta of pronotum reaching margins, slightly wider anteriorly; antenna yellow except brownish segments V–XI; vitta on elytra narrower towards the shoulder and wider posteriorly, entire elytra with very fine punctations .... *Medythia* sp. A **[Figs. 333, 334]**

105' Not as above 106

106(105') Median vitta of pronotum narrowed posteriorly but not reaching the posterior margin; vitta on each elytron brownish black, slightly concave at midlength and rounded posteriorly, entire elytron punctated; antenna brownish yellow, darker towards apices of VIII–XI .... *Medythia* sp. B **[Figs. 335, 336]**

106' Median mark of pronotum ovoid and dark brown; elytral longitudinal band up to midlength only, punctures moderately fine; antennae yellow in segments I–V and brownish yellow in VI–XI .... *Medythia* sp. C **[Figs. 337, 338]**

107(92') Body almost parallel-sided with 6-25 black spots on each elytron, 25 spots arranged in 4 longitudinal rows; humeral black spot always present; spherical punctures in the margins of pronotum and elytra without pattern; frons reddish brown forming a C-shaped ridge below antennal bases; antennae black except reddish brown segments I–V; legs and venter of thorax black .... *Aspidomorpha nigrosparsa* (Boheman) **[Fig. 339]**

107' Elytron not as above 108

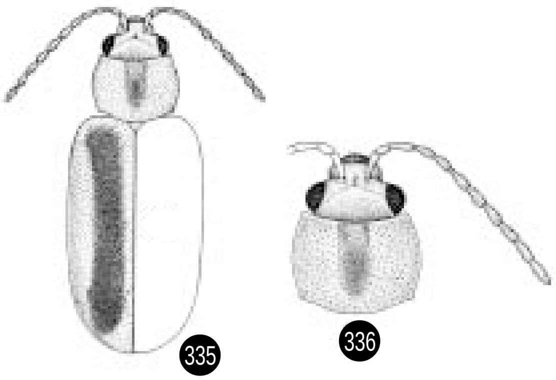
108(107') Pronotum with 4 black concavely arranged subspherical spots; elevated portion of elytra with 2 pairs of subglobose yellow spots in a black background or a B-band with brownish yellow margins in each elytron; antenna yellowish brown except black segments VIII–XI; legs black .... *Aspidomorpha areata* Klug **[Figs. 340, 341]**

108' Pronotum without black spots 109

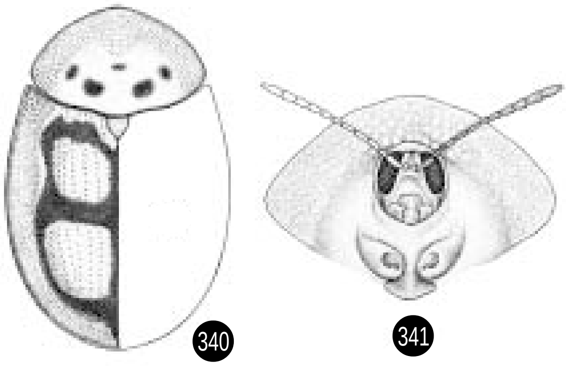
109(108') Elytra with a broad brownish red transverse band, transparent areas C-shaped and elevated near the scutellum; segment X of antenna reddish brown dorsally and yellow brown ventrally, segment XI black with a yellow patch apico-ventrally; underneath of body yellow; legs yellowish brown .... *Aspidomorpha* cf. *dissentanea* Boheman **[Figs. 342, 343]**

109' Not as above 110

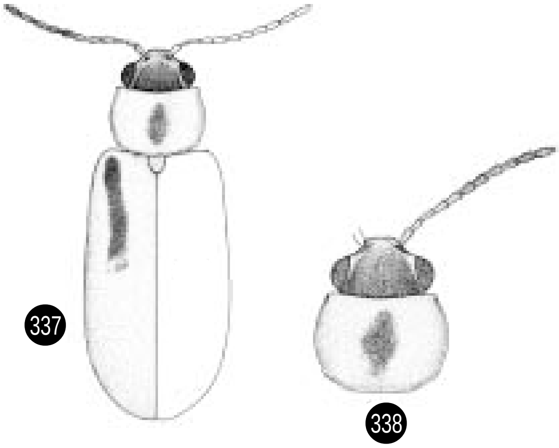
110(109') Expanded part of pronotum and elytra transparent and flattened; antenna yellow except reddish brown terminal segment with yellowish tip; venter of body and legs yellow to pale yellow brown .... *Aspidomorpha dissentanea* Boheman **[Fig. 344]**



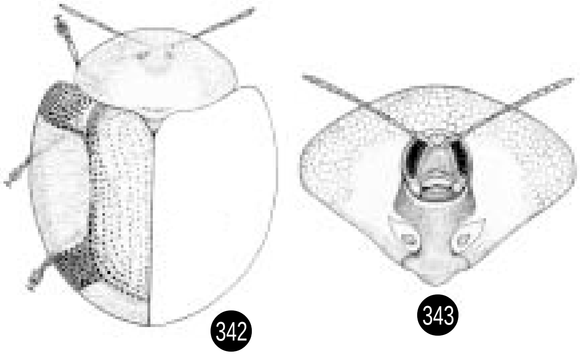
Figs. 335–336. *Medythia* sp. B, dorsal view (335; 15X) and dorsal view of head and pronotum (336; 22.5X).



Figs. 340–341. *Aspidomorpha areata* Klug, dorsal view (340; 6X) and frontal view head (341; 20X).



Figs. 337–338. *Medythia* sp. C, dorsal view (337; 14.7X) and dorsal view of head and pronotum (338; 21X).



Figs. 342–343. *Aspidomorpha* cf. *dissentanea* Boheman, dorsal view (34; 4.25X) and frontal view of head (343; 16.4X).

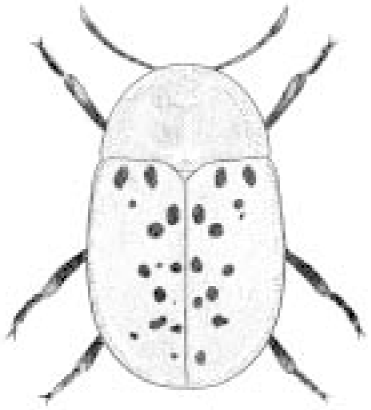


Fig. 339. *Aspidomorpha nigrosparsa* (Boheman), dorsal view (4.8X).

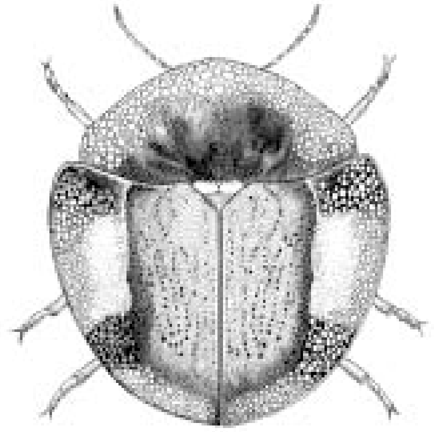


Fig. 344. *Aspidomorpha dissentanea* Boheman, dorsal view (6.4X).

110’ Not as above 111

111(110’) Elytra brownish yellow with expanded parts sloping downwards, without black spots; head yellowish brown with a swollen frons; antenna brownish yellow except black terminal segment with yellow tip; venter of body and legs pale yellow brown .... *Aspidomorpha obovata* Klug **[Fig. 345]**

111’ Green except yellowish brown inner area of pronotum and humeral area of pronotum; antenna yellowish green with reddish brown terminal segment; frons with a bluntly rounded structure below antennal base; venter of entire body yellowish brown...................................... *Cassida* sp. **[Figs. 346, 347]**

Order Hemiptera

Planthoppers, treehoppers, froghoppers, leafhoppers, and bugs

1 Beak arises from the back of head 2

1’ Beak arises in front of head extending back to the ventral side of thorax 25

2(1) Coxa II elongated and separated; antenna on sides of head underneath the eyes; two anal veins in fore wing apically form a Y-shaped vein 3

2’ Coxa II short and close together; antenna on front of head between eyes; anal area of fore wing without a Y-shaped vein 6

3(2) Head not prolonged anteriorly; tibia III with a broad movable apical spur [Family **Delphacidae**] 7

3’ Head prolonged anteriorly, if not frons with 2 or 3 ridges; median ocellus absent [Family **Dictyopharidae**] 4

4(3’) First tarsal segment of leg III with at least 3 spines; propleuron and mesonotum dark brown to black; tegula dark brown; paramere of male genitalia bifurcate apically .... *Nilaparvata maeander* **[Figs. 348–350]**

4’ Not as above; tegula whitish yellow 5

5(4’) Fore wing with a broad band in the lower apical one-half; paramere of male genitalia with a small inner tooth and a moderately slender and pointed tip ... . *Sogatella kolophon* (Kirkaldy) **[Figs. 351–353]**

5’ Fore wing without band; paramere of male genitalia with oblique apical ends directed to each other .... *Tagosodes cubanus* (Crawford) **[Fig. 354]**

6(2’) Head prolonged anteriorly, 5X longer than wide, median area with a broad groove; pronotum anterolaterals squarely cut, vertex with a short white median ridge; node yellowish brown ovoid, enclosing 3 veins close to each other; fore wing with 23 apical cells; tibia III with 4 equally spaced spines .... *Centromeriana* sp. **[Fig. 355]**

6’ Front of head short, slightly shorter than length of eyes, median groove with 3 ridges; anterolaterals of pronotum moderately concave, vertex with 2 grooves; node black to dark reddish brown, subtriangular enclosing two veins almost coalesce apically; fore wing with 21 apical cells; tibia III with 5 spines .... *Philotheria discalis* (Walker) **[Fig. 356]**

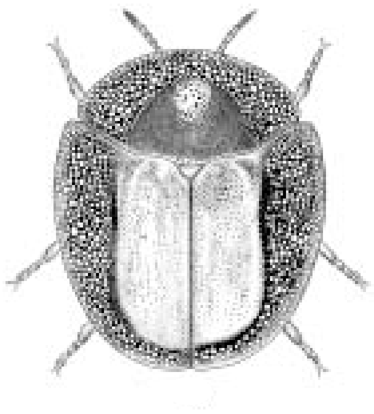
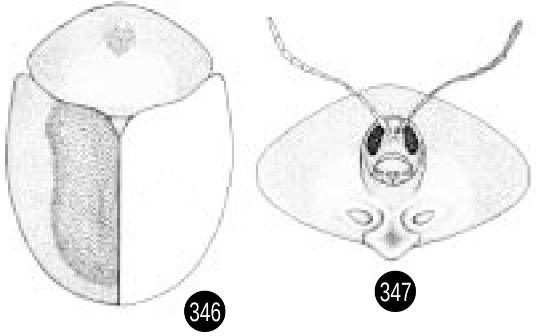
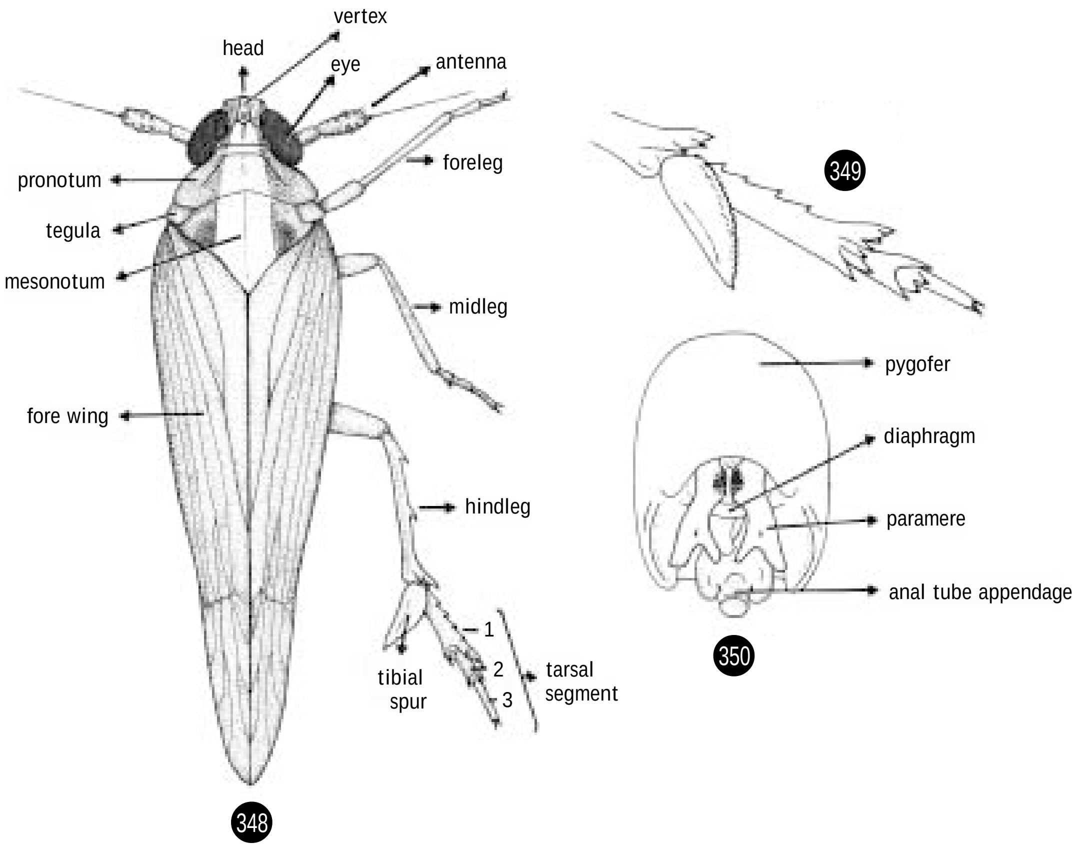


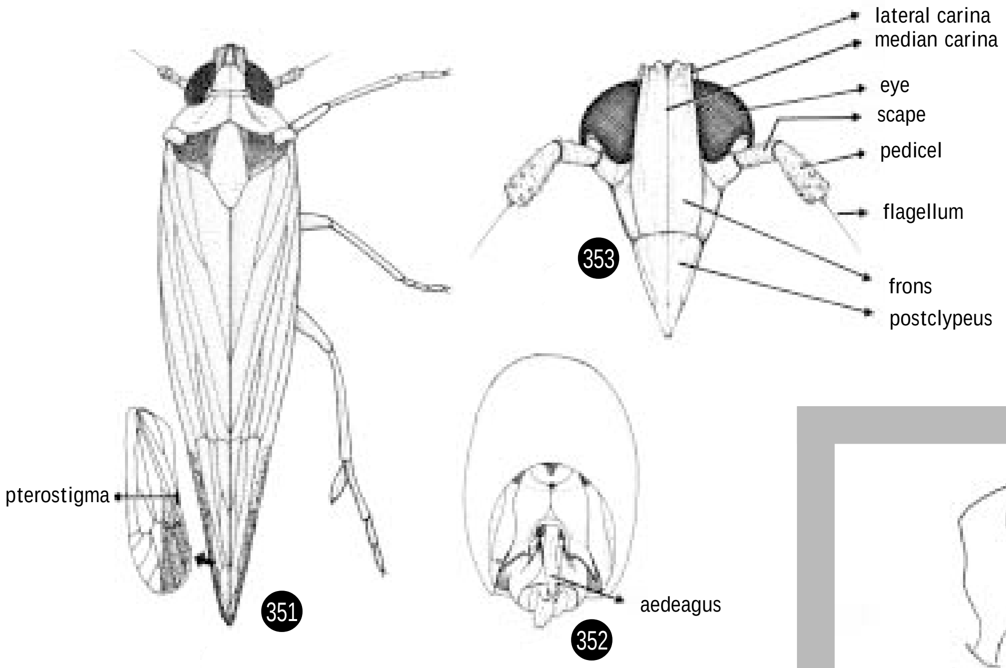
Fig. 345. ***Aspidomorpha obovata*** **Klug, dorsal view (8.1X).**



Figs. 346–347. ***Cassida*** **sp., dorsal view (346; 7.6X) and frontal view (347; 20X).**



Figs. 348–350. ***Nilaparvata maeander*** **Fennah, dorsal view (348; 24.3X), tibial spur in leg III (349; 65X), and male genitalia (350; 120X).**



Figs. 351–353. ***Sogatella kolophon*** **(Kirkaldy), dorsal view (351; 21X), male genitalia (352; 72X), and frontal view of head (353; 34X).**

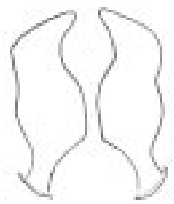


Fig. 354. ***Tagosodes cubanus*** **(Crawford), paramere of male genitalia (88X).**

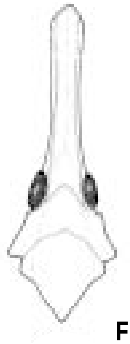


Fig. 355. ***Centromeriana*** **sp., dorsal view of head and pronotum (6X).**

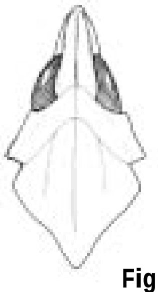
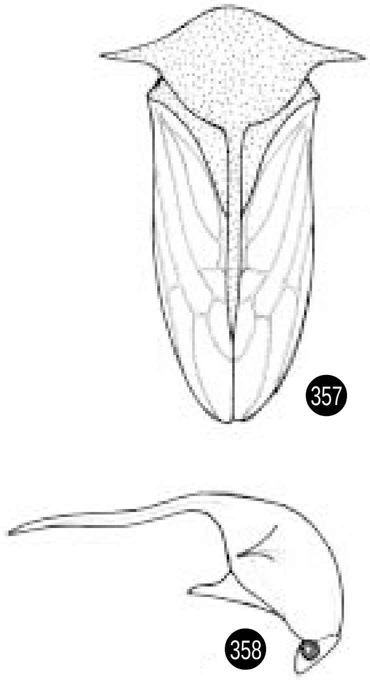


Fig. 356. ***Philotheria discalis*** **(Walker), dorsal view of head and pronotum (9.7X).**



Figs. 357–358. ***Tricoceps tenuosus*** **Capener, dorsal view (357; 8.5X) and lateral view of head and pronotum (358; 7X).**

7(3) Pronotum ornamented posteriorly extended over the abdomen; eyes underneath the posterior lateral depression of pronotum [Family **Membracidae**] 8

7’ Pronotum not ornamented, short; eyes not as above 11

8(7) Pronotum densely punctured, strongly rounded dorsally, lateral horns sharply pointed and slender posterior horn acute almost reaching apex of fore wings; posterior horn with a dorsal and two lateral ridges; fore wing with a brown triangular band passing through the largest ovoid anal cell; black species with yellowish tarsus; body length 6.6 mm .... *Tricoceps tenuosus* Capener **[Figs. 357, 358]**

8’ Pronotal lateral horns broad and leaf-like 9

9(8’) Pronotum and head punctured without spines, covered with short fine white hairs; vertex short not expanded in front of eyes, lateral notch dorsal of antennal base absent; ocelli closer to eyes than to each other; fore wing transparent without brown marks, both ends of costal area with reddish brown elongated band; body length 5.5 mm .... *Leptocentrus nubianus* Capener **[Fig. 359]**

9’ Pronotum and head with small spines 10

10(9’) Lateral horns of pronotum short, hardly longer than height of pronotum in frontal view, apex with 4 teeth; posterior horn with a dorsobasal tubercle, midlength concave and serrated, apical one-third broad and blade-like with a pointed tip; fore wing reddish brown basally and at apex of costal vein, apical one-fourth with a brown basal band; tibiae and tarsi dark reddish brown; body length 6 mm .... *Platybelus* sp. A **[Fig. 360]**

10’ Lateral horns of pronotum much longer than height of pronotum in dorsal view, leaf-like with a slightly concave tip and a subapical notch; posterior horn thinly blade-like and strongly C-shaped with peg-like teeth ventrally; fore wing mottled brown with brown costal vein; tibiae and tarsi yellow; body length 6 mm .... *Platybelus* sp. B **[Fig. 361]**

11(7’) Coxa III conically short; tibia III with 1–2 stout spines, apex with a ring of spines [Family **Cercopidae**] 12

11’ Coxa III transverse; tibia III with an articulated row of small spines [Family **Cicadellidae**] 15

12(11) Anterior margin of flat head widely rounded, 3 black spots at midlength and a subquadrate plate below the spots; eyes ovoid, reaching lateral margins of the anteriorly convex and posteriorly wedge-shape pronotum; ocelli on a flat plane widely separated; frons and clypeus slanted viewed laterally; scutellum brownish, flat with a pointed yellow apex and a median longitudinal yellow band; legs uniformly brown to yellowish brown, tibia III with a subbasal, subapical, and apical spines; apex with 15 spines in 2 transverse rows; body generally brownish, length 10.6 mm .... *Poophilus* sp. **[Fig. 362]**

12’ Not as above; usually red or orange and yellow with black bands; pronotum hexagonal 13

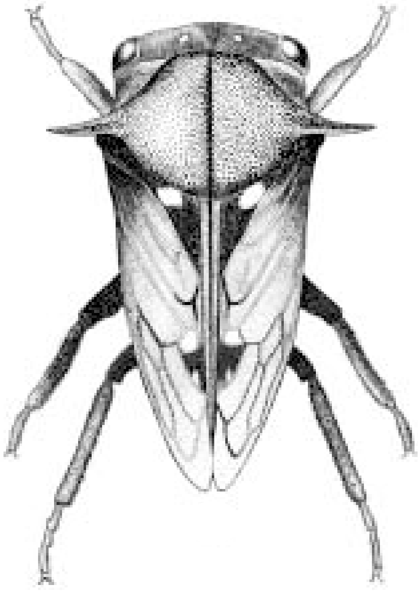


Fig. 359. *Leptocentrus nubianus* Capener, dorsal view (10X).

Fig. 362. *Poophilus* sp., dorsal view of head and pronotum (9.2X).

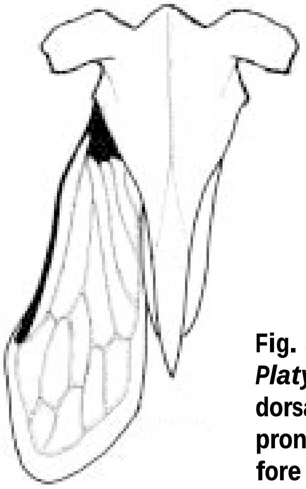


Fig. 360. *Platybelus* sp. A, dorsal view of pronotum and left fore wing (9.7X).

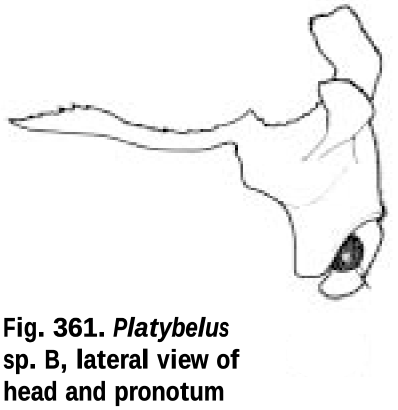


Fig. 361. *Platybelus* sp. B, lateral view of head and pronotum (9.4X).

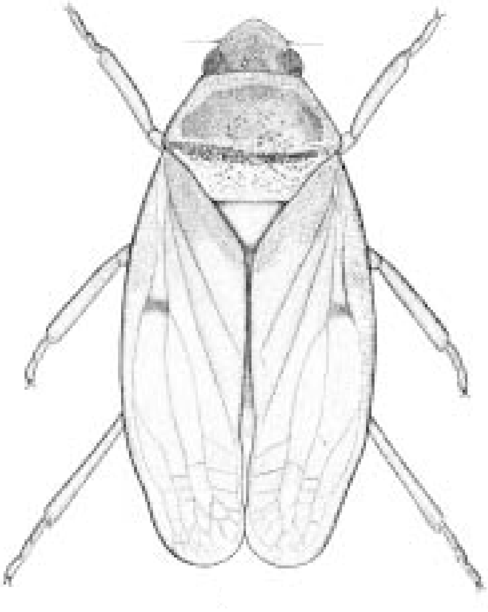


Fig. 363. *Locris rubra* Fabricius, dorsal view (5.8X).

13(12’) Red with transverse brown band in posterior pronotum, oblique reddish brown band in the fore wing, reddish brown spot in inner one-third of corium and clavus; ocelli on a tubercle closer to each other, head dorsally red and black; frons swollen and rounded, pronotum with straight anterior and lateral black margins, posterior one-third coarsely punctured; scutellum red; legs I and II black with reddish brown apices of femora; tibia III red with black anterior end, dark reddish brown basal one-half and a spine below midlength; body length 11 mm .... *Locris rubra* Fabricius **[Fig. 363]**

13’ Not as above; anterior margins of head always yellow 14

14(13’) Pronotum yellow with a large black disc, posterior one-third moderately punctured; fore wing red in apical one-third, orange yellow in basal two-thirds with a large black band basally and a small brown spot in basal one-third of corium; femora I and II black with yellow apices, tibiae I and II yellow outside and black to dark reddish brown inside; tibia III dark reddish brown with a spine below midlength; body length 10 mm .... *Locris* sp. **[Fig. 364]**

14’ Pronotum black with humeral band transversely broad and yellow or reduced to 4 spots; fore wing yellow with black apical one-third and shades of black spots in basal one-third; tibia II with red median band; tibia III black in basal one-half and red in apical one-half; body length 10.50 mm .... *Locris maculata maculata* Fabricius **[Fig. 365]**

15(11’) Large, 8–10 mm; white to pale green leafhopper with swollen frontoclypeus; ocelli closer to the posterior margin of vertex than to anterior margin 16

15’ Smaller, less than 7 mm; frontoclypeus not swollen; ocelli closer to anterior margin of vertex 18

16(15) Pale green leafhoppers; vertex more pointed with a rounded black spot between ocelli; junction of face and vertex without the central spot, brown striations very faint or absent .... *Cofana unimaculata* (Signoret) **[Fig. 366]**

16’ White leafhoppers; vertex rounded, median apical black spot and prominent brown striations present 17

17(16’) Vertex with a black spot between ocelli; pronotum smooth, without a longitudinal median black band extended to scutellum .... *Cofana spectra* (Distant) **[Fig. 367]**

17’ Vertex with two black spots aligned to the anterior median spot and median longitudinal band of pronotum and scutellum; posterior two-thirds of pronotum transversely striated .... *Cofana jedarfa* Young **[Fig. 368]**

18(15’) Green to dark green or yellowish green leafhoppers with or without black bands in the fore wings 19

18’ Wings tawny, veins normally brownish 24

19(18) Fore wing green except brownish apical one-third, apical cells, with white round spot; vertex flat and anterior ridge between face and vertex prominent .. .. *Hecalus* sp. **[Figs. 369, 370]**

19’ Fore wing without white spot on apical cells; anterior ridge not distinct 20

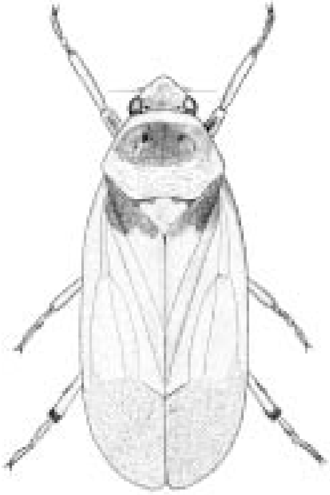


Fig. 364. *Locris* sp., dorsal view (5.1X).

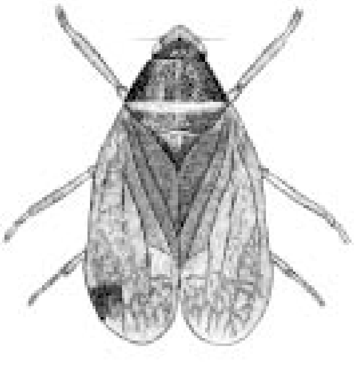


Fig. 365. *Locris maculata maculata* Fabricius, dorsal view (3.71X).

Fig. 366. *Cofana unimaculata* (Signoret), dorsal view (4.89X).

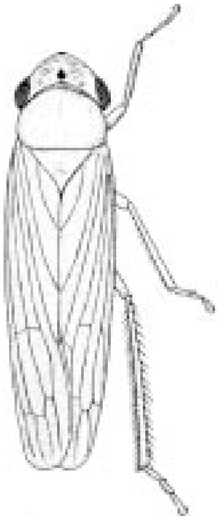
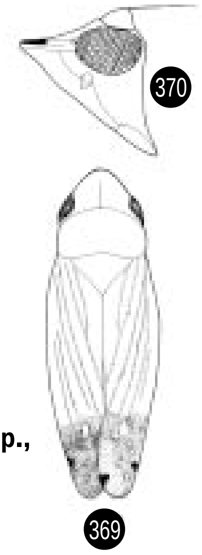


Fig. 367. *Cofana spectra* (Distant), dorsal view (6X).

Fig. 368. *Cofana jedarfa* Young, dorsal view (4.11X).



Figs. 369–370. *Hecalus* sp., dorsal view (369; 9.3X) and lateral view of head (370; 17X).

20(19’) Uniformly yellowish green; anterior tip of head pointed, strongly produced forward, posterior margin with 3 straight sides; eyes large, ovoid dorsally and inner corner converging; space between eyes shorter than eye length; ocelli on the face; wings shorter than abdomen, exposing terminal segment .... *Deltocephalus* sp. **[Fig. 371]**

20’ Green to dark green with black bands or spots on head or dull yellow green with reddish brown head and yellow scutellum 21

21(20’) Vertex narrow, not medially produced and 2 round black spots present; clypeus with a median black Y-band extended to vertex and 2 submarginal rows of dotted spots; pronotum with 4 dark brown spots and a short longitudinal band; scutellum black laterobasally with 2 black spots and a transverse median band .... *Amritodus* sp. **[Fig. 372]**

21’ Vertex broad midanteriorly; scutellum yellow or black 22

22(21’) Scutellum with two pale brown anterior median spots; head reddish brown with yellow mottles, widest medially, strongly convex posteriorly; pronotum dull green except yellow subanterior, posterior margin emarginate and anterior margin strongly convex; fore wing dull green with yellow veins .... *Hortensia* sp. **[Fig. 373]**

22’ Scutellum without spots; head green with black transverse bands; posterior margin of pronotum straight; fore wing green with black markings apically 23

23(22’) Submarginal transverse black band well-developed, connects two compound eyes; scutellum yellow or black; tergum IX of male with a short spine .... *Nephotettix afer* Ghauri **[Fig. 374]**

23’ Submarginal transverse black band interrupted, separates two compound eyes; scutellum yellow; tergum IV of male with a long spine .... *Nephotettix modulatus* Melichar **[Fig. 375]**

24(18’) Head pointed with 6 small brown spots anteriorly, midvertex with a yellowish brown M-band; pronotum brownish with yellow spots subanteriorly; scutellum yellow with dark brown lateral bands; fore wing with cells containing brownish margins .... *Recilia mica* Kramer **[Fig. 376]**

24’ Head with a prominent transverse black submarginal band; pronotum with 2 brown transverse parallel bands interrupted medially; scutellum uniformly yellow; fore wing hyaline with brownish veins .... *Exitianus* sp. **[Fig. 377]**

25(1’) Aquatic or semiaquatic bugs; antenna usually shorter than head, hidden beneath the eyes; ocelli present 26

25’ Terrestrial species; antenna as long as or longer than head, visible from above; ocelli may be present or absent 27

26(25) Front leg not raptorial, femur not enlarged and without pincer-like claws; head moderately transverse; large eyes emarginate; antenna visible from above; proboscis long extended beyond coxa III; pronotum finely punctured, lateral margins yellow, slightly expanded and without clubbed setae; scutellum black and punctured; fore wing black, punctured except membrane with 4 costal and 2 apical yellow spots; membrane brown with 7 closed cells; legs yellowish brown, coxa I black and reddish brown in coxae II and III; body length 3.5–5.0 mm [Family **Ochteridae**] .... *Ochtera* sp. **[Figs. 378, 379]**

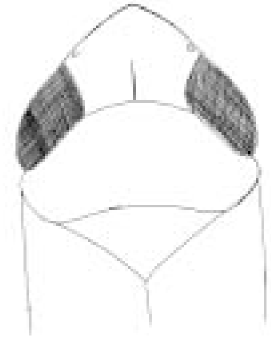


Fig. 371. *Deltocephalus* sp., dorsal view of head, pronotum, and mesonotum (23.9X).

Fig. 374. *Nephotettix afer* Ghauri, dorsal view (8.2X).

Fig. 372. *Amritodus* sp., dorsal view (9.8X).

Fig. 375. *Nephotettix modulatus* Melichar, dorsal view (7X).

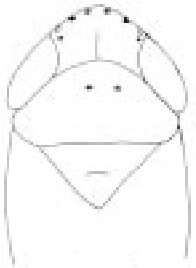


Fig. 376. *Recilia mica* Kramer, dorsal view of head, pronotum, and mesonotum (23.3X).

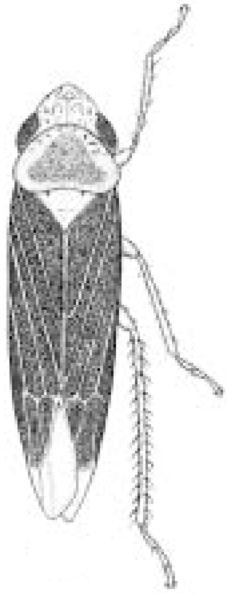


Fig. 373. *Hortensia* sp., dorsal view (12.6X).

Fig. 377. *Exitianus* sp., dorsal view of head, pronotum, and mesonotum (22.6X).

26’ Front leg raptorial, femur broad and claw pincher-like; head narrow, strongly transverse with small eyes and 9 tubercles covered with short club setae; antenna hidden; proboscis short not reaching posterior fore coxa; pronotum rough, disc elevated with 3 transverse humps lined with series of tubercles, lateral margins flat, widely expanded with clubbed setae; scutellum blackish brown with 3 transverse grooves and 3 ridges; fore wings moderately convex, blackish brown almost entirely sclerotized with scattered humps of black club setae; legs dull brown; body length 11 mm [Family **Gelastocoridae**] .... *Nerthra grandicollis* Germar **[Fig. 380]**

27(25’) Antenna 5-segmented; scutellum large, usually triangular, reaching to or beyond middle of abdomen, sometimes much enlarged, covering entire abdomen [Family **Pentatomidae**] 28

27’ Antenna less than 5 segments; scutellum smaller, not reaching middle of abdomen 54

28(27) Humeral angle not spinose 29

28’ Humeral angle spinose 37

29(28) Green bug with a dense network of punctures (pits) close to each other; head rounded anteriorly, slightly wider than long and broadest across; antennae green except segments IV and V brown, length of segments: V>II>IV>III>I, base of antenna with a lateral flap; legs yellowish green; scutellum green with fovea black; body length 12 mm .... *Aethemenes chloris* (Dallas) **[Fig. 381]**

29’ Not entirely as above, or if head rounded anteriorly, it is not green 30

30(29’) Anterior part of head rounded, tylus as long as juga 31

30’ Anterior part of head with median notch; tylus shorter than juga 33

31(30) Metallic bluish black bug with head nearly impunctate; prothorax, scutellum and corium moderately punctured; head slightly truncate anteriorly, as wide as long; antennae bluish black, length of segments: V>IV>II>III>I, bases of antennae without lateral flaps; legs black except basal one-half and subapical portion of femora, midtibiae and basal two segments of tarsi yellow; scutellum uniformly bluish black; body length 6.5–8 mm .... *Dorycoris pavoninus* Westwood **[Fig. 382]**

31’ Without the above combination of characters 32

32(31’) Prothorax often with transverse orange red band; body color yellowish green to yellowish brown; antennae orange red except yellow segments I, II, and basal one-fourth of III, length of segments: V>IV>III>II>I; head yellow brown, lateral sides narrowed anteriorly forming rounded tip; scutellum without basolateral pale spots; body length 8–9.5 mm .... *Piezodorus rubrofasciatus* Fabricius **[Fig. 383]**

32’ Prothorax lacking distinct transhumeral orange red band; body color brown; antennae yellowish brown; length of segments: V>IV>II>III>I; dark brown head with a trifurcate yellow median band heavily punctured, parallel sided in front of eyes; scutellum with pale basolateral spots; body length 5 mm .... *Eysarcoris ventralis* (Westwood) **[Fig. 384]**

33(30’) Small pentatomids, 7.5 mm or less in length 34

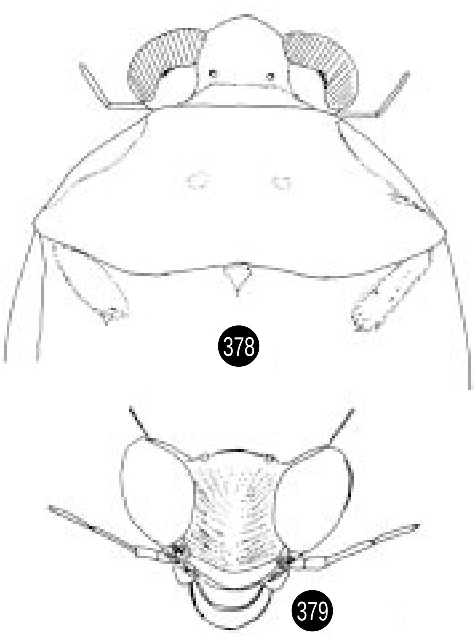


Fig. 378–379. *Ochtera* sp., dorsal view of head, pronotum and mesonotum (378; 17.7X) and frontal view of head (379; 24X).

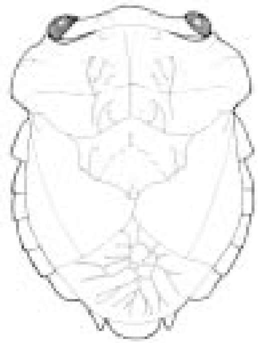


Fig. 380. ***Nerthra grandicollis*** **Germar, dorsal view (4.4X).**

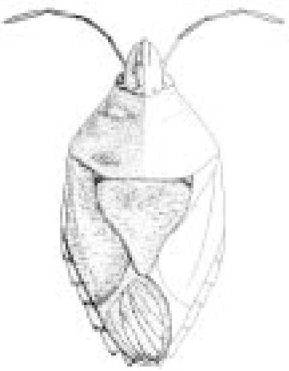


Fig. 381. ***Aethemenes chloris*** **Dallas, dorsal view (3.17X).**

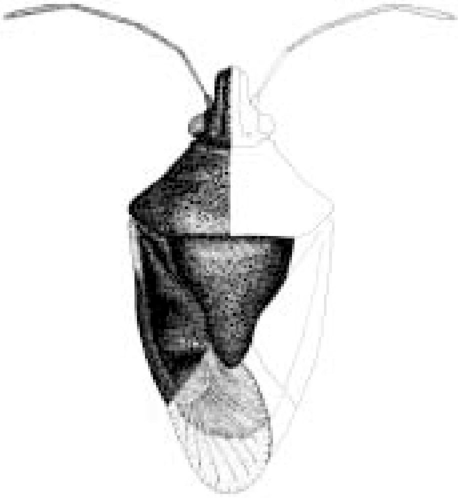


Fig. 382. ***Dorycoris pavoninus*** **Westwood, dorsal view (6.5X).**

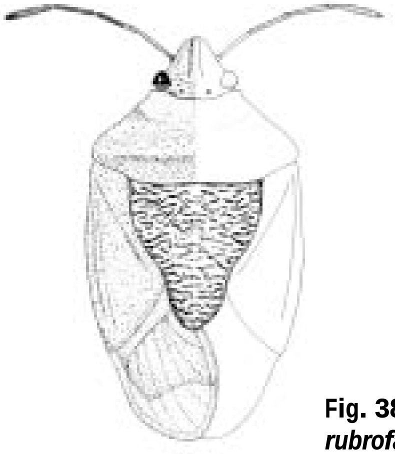


Fig. 383. ***Piezodorus rubrofasciatus*** **Fabricius, dorsal view (5.37X).**

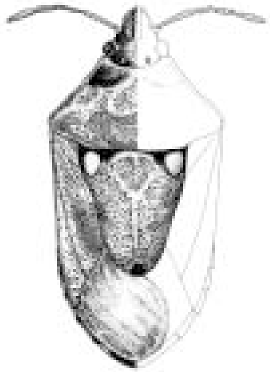


Fig. 384. ***Eysarcoris ventralis*** **(Westwood), dorsal view (8.4X).**

33’ Moderately large species, 11 mm or more in length 35

34(33) Head wider than long, black with 5 longitudinal yellow bands and 2 yellow bands around compound eyes; pronotum yellow with punctures, sublateral and subanterior margins and shoe-like calli black; pronotal punctures denser near the humeri; scutellum yellow to orange yellow with black punctures; corium without H-mark; antennae brown with segments I and II yellow and black inner portions of segment II and basal one-third of III; length of segments: IV>V>III>II>I; venter of body yellow with a broad black band subventrally and a narrow middle band; sternite III with a process projected between coxa III .... *Menida transversa* (Signoret) **[Fig. 385]**

34’ Head longer than wide, uniformly pale brown with black punctures in the margins and median area; pronotum, scutellum and corium pale brown and uniformly punctured; dull brown calli holster-like with 6–8 punctures in the middle; corium with an H-mark; antennae yellowish brown becoming reddish at apical one-half of segment IV, length of segments: III>IV>V>I>II; abdominal venter dull brown, sternite III without a peg-like structure projected towards coxa III ....*Aeliomorpha griseoflava* (Stål) **[Fig. 386]**

35(33’) Punctures smooth, glabrous even throughout head, pronotum, scutellum. and corium; margins of head almost parallel-sided in front of eyes; each anterolateral tooth of pronotum small, directed posterolaterally; antennae yellowish brown except dark brown apex of segment III, orange red middle portion of IV and V, length of segments: IV>V>II>III>I; corium reddish with dark brown punctures; each propleuron with 2 black spots, one each on meso- and metapleuron; scent gland opening relatively large; proboscis reaching to middle of sternite III; all legs yellowish brown; body length 14.5–15 mm ....*Boerias ventralis* (Dallas) **[Fig. 387]**

35’ Punctures with hairs, sculpture rough throughout the head, pronotum, scutellum and corium; antennae black 36

36(35’) Head black with 3 longitudinal yellow bands; tylus heavily punctured in black areas; anterolateral margins of pronotum bluntly rounded; pronotum reddish brown except black punctured areas on calli and towards humeri; propleuron with one black spot, 2 in the meso- and 1 in metapleuron; abdominal sternites with paired black spots in the midanterior of segments IV, V, VI, and VII and widely separated posteroventrolateral spots in segments IV, V, VI, and VII; scutellum with a pale Y-shaped orange yellow and highlighted by dense black punctures in basal one-fifth and near the apex; corium orange red except yellow and black areas in costal area; basally dark brown membrane interrupted by a yellow band, all 9 veins dark brown; legs yellow except black tibiae and tarsi, femur with an outer black spot towards apical one-third; body length 13 mm .... *Agonoscelis versicolor* (Fabricius) **[Fig. 388]**

36’ Head yellow with brown punctures, sparse on tylus but moderately dense on juga; anterolateral spine of pronotum projected slightly laterally; pronotum yellow with brown punctures and orange lateral margins in apical three-fourths; calli brownish yellow; antennae segment II longer than III; propleuron and mesopleuron each with a black spot; abdominal segments III–VI pale brown ventrolaterally; paired median spots absent; scutellum coarsely punctured; corium orange red with coarse yellow ridges along costal area; membrane with a dark brown spot near the closed cell, veins transparent with brown marks anteriorly; legs uniformly yellowish brown with orange tinge; each hind femur with a small black spot in the apical one-fourth; body length 11–12 mm .... *Agonoscelis haroldi* Bergroth **[Fig. 389]**

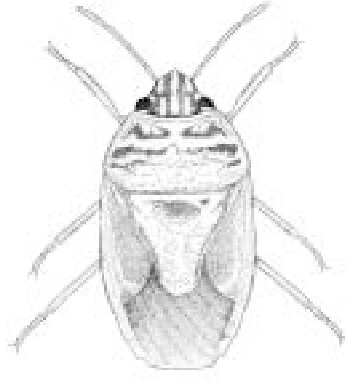


Fig. 385. *Menida transversa* (Signoret), dorsal view (7.1X).

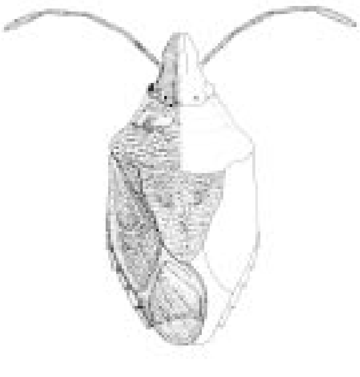


Fig. 386. *Aeliomorpha griseoflava* (Stål), dorsal view (5.9X).

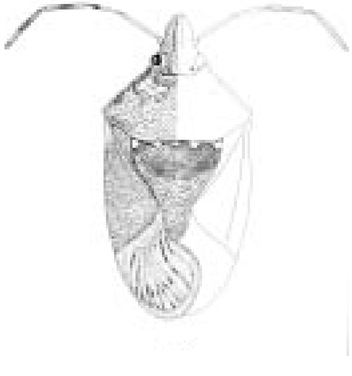


Fig. 387. *Boerias ventralis* (Dallas), dorsal view (2.24X).

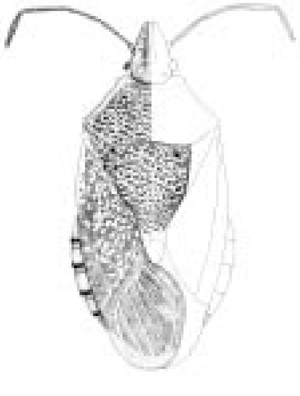


Fig. 388. *Agonoscelis versicolor* (Fabricius), dorsal view (3.08X).

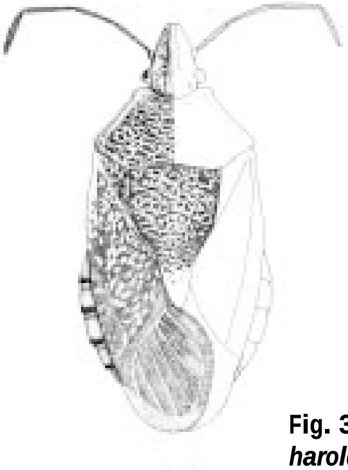


Fig. 389. *Agonoscelis haroldi* Bergroth, dorsal view (4.0X).

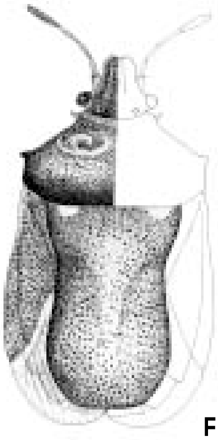


Fig. 390. *Scotinophara mixta* Linnavouri, dorsal view (6.37X).

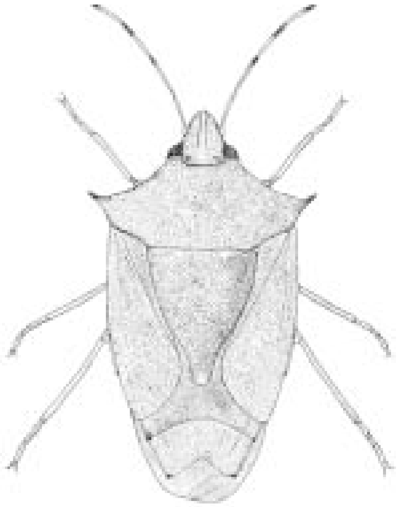


Fig. 391. *Acrosternum acutum* (Dallas), dorsal view (4X).

37(28’) Scutellum reaching abdominal tip, uniformly punctured with short white hairs similar to those on the prothorax, head and corium; head black densely clothed with white hairs; eyes prominently bulging; antennal segments II-IV brown, segments I and V black; length of segments: V>III>IV>II>I; pronotum with elevated blackish calli, each callus with medial yellow spot; anterolateral and humeral spines present both projected laterally; leg yellow brown with femur black; venter of head, thorax, and abdomen entirely black; body length 6.5–7.0 mm .... *Scotinophara mixta* Linnavouri **[Fig. 390]**

37’ Scutellum not reaching abdominal tip 38

38(37’) Lateral margins of the head, pronotum, abdomen and costal area of corium yellow; posterolateral edges of tergites black; humeral angles strongly spinose and yellow, humeral tip black; antennae green except segment III dark reddish brown apically, brown apical one-half of segment IV and apical two-thirds of V brown; legs all green except brown claws with black tips .... *Acrosternum acutum* (Dallas) **[Fig. 391]**

38’ Mostly brown to yellowish brown in color 39

39(38’) Anterior tip of head without distinct notch, juga as long as tylus 40

39’ Anterior tip of head with prominent notch, juga distinctly longer than tylus 48

40(39) Proboscis long; femoral apical spine usually absent 41

40’ Proboscis short; femoral apical spine always present 51

41(40) Ostiolar rugae elongate, apically acuminate; humeral spine usually blunt and short; antennal segment III longer than II; each pleuron with a small black spot in a straight line; legs green except tarsi brown; abdominal venter green except sometimes sternites III and IV red medially; body length 7.5 mm .... *Eudryadocoris goniodes* (Dallas) **[Fig. 392]**

41’ Not the combination of above characters; ostiolar rugae often short and auriculate 42

42(41’) Scutellum with a Y-shaped yellow band formed by the merging of basolateral spots to the apical spot; head black and densely punctured; humeral spine black, moderately acute, projected posterolaterally; ventrolateral band on abdomen weak, slightly punctate; body length 6 mm .... *Aspavia brunnea* (Signoret) **[Fig. 393]**

42’ Scutellum without a Y-shaped yellow band 43

43(42’) Pronotum with pair of median yellow spots near the inner arm of each callus; tylus longer than the heavily punctured juga; anterolateral margins of pronotum yellow; humeral spine black, posterior part rough, projected slightly lateroposteriorly; scutellum brownish yellow with 3 yellow spots (2 basolateral and 1 midbasal), margins of anterior tip slight yellow, inner costal area of corium whitish yellow; legs yellow mottled with brown spots; apex of femora with spine; antennae yellow except dark brown apex of segments III and IV and most of V; abdominal venter dark brown mottled with white; body length 8 mm .... *Aspavia hastator* (Fabricius) **[Fig. 394]**

43’ Midpronotum without paired yellow spots 44

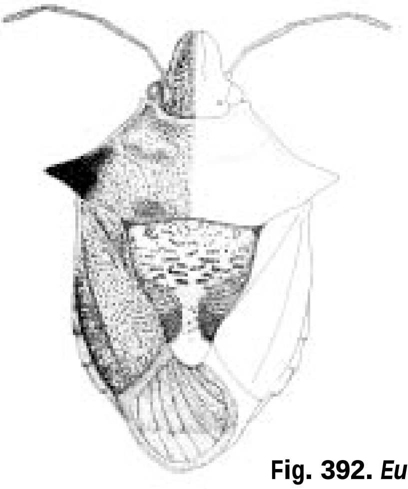


Fig. 392. *Eudryadocoris goniodes* (Dallas), dorsal view (6.67X).

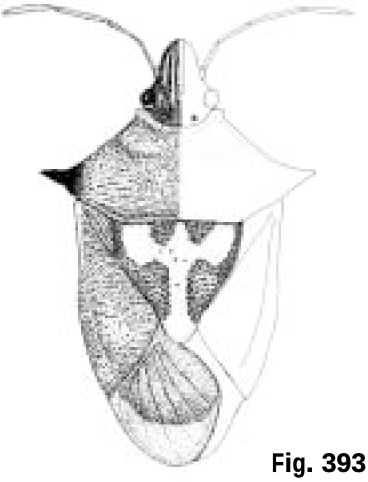


Fig. 393. *Aspavia brunnea* (Signoret), dorsal view (8.0X).

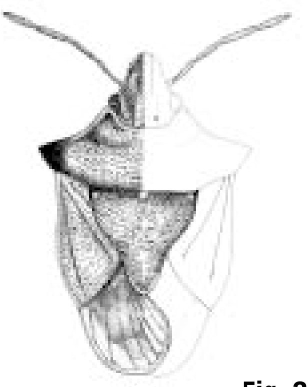


Fig. 394. *Aspavia hastator* (Fabricius), dorsal view (4.5X).

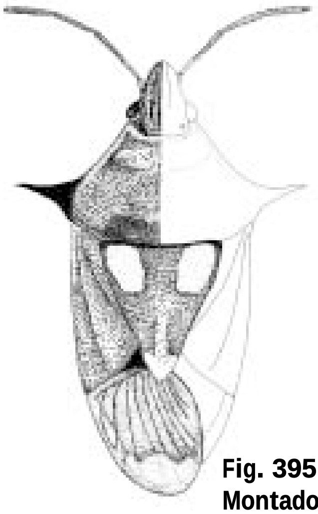


Fig. 395. *Aspavia acuminata* Montadon, dorsal view (8.2X).

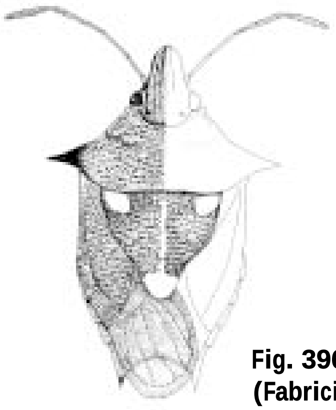


Fig. 396. *Aspavia armigera* (Fabricius), dorsal view (5.8X).

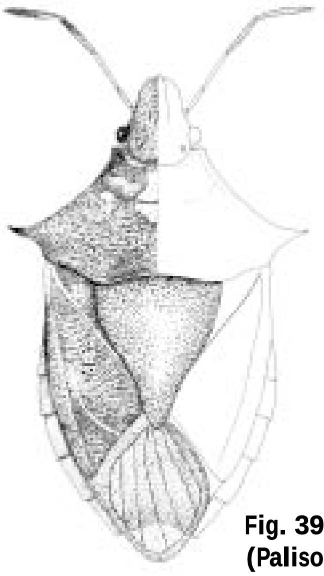


Fig. 397. *Lerida punctata* (Palisot de Beauvois), dorsal view (5.33X).

44(43') Scutellum with yellow spots or almost entirely yellow; distal end of femora without spine 45

44' Scutellum without yellow spots; distal end of femora with spine 46

45(44) Scutellum with large whitish yellow spots, basolateral spots cover two-thirds basal width and apical spot made up approximately one-fourth of scutellum's length; humeral spine acutely black, projected at about 15º angle dorsoanteriorly; apex of corium with a reddish band; ventrolaterals of abdomen with few punctures forming a longitudinal band on the sternites .... *Aspavia acuminata* Montadon **[Fig. 395]**

45' Scutellum spots rather small, each basolateral spot approximately one-sixth of scutellum's width; apical spot occupy one-fifth of scutellum' length; punctures in the brown scutellum evenly spaced; black humeral spines acutely pointed laterally; ventrolaterals of male abdomen with a broad brown band, posterior end with 4 spine-like processes .... *Aspavia armigera* (Fabricius) **[Fig. 396]**

46(44') Pronotum usually with a large whitish yellow globular spot extended between the smooth calli, anterolateral margins with black punctures towards the eye; juga with black punctures in basal half of margins; humeral spine acute, dark brown at tip; scutellum brownish yellow with brown punctures and anterior tip yellow along margins; fore wings at rest expose sides of abdomen; sternites glabrous; legs uniformly yellowish brown; body length 10–11 mm .... *Lerida punctata* (Palisot de Beauvois) **[Fig. 397]**

46' Pronotum not as above; abdominal sternites hairy along posterior margins 47

47(46') Scutellum yellow with moderately dense laterally and basally brown punctures; humeral spine blunt and weakly developed; pronotum with broadly scattered yellow patches between humeri; costal area of corium yellow in basal one-half, entire length with brown punctures; ventrolaterals of a broad reddish brown band in abdominal sternites III–VI with a fine mass of white hairs in males; legs yellow brown except tibia I and femur I with brown spots; body length 7 mm .... *Durmia tomentoventris* (Germar) **[Fig. 398]**

47' Scutellum yellow with a few brown punctures; humeral spine black, prominently acute and projected slightly upward with a yellow transverse band in between; costal area of corium uniformly punctured yellow in its entire length; ventrolaterals of male abdomen with a narrow reddish brown band clothed with white fine hairs in segments III–V and a small portion of segment VI; legs uniformly yellowish brown, tibia I without brown mottles; body length 7.5 mm .... *Durmia haedula* Stål **[Fig. 399]**

48(39') Distal femoral spine long and acute; humeral spine dark reddish brown, usually slender, oblique and sharply pointed; pronotum lightly punctured with a smooth yellow transverse area; juga slender, sharply pointed, diverge apically; antennae yellow except dark reddish brown apical fourth-fifth of segment V and one-half of segment IV; anterior median part of abdominal venter with a red mushroom-like band; legs yellow with sparse brown spots; body length 13 mm .... *Diploxys senegalensis* Amyot and Audinet-Serville **[Fig. 400]**

48' Distal femoral spine short; humeral spine pointed but relatively small 49

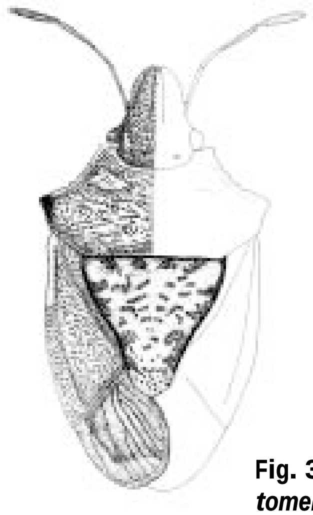


Fig. 398. *Durmia tomentoventris* (Germar), dorsal view (6.57X).

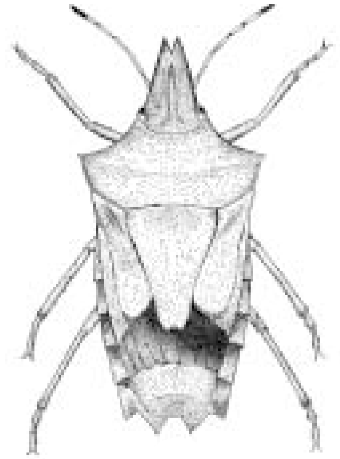


Fig. 401. *Diploxys acanthura* (Westwood), dorsal view (4.2X).

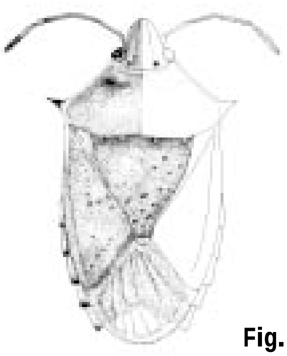


Fig. 399. *Durmia haedula* Stål, dorsal view (5.07X).

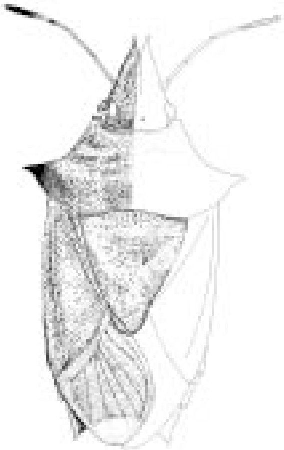


Fig. 402. *Diploxys* sp., dorsal view (3.52X).

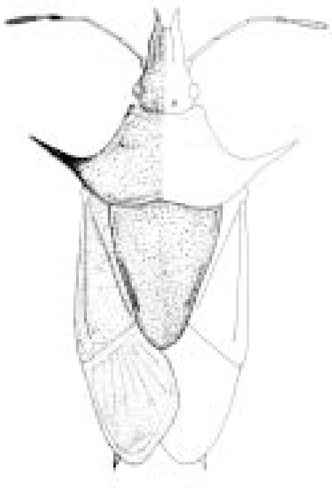


Fig. 400. *Diploxys senegalensis* Amyot and Audinet-Serville, dorsal view (3.69X).

Fig. 403. *Diploxys bipunctata* Amyot and Audinet-Serville, dorsal view (3.43X).

49(48’) Jugal tip diverging; humeral spine distally black and dark brown basally, projected anterolaterally; antenna with yellow segment I, yellow with brown spots in II and III, dark reddish brown in apical one-half of IV and entire segment V; legs yellowish brown with uniform dark brown spots; body length 10 mm .... *Diploxys acanthura* (Westwood) **[Fig. 401]**

49’ Not as above 50

50(49’) Anterior tip of head with a deep cleft, prominently V-shaped; antenna yellow except dark reddish brown apical three-fourths of segment V and apical one-third of IV; midposterior head yellow with a pair of swollen areas; humeri blackish brown with a short black spine; scutellum with brown punctures; lateral margins of tergites only slightly exposed; midsternite VII with a dark red U-shaped band; body length 12.5 m .... *Diploxys* sp. **[Fig. 402]**

50’ Anterior tip of head with a shallow cleft, slightly V-shaped; antennae yellow except dark reddish brown segment V; posterior area of head with a reddish brown transverse band; humeri with black and slightly blunt spine; scutellum with yellow posterolateral spots; lateral margins of tergites widely exposed with black to dark brown punctures; midsternite VII with a median ovoid dark brown spot ; body length 10.5 mm .... *Diploxys bipunctata* Amyot and Audinet-Serville **[Fig. 403]**

51(40’) Humeral spine usually short and blunt, projected straight laterally; lateral edge of pronotum shallow and serrated; scutellum, pronotum and corium coarsely punctured forming black lines; antenna uniformly brown; anterior tip of juga converging; a black ovoid spot present on all sternites posterior to spiracles; membranes of fore wings with brown spots on longitudinal veins; legs black except brown one-third to basal one-half of femora brown; body length 16 mm .... *Gonopsia dimorphus* Linnavouri **[Fig. 404]**

51’ Humeral spine slender, acutely pointed and projected anteriorly; lateral edge of pronotum deeply concave; scutellum, pronotum and corium relatively smooth; spiracles in broad longitudinal band; membranes of fore wings without spots, 3-6 longitudinal veins present; body length 14–19 mm 52

52(51’) Black except yellow brown margins of juga, posterior pronotum, scutellum, costal area of corium, lateral margins and venter of abdomen, femora I–III, and proboscis except its black tip and apical one-half of segment V yellow brown; outer margin of closed cell in the membrane bears 3 longitudinal veins; body length 15–19 mm .... *Macrina* sp. A **[Fig. 405]**

52’ Brownish throughout except black legs and antennae in some species 53

53(52’) Robust humeral spine projected forward at 60º angle; antennal segments II–IV and basal one-third of V black; legs yellow brown except tibia I black; outer margin of closed cell with 4 longitudinal veins; body length 20 mm .... *Macrina* sp. B **[Fig. 406]**

53’ Humeral spine moderately small, projected at 30º angle; antennae and legs uniformly yellowish brown; outer margin of closed cell with 5–6 longitudinal veins; body length 14 mm .... *Macrina juvenca* (Burmeister) **[Fig. 407]**

54(27’) Ocelli absent; brightly orange red bugs with laterally margined pronotum; membrane of hemelytron bears many longitudinal veins emanating from 2 basal cells; scutellum, membrane and transverse band in midcorium black; sides of abdomen with white spots, 6th sternite in both sexes without cleft [Family **Pyrrhocoridae**] .... *Dysdercus superstitiosus* Fabricius **[Fig. 408]**

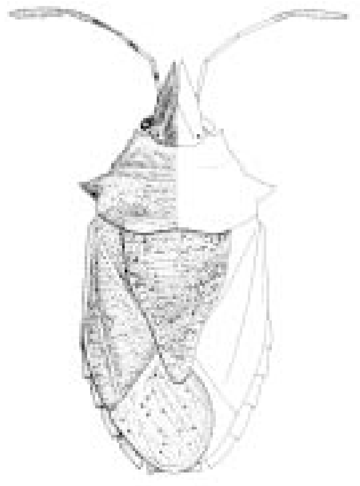


Fig. 404. *Gonopsia dimorphus* Linnavouri, dorsal view (2.88X).

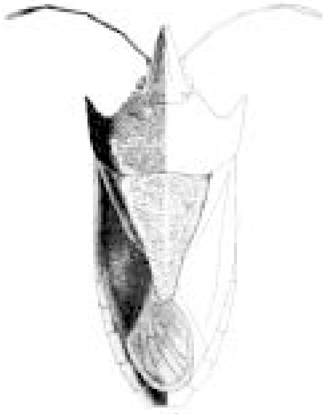


Fig. 405. *Macrina* sp. A, dorsal view (2.52X).

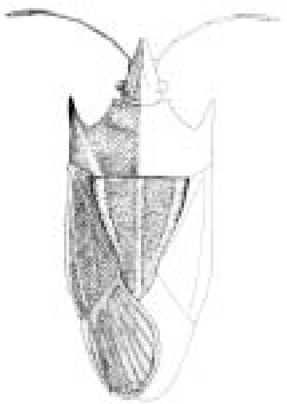


Fig. 406. *Macrina* sp. B, dorsal view (2.05X).

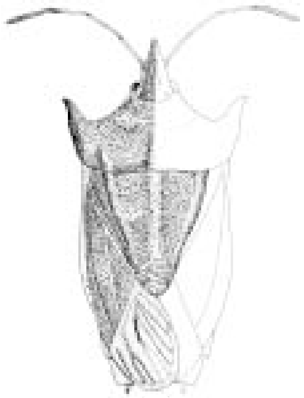


Fig. 407. *Macrina juvenca* (Burmeister), dorsal view (2.93X).

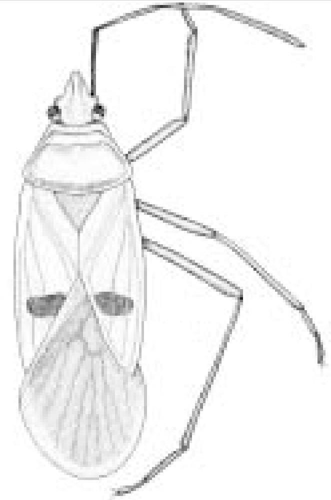
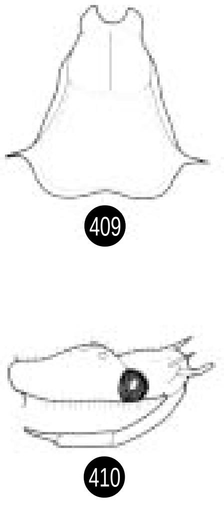


Fig. 408. *Dysdercus superstitiosus* Fabricius, dorsal view (2.7X).



Figs. 409–410. *Nagusta* sp., dorsal view of pronotum (409; 10.4X) and lateral view of head (410; 12.3X).

54’ Ocelli present 55

55(54’) Head elongate, narrow and constricted behind eyes; 3-segmented beak with a stout basal segment, curved tip fits into the posternal groove; abdominal margins often exposed beyond the wings at midlength [Family **Reduviidae**] 56

55’ Head and beak different from above 66

56(55) Humeral spine, projected laterally; anterior lobe of pronotum with 3 peg-like spines arranged circularly; neck long and narrow; eyes prominently beyond middle of head; ocelli not well elevated; head with 2 spines near antennal base; antennal segment I almost twice longer than head; legs yellowish brown; femur I thicker than II and III; dull yellowish brown bug except dark brown patch in the membrane .... *Nagusta* sp**. [Figs. 409, 410]**

56’ Humeral spine not projected laterally 57

57(56’) Apex of femur I black and enlarged 58

57’ Apex of femur I not black and normal 61

58(57) Apex of femur I enlarged with 2 black rings in apical half; black head except yellow lateral margins of moderately slender neck; ocelli on a tubercle with a white spot in between; pronotum brown with 4 and 5 lateral white spots, posterior pronotal lobe black, anterior and posterior margins with white bands; scutellum black and triangular with 2 white spots .... *Peprius nodulipes* Signoret **[Figs. 411, 412]**

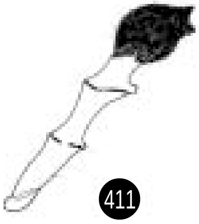
58’ Apex of femur I not swollen 59

59(58’) Orange red to yellowish red, head short and black with yellow spot near eyes and antennal base; ocelli with red spot in between; anterior pronotum concave medially, black lobes deeply notched in between; posterior pronotum without distinct lobes, reddish brown with a pair of yellow spots anteriorly and yellow posterior margins, midposterior margin truncate; tip of scutellum yellow with short setae; proboscis reddish brown except yellow basal segment .... *Sphedanolestes picturellus* Schouteden **[Fig. 413]**

59’ With yellow, black and orange red color combinations; tip of scutellum and proboscis different 60

60(59’) Pronotum yellow, anterior lobe distinct, posterior end without lateral indentions with an inverted black T-band; head black with yellow jugal area and a small red spot in between ocelli; scutellum yellow apically and black basally; membrane blackish brown with apical margins of closed cells more rounded; corium yellow with median transverse dark brown bands, subanterior end reaching the closed cells; legs black except yellow femur with black to dark brown apices; body length 11.5 mm .... *Sphedanolestes* sp. A **[Fig. 414]**

60’ Pronotum black, anterior lobe with 4 dorsal yellow bands, and posterior lobe with 5; midposterior margin of pronotum strongly truncate indented laterally; head black with yellow spots between ocelli, laterals of juga and neck and eye margins; scutellum black with a truncate yellow tip; membrane brown with apical margins of closed cells slightly rounded; corium dark brown with yellow median patches near the membrane; legs black except orange femur with midyellow ventral band .... *Sphedanolestes* sp. B **[Fig. 415]**



411

412

Figs. 411–412. ***Peprius nodulipes*** **Signoret, lateral view of tibia I (411; 10X) and dorsal view of pronotum (412; 11.25X).**

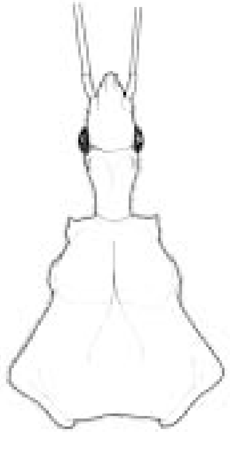
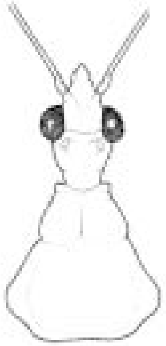


Fig. 415. ***Sphedanolestes*** **sp. B, dorsal view of head and pronotum (7.5X).**

Fig. 413. ***Sphedanolestes picturellus*** **Schouteden, dorsal view of head and pronotum (10X).**



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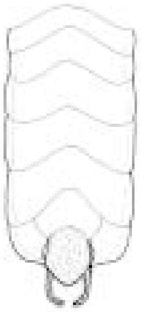


417

Figs. 416–417. ***Hediocoris tibialis*** **Stål, dorsal view of head and pronotum (416; 8.8X) and venter of abdomen (417; 8.4X).**

Fig. 414. ***Sphedanolestes*** **sp. A, dorsal view of head and pronotum (8.2X).**

Fig. 419. ***Coranus varipes*** **Stål, antenna (8.3X).**

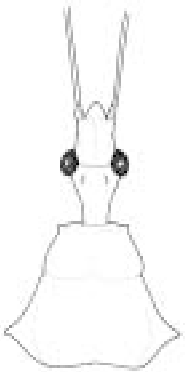


Fig. 418. ***Vestula obscuripes*** **Stål, dorsal view of head and pronotum (8.6X).**

61(57’) Head, anterior lobe of pronotum, venter of thorax and abdomen and all of femur orange red; ocelli on a small tubercle, pearl white; posterior pronotum and corium yellowish brown; venter of abdomen with 6 transverse white bands in the posterior of each sternite; similar to *Dysdercus*; body length 9–10 mm .... *Hediocoris tibialis* Stål **[Figs. 416, 417]**

61’ Without the combination of above characters 62

62(61’) Pronotum with a blunt humeral spine and a large dark brown median spot; head yellow, divided by a concave transverse groove between eyes anterior of ocelli, bears no spines near antennal base; legs reddish brown with irregularly shaped femur; tibia yellowish brown with two subapical brown bands; body length 13 mm .... *Vestula obscuripes* Stål **[Fig. 418]**

62’ Pronotum with less pronounced humeral spine; head black 63

63(62’) Scutellum with tubercle 64

63’ Scutellum without tubercle 65

64(63) Uniformly black except yellow tubercle on scutellum and 5 yellow patches on abdominal margins; segment II of antennae yellow except black anterior end, segment III noticeably short about half the length of segment IV, segment V longest; pronotum densely punctured and hairy; legs with yellow bands .... *Coranus varipes* Stål **[Fig. 419]**

64’ Orange red except dark reddish brown corium, anterior pronotum with mixed color of branching red and black spots; head black with 3 orange red longitudinal bands in anterior lobe and a median orange longitudinal band between ocelli and neck; antennal segment II brownish with black apex, rest of segments yellowish brown; legs black with yellow patches, tibia III mostly brownish yellow; abdomen, black ventrolaterally and in the last two ventrites .... *Coranus palliadus* Reuter **[Figs. 420, 421]**

65(63’) Uniformly black except brownish red membrane; small yellow spot between ocelli; anterolateral spine of pronotum weak or absent; abdominal venter with yellowish white V-band and yellowish ventrolateral spots; body length 11 mm .... *Rhinocoris albopilosus* Signoret **[Fig. 422]**

65’ Black with orange red posterior pronotal lobe, corium and 7 lateral abdominal spots; anterolateral spine of pronotum prominent; abdominal venter black without V-band; body length 18–20 mm .... *Rhinocoris segmentarius* Germar **[Fig. 423]**

66(55’) Ocelli absent; hemelytra with a cuneus, 1 or 2 closed cells present in the membrane; tarsi 3-segmented [Family **Miridae**] 67

66’ Ocelli present 69

67(66) Head triangularly pointed apically; distance between eyes much shorter than length of scape; collar distinct; pronotum smooth, subtriangular with a slight transverse depression in anterior one-third, posterior margin concave but moderately straight at base of scutellum; antennal segments in decreasing diameter towards apex, segment I black, II yellow brown becoming dark brown at apex, III dark brown with white base and IV dark brown; scutellum black with yellow apex; fore wing black with 2 white spots on both ends of cuneus; 2 closed cells present; black to dark reddish brown; body length 5 mm .... *Proboscidocoris fuliginosus* Reuter **[Fig. 424]**

Figs. 420–421. ***Coranus palliadus*** **Reuter, dorsal view of head and pronotum (420; 5.4X) and lateral view of femur and tibia of leg III (421; 5.3X).**

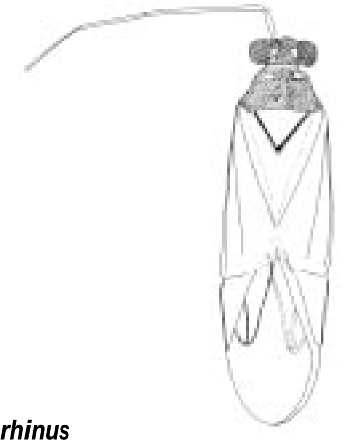


Fig. 426. ***Cyrtorhinus rectangulus*** **Ghauri, dorsal view (17X).**

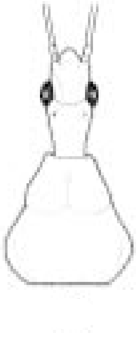


Fig. 422. ***Rhinocoris albopilosus*** **Signoret, dorsal view of head and pronotum (7X).**

Fig. 423. ***Rhinocoris segmentarius*** **Germar, dorsal view of the head and pronotum (4.9X).**

Fig. 427. ***Arbela*** **sp., lateral view of femur I and tibia I (12.9X).**

Figs. 428–429. ***Gorpis*** **sp., dorsal view of head and pronotum (428; 10.5X) and lateral view of femur I and propleuron (429; 7X).**

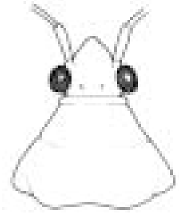


Fig. 424. ***Proboscidocoris fuliginosus*** **Reuter, dorsal view of head and pronotum (11.7X).**

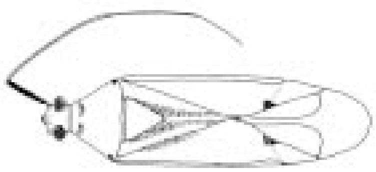
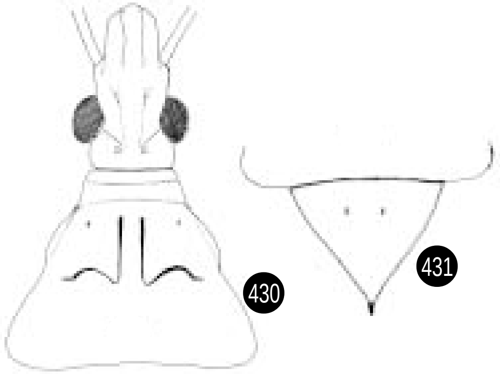


Fig. 425. ***Creontiades*** **sp., dorsal view (8X).**



Figs. 430–431. ***Stenonabis conspurcatus*** **Reuter, dorsal view of head and pronotum (430; 16X) and scutellum (431; 18.9X).**

67’ Not as above 68

68(67’) Collar distinct; head yellow brown with black tylus, clypeus and eyes; antenna yellowish brown with black scape longer than distance between eyes, segment II 3 times longer than scape and twice longer than segment III; subtriangular pronotum light brown, shiny with dark brown anterior one-third, yellow median and posterior margin and black spot on shoulders; scutellum yellow with brown base; clavus dark brown with a median longitudinal yellow band; dark brown triangular spot between apex of corium and single closed cell; brownish yellow; body length 5 mm .... *Creontiades* sp. **[Fig. 425]**

68’ Collar absent; head black with yellow spots along inner eye margins; antennae black with both ends of segment I yellow; scape slightly shorter than distance between eyes; segment II about 4–5 times longer than scape but less than twice length of segment III; pronotum almost rectangular, black with yellow anterior one-half; scutellum black; fore wing greenish yellow with an elongate closed cell; body length 2.5 mm ...... *Cyrtorhinus rectangulus* Ghauri **[Fig. 426]**

69(66’) Front legs raptorial, slightly swollen; membrane of hemelytra with many elongated cells around the margin; body narrowed anteriorly with a distinct collar; tibia usually with peg-like spines [Family **Nabidae**] 70

69’ Front legs not raptorial; membrane of hemelytra without elongated cells 73

70(69) Black nabid bugs; ocelli on a small tubercle; collar slightly punctured; anterior pronotal lobe glabrous and shortly cylindrical; posterior lobe coarsely punctured with a yellow median and lateral band; scutellum black with a pale yellow brown apex and subdorsal grooves; legs uniformly yellow, femur with slender ventral spines; tibia with slender spines and peg-like teeth ventrally; antenna uniformly yellow, long and slender, segment I prominently longer than length of pronotum; body length 6 mm .... *Arbela* sp. **[Fig. 427]**

70’ Straw-colored bugs; ocelli not on a tubercle; collar smooth; anterior lobe of pronotum with a median longitudinal dark brown band and a pair of transverse 8-shaped or ovoid calli posteriorly; posterior lobe smooth to finely punctated; legs yellowish brown, tibia I with two rows of longitudinal peg-like teeth ... 71

71(70’) Posterior one-half of pronotum densely punctured, median brown band present, anterior lobe with a pair of brownish red L-bands; collar with a median and lateral reddish brown longitudinal band; posterior of eyes dark reddish brown; antenna brown with yellow mottles, apex of segment II dark reddish brown; leg brown speckled with yellow, anterior end of tibia I black, peg-like teeth absent; lateral side of thorax and abdomen with a broad dark reddish brown longitudinal band; scutellum black with yellow lateral margins; fore wing dull brown with pale yellow brown mottles in the corium and part of clavus; body length 8.5 mm .... *Gorpis* sp. **[Figs. 428, 429]**

71’ Posterior one-half of pronotum smooth to very finely punctate; tibia with peg-like teeth 72

72(71’) Scutellum black distally; head with diverging reddish brown lines emanating from the ocelli; collar brown; anterior lobe of pronotum with a pair of longitudinal reddish brown stripes medially; fore wing yellow except yellowish brown veins; antenna and legs uniformly yellow; body length 7.5 mm .... *Stenonabis conspurcatus* Reuter **[Figs. 430, 431]**

72’ Scutellum with a broad black median longitudinal band; head with a dark brown longitudinal median band passing ocelli; collar with a black ring band; anterior lobe of pronotum with a dark brownish red median longitudinal band; fore wing straw-colored with or without brown spots; leg and antenna yellow brown; body length 7.0 mm .... *Stenonabis* sp. **[Figs. 432, 433]**

73(69’) Body long and narrow with very slender legs; short bucculae not extended exteriorly; head wider than one-half of pronotal base [Family **Alydidae**] 74

73’ Body and legs not narrow and slender 78

74(73) Pronotum gently sloped anteriorly; humeral spine absent; femur III long and slender without ventral spines; similar to the Asian *Leptocorisa* known as rice bugs 75

74’ Pronotum strongly sloped anteriorly; humeral spine present; leg with femur III enlarged and bear ventral spines 76

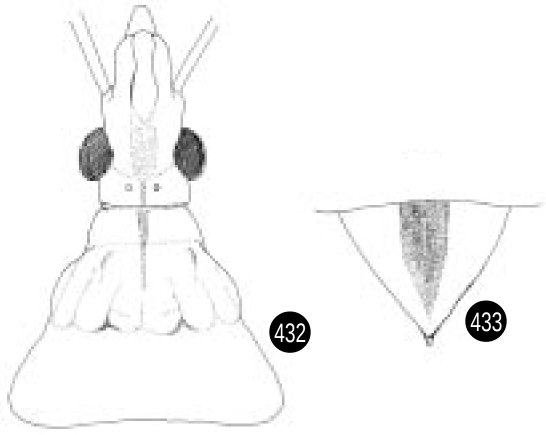
75(74) Lateral margins of pronotum with a dark reddish brown band extended at the base of antenna; humeral dark reddish brown spot spherical; scutellum yellow, prominently triangular, pointed apically and evenly punctured; male clasper pointed apically, almost parallel to each other; apical end of ovoid pygophore rounded, basal end with a deep notch and one tooth each at the lip of the notch; posterior margin of the seventh abdominal sternite with a median rectangular projection in female; generally yellow brown .... *Stenocoris stali* Ahmad **[Figs. 434, 435]**

75’ Lateral margins of pronotum light brown, dark reddish brown band present in the collar, back and front of eyes up to the base of antenna; humeral dark reddish brown spot ovoid; scutellum punctured in the midbasal one-half; apical one-half of corium smooth to lightly punctured, clavus densely punctured; male claspers cross each other; apical end of pygophore with a notch, basal end widely concave without teeth; posterior margin of the seventh abdominal sternite with a wide median notch in the female; brown to yellowish brown with dark reddish brown margins of clavus .... *Stenocoris claviformis* Ahmad **[Figs. 436–438]**

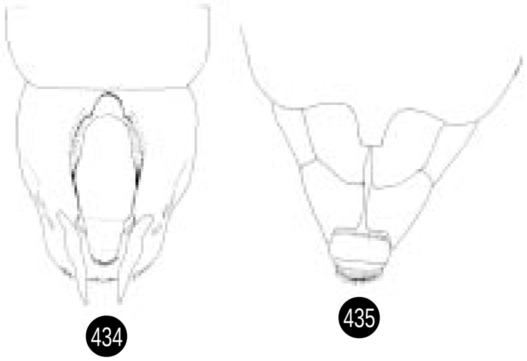
76(74’) Lateral sides of head and thorax brownish red to dull yellow brown with a wide yellow longitudinal band; eyes prominent, distant from pronotum; head distinctly exserted, brown with a black longitudinal band laterally; pronotum with a distinct collar and peg-like teeth dorsally and laterally, lateral margins with a row of small teeth and a T-groove in the middorsum; humeral spine projected posterolaterally forming a smaller tooth behind; antennal segments brown, long and slender, segment I longer than either head or pronotum; femur III thick with a row of 9–11 ventral teeth in the outer margin .... *Riptortus dentipes* (Fabricius) **[Figs. 439, 440]**

76’ Without the combination of above characters 77

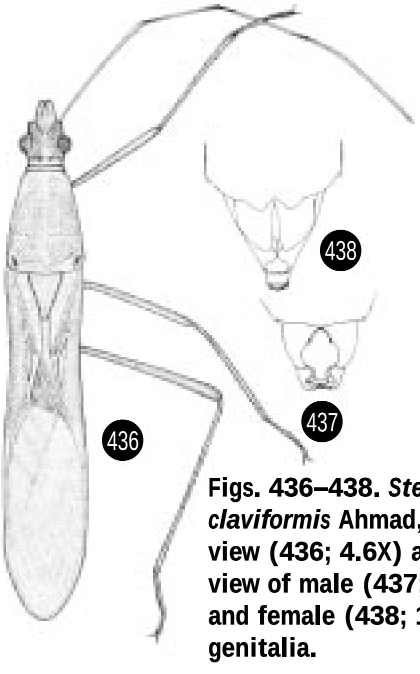
77(76’) Humeral spine black, relatively long and oblique; lateral margins of pronotum black, slightly serrated, anterolateral corner rounded; metapleuron band wrench-like; head with a pair of pale median longitudinal black and yellow bands; antennal segment I flat and black with a yellow basodorsal portion, II black except yellow median ventral side, III yellow with a black base and anterior one-third, IV pale brown; femur III reddish brown dorsally and black ventrally with 11–13 ventral teeth; venter of body black from head to abdomen



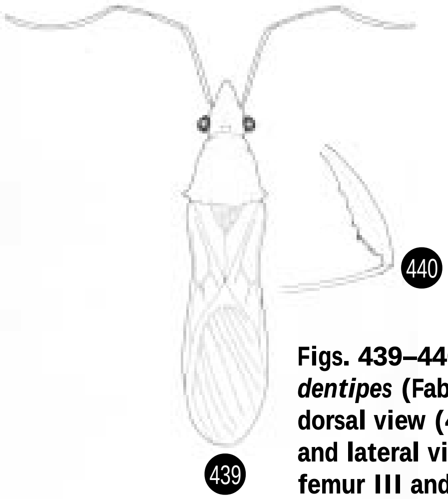
Figs. 432–433. ***Stenonabis*** **sp., dorsal view of head and pronotum (432; 24.5X) and scutellum (433; 27.7X).**



Figs. 434–435. ***Stenocoris stali*** **Ahmad, dorsal view of male (434; 20X) and female (435; 20X) genitalia.**



Figs. 436–438. ***Stenocoris claviformis*** **Ahmad, dorsal view (436; 4.6X) and dorsal view of male (437; 7.3X) and female (438; 12.5X) genitalia.**



Figs. 439–440. ***Riptortus dentipes*** **(Fabricius), dorsal view (439; 3.8X) and lateral view of femur III and tibia III (440; 3.6X).**

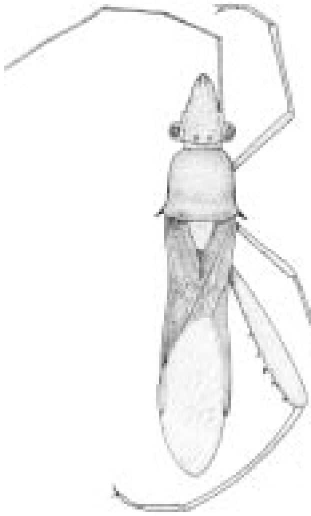


Fig. 441. ***Mirperus torridus*** **(Westwood), dorsal view (3.14X).**

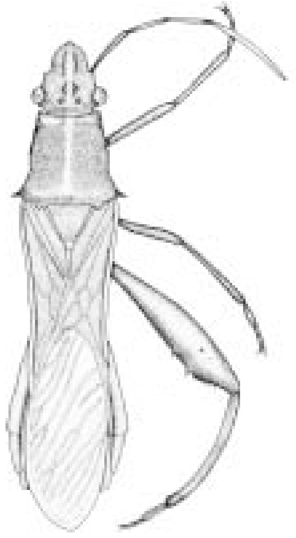


Fig. 442. ***Mirperus jaculus*** **Thunberg, dorsal view (5.09X).**

except yellow median of metathorax, abdominal sternites I and II, midanterior of III and four yellow spots each in the posterior margin of sternite III–V; body length 14 mm .... *Mirperus torridus* (Westwood) **[Fig. 441]**

77’ Humeral spine reddish brown, shortly triangular and projected straight laterally; black lateral margins of pronotum more serrated in anterior one-half, anterior one-fifth with a pair of black spots middorsally; mesopleuron with black wrench-like band and 3–4 black spots in the metapleuron; head with a 6-branched black band; segment I of antenna reddish brown, apices of II and III black and IV yellowish brown; femur III red with 8–9 ventral teeth; thoracic venter with a yellow median longitudinal band extended to abdominal sternite V; body length 11 mm .... *Mirperus jaculus* Thunberg **[Fig. 442]**

78(73’) Large-sized bug with thick legs, femur III usually enlarged or more robust than I and II; small head less than one-half the width of pronotum at base; corium opaque; absence of large basal cells in the membrane compensated for by 7 or more longitudinal veins; 4-segmented antennae arise above a line through midlength of eyes and tip of head; trichobothria on sterna V and VI situated posterior of the spiracle [Family **Coreidae**] 79

78’ Moderately small and slender bug without humeral spines; legs with moderately swollen femur and ventral spines in femur I; head as long as or more than one-half basal diameter of pronotum; corium often hyaline, with or without punctations; membrane of hemelytron with 4–5 longitudinal simple veins; antennae 4 segmented arising below a line drawn between mideye and tip of head; 3 trichobothria on sterna V and VI, 1 anterior of the spiracle near the margin of the sternite and 2 close to each other behind the spiracle [Family **Lygaeidae**] 86

79(78) Humeral spines absent 80

79’ Humeral spines present 82

80(79) Femur III not enlarged, yellowish brown similar to other legs; antennal base almost at tip of head; black dots scattered throughout pronotum, head, scutellum, corium, antennae, and legs; subtriangular pronotum with white border in anterior one-half; segment I of antenna yellow with orange longitudinal bands, II yellow except black apical one-third, III yellow with black apical one-half and light orange brown terminal segment; membrane dark reddish brown with more than 15 longitudinal veins; body length 16 mm .... *Homoeocerus pallens* Fabricius **[Fig. 443]**

80’ Femur III enlarged, anteroventral one-third with a large tooth or entirely with small teeth; body length 11–25 mm 81

81(80’) Dark brown; peg-like teeth all around the legs, head, pronotum, antennal segment I and abdominal venter; segments II and III equally long and slender, IV reddish brown and shorter than either II or III; median venter of abdomen with 2 longitudinal rows of peg-like spines; body length 11 mm .... *Acanthocoris* sp. **[Fig. 444]**

81’ Black to dark reddish brown; body generally smooth including legs and antennae; antennae black except longest segment IV with orange color on both ends and dark brown at middle; femur III with a large ventral tooth in anterior one-third; midventer of abdominal segment III with a flap-like swollen structure; body length 15–25 mm .... *Anoplocnemis curvipes* Walker **[Fig. 445]**

82(79') Abdominal edges with spines; humeral spine oblique at 45º angle anteriorly 83

82' Abdominal edges without spines; humeral spine straight laterally 84

83(82) Humeral spine brown, prominently developed with small spines basally; anterior area of pronotum with short spines, coarse between humeri; antenna yellow brown with slender segments, segment I the longest; scutellum swollen medially with longitudinal rows of hairs; posteroventer of femur III with 3 prominent spines; lateral sides of abdomen with 6 spines in decreasing size towards the thorax; entire body covered with fine hairs; grayish brown; body length 9 mm..................................... *Acanthomia horrida* Germar **[Fig. 446]**

83' Humeral spine black and acutely pointed; entire body clothed with club setae except proboscis, segments II–IV of antennae, tibiae, tarsi, and membrane; antenna yellowish brown with orange red segment I, segment I almost as long as III; scutellum normal; posteroventer of femur III with 4 brown to reddish brown spots; body length 9–10 mm................... *Acanthomia* sp. A **[Fig. 447]**

84(82') Humeral spine weakly developed; antennal segment II as long as III, segment I robust; slightly narrow apically; short and uniformly coarse; head and anterior pronotum coarse, small lateral spine between eyes and base of antenna; each corium of fore wing with one whitish yellow spot; body length 6.5 mm.. *Cletus* sp. **[Fig. 448]**

84' Humeral spine prominent; antennal segment II distinctly longer than III, segment I smooth and narrow in basal one-third 85

85(84') Corium without yellow spot or band; antennal segment I longer than III; body length 9 mm.. *Cletus unifasciata* Blote **[Fig. 449]**

85' Corium with a transverse yellow line or band adjacent to the membrane; antennal segment I shorter than III; body length 7 mm .... *Cletus fuscescens* (Walker) **[Fig. 450]**

86(78') Femur I with ventral spines; if absent, pronotum with a pair of spherical spots dorsally and laterally 87

86' Femur I without ventral spines 92

87(86) Orange red bugs with black areas in the prothorax, scutellum and fore wings 88

87' Not as above, color different and variable; pronotal bands not distinct 89

88(87) Head red with a black median Y-based between ocelli; pronotum with two round black spots between the uninterrupted transversely concave subanterior black band and an interrupted blackish brown band subposteriorly; scutellum black with red apex; corium with an oblique dark brown band in the center; lateral sides of prothorax with 2 ovoid black spots and one each in the meso- and metathorax; legs uniformly dark reddish brown and clothed with white hairs .... *Graptostethus servus* (Fabricius) **[Fig. 451]**

88' Head red with a black tylus and part of jugum and around ocelli margins; pronotum black with orange red margins and a knob-like median longitudinal band; apical one-third of scutellum red; clavus with a black longitudinal band; corium with a wide triangular band; lateral side of black thorax with 3 red

Fig. 443. *Homoeocerus pallens* Fabricius, dorsal view (2.75X).

Fig. 448. *Cletus* sp., dorsal view (4X).

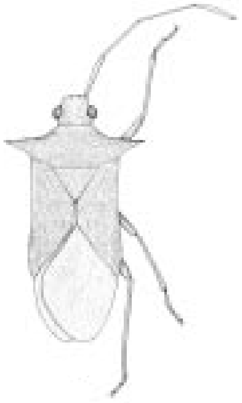


Fig. 449. *Cletus unifasciata* Blote, dorsal view (3.22X).

Fig. 444. *Acanthocoris* sp., dorsal view (3X).

Fig. 445. *Anoplocnemis curvipes* Walker, dorsal view (1.4X).

Fig. 450. *Cletus fuscescens* (Walker), dorsal view (3.9X).

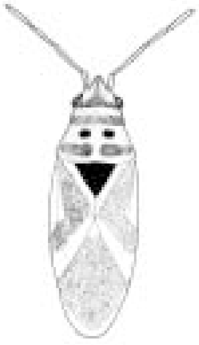


Fig. 451. *Graptostethus servus* (Fabricius), dorsal view (4X).

Fig. 446. *Acanthomia horrida* Germar, dorsal view (3.4X).

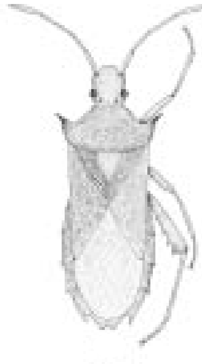


Fig. 447. *Acanthomia* sp., dorsal view (3X).

Fig. 452. *Graptostethus lectus* Distant, dorsal view (4.9X).

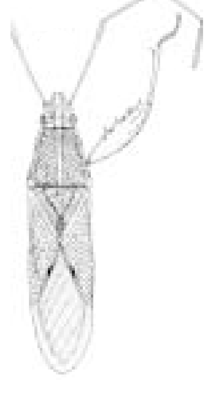


Fig. 453. *Pachygrontha* sp., dorsal view (4.7X).

spots; legs uniformly black, femur I with 4 inner and 5 outer rows of ventral spines; II with 5 outer and 6 inner spines, III with 4 outer and 6 inner spines; tibiae I and II all with peg-like teeth ventrally .... *Graptostethus lectus* Distant **[Fig. 452]**

89(87') Head blunt anteriorly, punctured with a lateral ridge antennal base; pronotum densely punctured, lateral margins with a narrow ridge; antennal segment I slender, swollen distally, combined length of segments II and IV as long as segment I; corium and apical one-half of scutellum punctured; all femora with brown specks, femur I stouter than II and III with 8–9 ventral inner teeth; brownish yellow with lateral black bands in sternites II–IV; body length 7.3 mm .... *Pachygrontha* sp. **[Fig. 453]**

89' Head pointed apically; scape always short 90

90(89') Pronotum flat with a lateral flange, squarish without distinct anterior ring-like collar and lobe, anterior margin truncate with two yellow spots, anterolateral one-half yellow and 5 yellow spots in a transverse row below midlength; head black with an apically rounded and porrect tylus; antenna brownish except yellow basal half of segment III, II with brownish tip and black scape, segments II, III, and IV subequal; corium whitish yellow with black to dark reddish brown bands near the membrane and entire clavus; femur I black except yellow basal one-fourth, venter with 4 outer and 9–10 inner spines, 5th inner tooth the largest; apical one-third of femora II and III black with basal two-thirds yellow; body length 8.50 mm .... *Dieuches* sp. **[Fig. 454]**

90' Pronotum with prominent anterior and posterior lobes 91

91(90') Anterior pronotal collar yellowish brown; anterior lobe of pronotum rectangular, distinctly longer than the posterior lobe and narrows anteriorly; posterior lobe yellow brown, twice wider than long; corium whitish yellow with light brown punctures and whitish apical end; membrane with 4 veins, apical vein without branch; yellow femora I–III mottled with brown spots, femur I with 5 ventral spines each in the outer and inner sides .... *Paromius gracilis* Rambur **[Fig. 455]**

91' Anterior pronotal collar black; anterior lobe of pronotum shortly cylindrical, wider than long, as long as the reddish brown posterior lobe; corium with heavy and dark brown punctations in the clavus, apex blackish brown and a white spot near the claval suture; membrane with 5 veins, apical vein short and branched; femur I stouter than II and III, black except yellow anterior and posterior ends, II uniformly yellow and III with dark brown apical one-half and yellow basal-half .... *Pachybrachius* sp. **[Fig. 456]**

92(86') Head strongly transverse, yellow except reddish eyes and pointed midanteriorly; antenna yellow brown except dark reddish brown apex of segment I and entire segment II; pronotum black, transverse with fine punctures and yellow lateral and posterior margins; corium yellow medially, punctured brown around it and with a black to reddish brown band near the membrane; scutellum triangular with a smooth unpunctured T-area in the middle .... *Geocoris* sp. **[Fig. 457]**

92' Head not strongly transverse 93

93(92') Body strongly flattened and thin, densely puntured in pronotum and scutellum; short white fine hairs present in head, pronotum, scutellum, and corium; anterior pronotal collar distinct; pronotum with a shallow transverse


Fig. 454. *Dieuches* sp., dorsal view (4.12X).

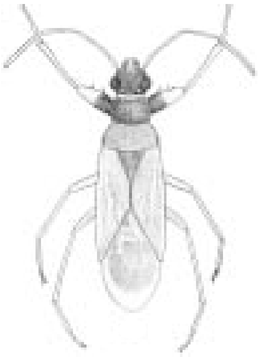


Fig. 455. *Paromius gracilis* Rambur, dorsal view (4.8X).

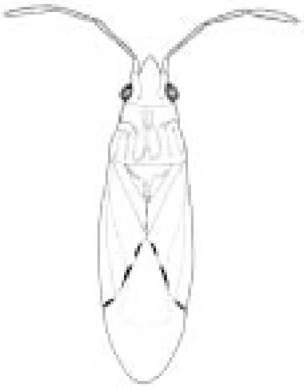


Fig. 459. *Nysius* sp., dorsal view (10.56X).


Fig. 456. *Pachybrachius* sp., dorsal view (6.7X).

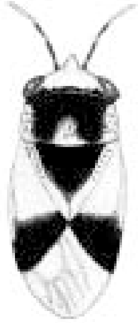


Fig. 457. *Geocoris* sp., dorsal view (9.4X).

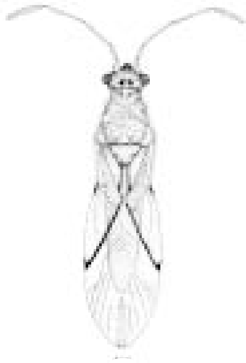


Fig. 460. *Ninus* sp., dorsal view (7X).


Fig. 458. *Dimorphopterus* sp., dorsal view (13.8X).

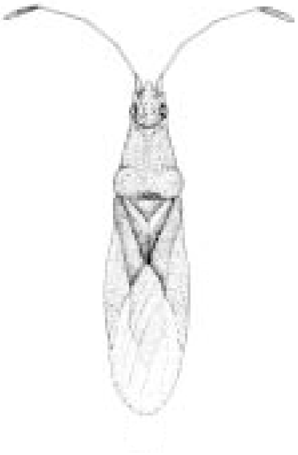


Fig. 461. *Cymodema* sp., dorsal view (8.9X).

groove; antenna black with a short and stout scape, order of length of segments: IV>II>III>I; fore wing with apex of corium brown and punctured membrane with 5 veins; short terminal segment of abdomen exposed .... *Dimorphopterus* sp. **[Fig. 458]**

93’ Body not flattened 94

94(93’) Head triangular; eyes close to anterior margin of the subquadrate and punctured pronotum; anterior pronotum relatively flat with a transversely concave black narrow band, posterior four-fifths sloping and more punctated; scutellum punctured, elevated T-mark present medially; antenna yellowish brown except black scape, brownish basal segments II and III and entire IV; fore wing transparent with 3 dark brown bands at corium; leg yellow with all femora mottled brown; apical one-third of basal and entire tarsal segment III dark brown; body color grayish brown with black and yellow tinge; body length 3.6 mm ....*Nysius* sp. **[Fig. 459]**

94’ Without the combination of above characters 95

95(94’) Head, thorax, scutellum, costal margin, and antennae with long whitish yellow hairs; proboscis expanded basally; tip of head bluntly rounded; anterior margin of pronotum straight; calli black and comma-shaped; antennae yellow except 4th with orange tinge; 2nd the longest segment; scutellum bifurcate and yellow apically; generally reddish brown, body length 5 mm .... *Ninus* sp. **[Fig. 460]**

95’ Head, thorax, scutellum, and corium punctured and hairless; proboscis without an expanded process; eyes not on a tubercle; tip of head pointed; anterior margin of pronotum concave; calli yellow brown; antennae yellow except brownish 4th segment, 3rd the longest segment; scutellum triangular, pointed apically; brownish yellow bugs, body length 4.5 mm .... *Cymodema* sp. **[Fig. 461]**

Order Hymenoptera

Ants and wasps

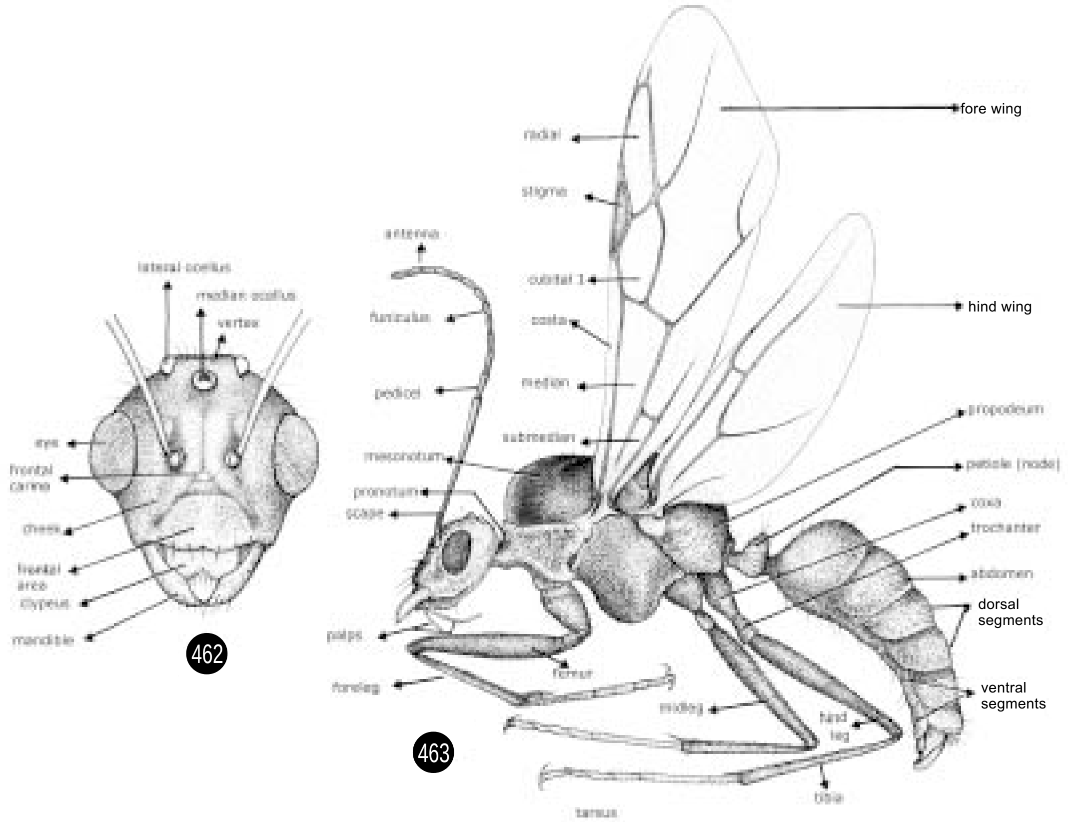
1 Abdomen connected to the thorax with one dorsal node; posterior lobe of mesopleuron distinctly rounded and extended ventrally; antennae 13-segmented, arising slightly below midlength of eyes; clypeus with a small notch midanteriorly [Family **Formicidae**] ...... *Anoplolepis* sp. **[Figs. 462, 463]**

1’ Node absent 2

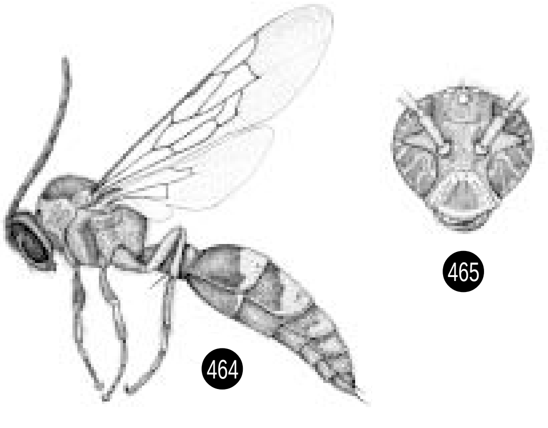
2(1’) Membrane of both wings corrugated apically; second cubital cell of fore wing strongly pointed basally; eyes deeply indented at a level above the antennal bases; face yellow with a black subtriangular band in the center; antennae 13-segmented, with a rounded pedicel; black abdomen with yellow band posterodorsally; entire body, head and legs strongly setose [Family **Scoliidae**] .... *Campsomeris* sp. **[Figs. 464, 465]**

2’ Wings without corrugations apically 3

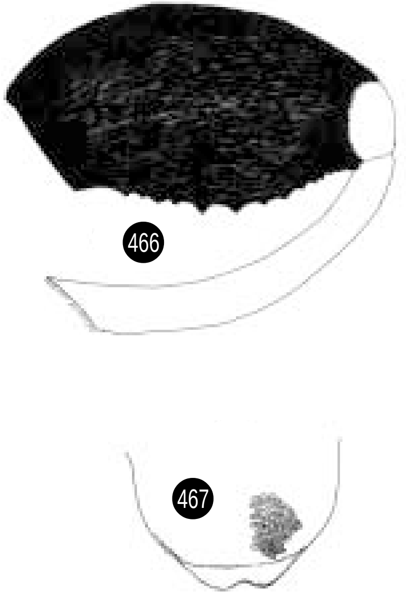
3(2’) Sides of pronotum not extended posteriorly to meet the tegulae; small wasps with strongly reduced wing venation in the fore wings; antennae with less than 13 segments 4



Figs. 462–463. ***Anoplolepis*** **sp., frontal view of head (462; 19X) and lateral view of winged adult (463; 9.5X).**



Figs. 464–465. ***Campsomeris*** **sp., lateral view of adult (464; 4.8X) and frontal view of head (465; 6.3X).**



Figs. 466–467. ***Brachymeria*** **sp., lateral view of femur III and tibia III (466; 25.4X) and dorsal view of scutellum (467; 20X).**

3’ Not as above 5

4(3) Tarsi 5-segmented; femur III prominently swollen, venter serrated or toothed; tibia III concave with an apical spur; thoracic pits setose, not humplike; propodeum coarse with a network of pits and ridges; occiput not deeply concave; frontogenal suture distinct and ridged; antennae relatively short; abdomen with 7 visible tergites [Family **Chalcididae**] .... *Brachymeria* sp. **[Figs. 466, 467]**

4’ Tarsi 4-segmented; mesoscutum with a median longitudinal furrow and yellow spots at apices of notauli; scutellum slightly convex with two submedian longitudinal furrows; antenna 8-segmented with 3 ring segments; yellow scape long; pedicel with a black dorsal band; marginal and stigmal veins prominent, postmarginal weakly developed; legs yellow including coxae except brown bands on femora I and II dorsally [Family **Eulophidae**] .... *Aprostocetus pachydiplosisae* (Risbec) **[Figs. 468, 469]**

5(3’) Antennae short and 10-segmented; moderately long scape and legs pale yellowish brown and at least 4 antennal apical segments light brown; posterior part of thorax densely setose laterally; fore wings without veins; tibiae II and III with only one spur [Family **Platygasteridae**] ..... *Platygaster* sp. **[Fig. 470]**

5’ Antennae with 13 segments or more, scape always very short; fore wings multiveined and multicelled with 1 or 2 recurrent veins; hind wings with 2 closed basal cells 6

6(5’) Fore wings with 2 recurrent veins; hind wings with an elongated median cell beyond the base of marginal vein [Family **Ichneumonidae**] 7

6’ Fore wings with 1 recurrent vein; median cell in hind wings not extending to base of marginal vein [Family **Braconidae**] 16

7(6) Eyes moderately converging towards the mouth or vertex 8

7’ Eyes indented or parallel-sided as seen frontally 9

8(7) Eyes almost occupy entire height of head, converging towards the mouth; antennae arise above midlength of eyes; fore wings with a brown band at apex; abdominal tergites II and III long and slender .... *Clatha* sp. **[Figs. 471, 472]**

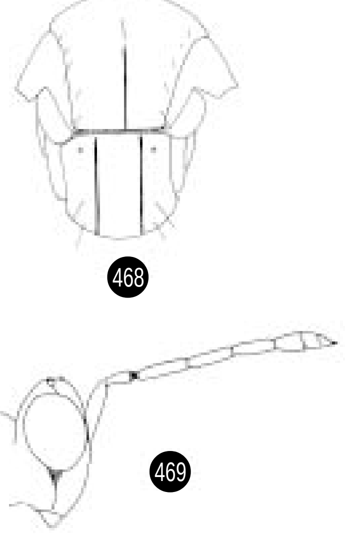
8’ Eyes relatively small, about one-half head height and converging slightly towards the vertex; antenna arises a little below midlength of eyes; fore wings with a small areolet (second cubital cell); tergites II and III short and broad particularly tergite III; abdominal tip usually black .... *Ischnojoppa* sp. **[Fig. 473]**

9(7’) Eyes indented 10

9’ Eyes parallel-sided as seen frontally 13

10(9) Areolet absent in the fore wings; tergites I and II long and slender with tergite I inclined upward forming an angle at the junction of both tergites; hind wings with aborted radiella, cubitella and discoidella .... *Charops* sp. **[Figs. 474, 475]**

10’ Areolet present 11



Figs. 468–469. ***Aprostocetus pachydiplosisae*** **(Risbec), meso- and metanotum (468; 77.5X) and side view of head (469; 74X).**

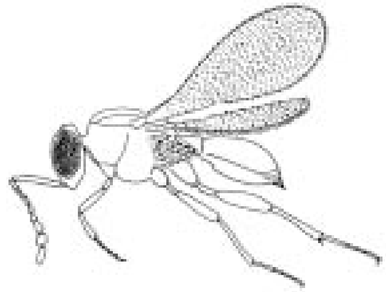
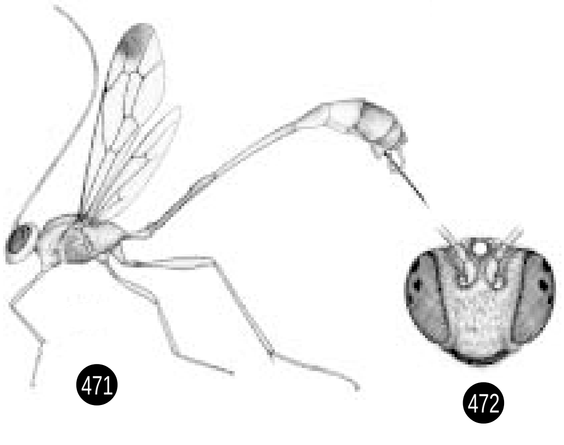


Fig. 470*.* ***Platygaster*** **sp., lateral view (32.2X).**



Figs. 471–472. ***Clatha*** **sp., lateral view (471; 4.7X) and frontal view of head (472; 11.4X).**

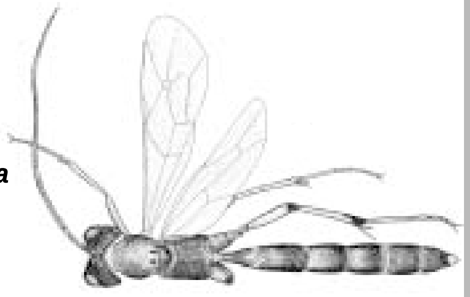
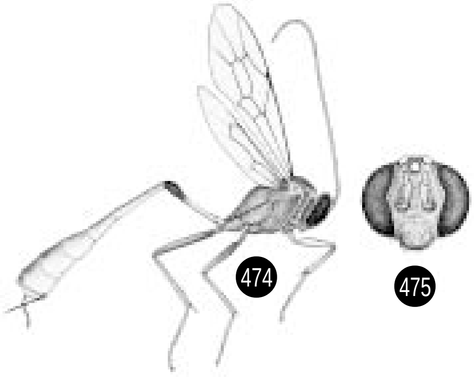
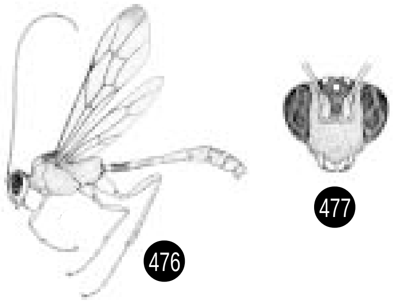


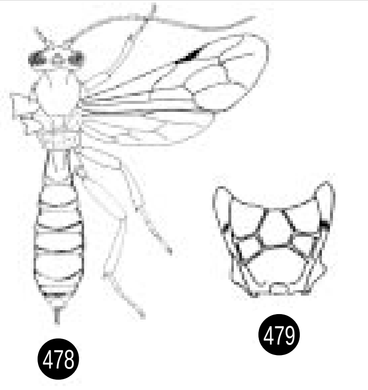
Fig. 473. ***Ischnojoppa*** **sp., dorsal view (3.48X)**



Figs. 474–475. ***Charops*** **sp., lateral view (474; 4.2X) and frontal view of head (475; 14.2X).**



Figs. 476–477. ***Leptobatopsis*** **sp., lateral view (476; 4.8X) and frontal view of head (477; 9.3X).**



Figs. 478–479. ***Xanthopimpla flavolineata*** **(Cameron), dorsal view (478; 3.7X) and propodeum (479; 13.6X).**

11(10') Apex of fore wing with black spot; tergites I, II, and III flattened with black dorsal bands; tibia III with small spines; face setose with slight eye indentions just above level of antennal base; ocellar area darker than face .... *Leptobatopsis* sp. **[Figs. 476, 477]**

11' Fore wing without black spot 12

12(11') Abdominal tergites each with a concave transverse row of shallow pits posteriorly; eyes emarginate above eye midlength, higher than level of antennal base; ocelli in a black triangle on a yellow head; propodeum carinated with about 6 closed cells; all legs yellow, femur III short and stout, tibia III with 11–12 spines in outer apical one-half; uniformly yellow to pale yellow orange .... *Xanthopimpla flavolineata* (Cameron) **[Figs. 478, 479]**

12' Abdomen finely punctated without a transverse row of shallow pits, yellowish brown with 3 black posterior segments; area between ocelli and base of antenna deeply concave forming moderately emarginate eyes; ocelli on a uniformly black head; scutellum orange yellow; propodeum without carina; femur III reddish brown, long and slender, tibia III without spines in outer posterior sides; fore wings with a bulla in second intercubitus, 2 in second recurrent vein, and 1 in discocubitus.. .... *Coccygomimus* cf. *crocatus* Tosquinet **[Figs. 480–482]**

13(9') Fore wing with brownish gray band in the discocubital and second discoidal cell; posterior end of tergites II, VII, and VIII with a white transverse band; antennae arise at a level below midlength of eye height, segments VII–X white .... *Isotima* sp. **[Figs. 483, 484]**

13' Not as above 14

14(13') Black wasp with orange red propodeum; posterior end of tergite VII white; radius and cubitus narrowed along the first intercubitus; hind wing with complete radiellan, cubitellan, discoidellan and brachiellan cells; face slightly humped medially .... *Amauromorpha* sp. **[Figs. 485, 486]**

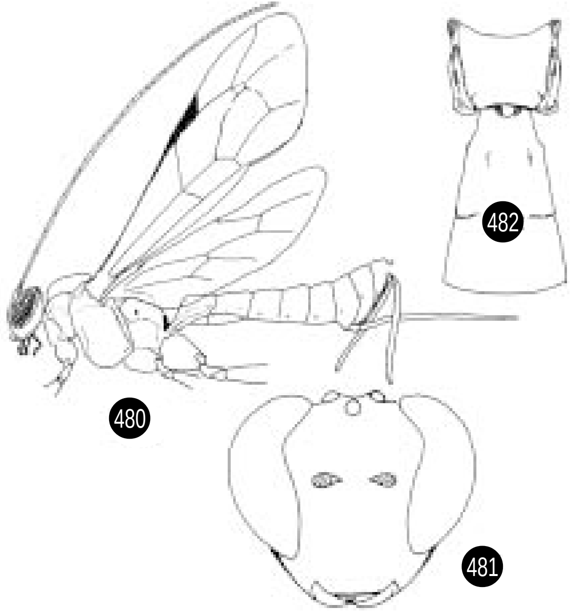
14' Orange yellow wasp with nearly rounded apical end of first brachial cell (postnervulus end) 15

15(14') Stigma large; midventer of femur III with a spine and a series of small teeth up to apicoventral end; apex of tergite I moderately black dorsally; tibia III reddish brown on both ends; antenna with 34 segments; ocelli not on a blackened triangle ....*Xiphosomella* sp. **[Figs. 487, 488]**

15' Stigma small; femur III without spine and small teeth ventrally; tergite I long and slender, black in apical one-third and swollen posteriorly; tibia III brown apically; antenna with more than 40 segments; ocelli on a black triangle........ .... *Temelucha* sp. **[Figs. 489, 490]**

16(6') Coxa III with a big spine; both wings opaque, uniformly brown with white lines passing obliquely at the middle of first cubital cell and forming a right angle in the first intercubitus and second intercubitus; head shiny orange brown, face coarsely punctured, temple wide; mandibles widely separated each with 3 teeth; toruli closer to eyes than to each other; antenna black and hirsute in basal 6–8 segments except yellow brown apical segments; notauli distinct; general color reddish brown .... *Odontobracon* sp. **[Figs. 491, 492]**

16' Coxa III normal 17



Figs. 480–482. *Coccygomimus* cf. *crocatus* Tosquinet, lateral view (480; 4.09X), frontal view of head (481; 19.2X), and propodeum and abdominal tergites I and II (482; 12.3X).

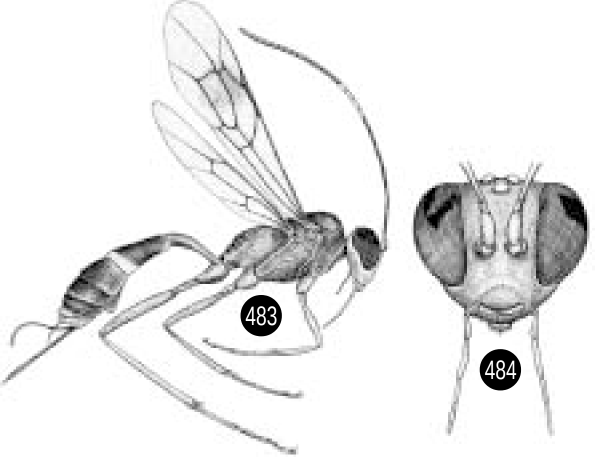
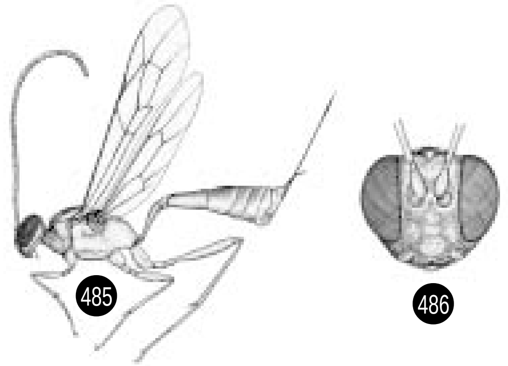
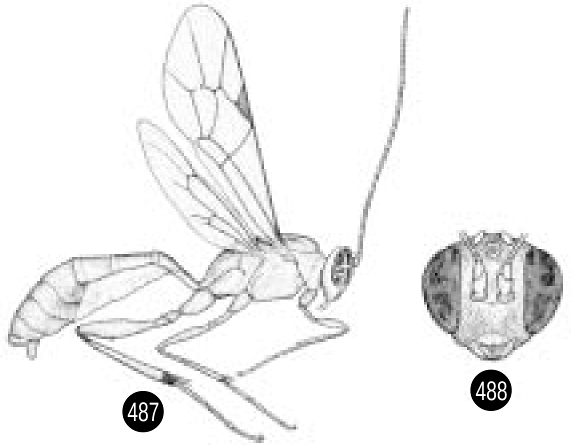


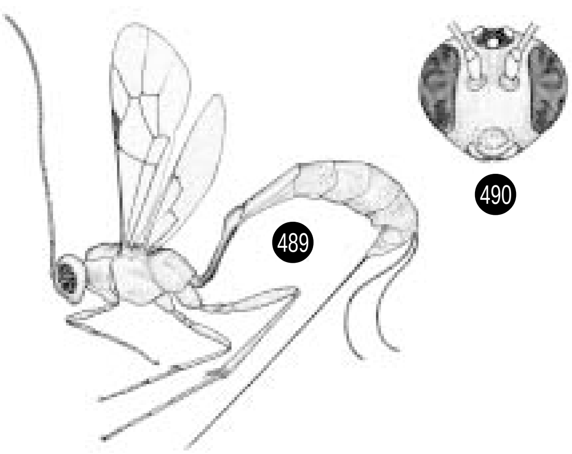
Fig. 483–484. *Isotima* sp., lateral view (483; 6.5X) and frontal view of head (484; 14.2X).



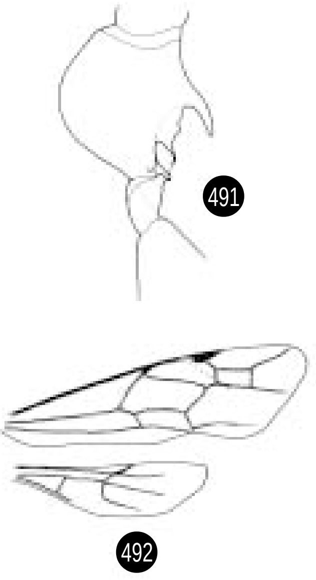
Figs. 485–486. *Amauromorpha* sp., lateral view (485; 2.4X) and frontal view of head (486; 7.6X).



Figs. 487–488. *Xiphosomella* sp., lateral view (487; 10.2X) and frontal view of head (488; 18.6X).



Figs. 489–490. *Temelucha* sp., lateral view (489; 4.4X) and frontal view of head (490; 16X).



Figs. 491–492. *Odontobracon* sp., hind coxa (491; 23X) and fore and hind wings (492; 3.6X).

17(16') Abdomen convex with 3 visible tergites; spherical eyes rather small located in the midheight of head; clypeus with 3 small teeth; antenna with more than 21 segments; basal funicles long; mesoscutum not 3-lobed; second cubital cell connected to the stigma by radial vein at midlength; general color yellowish brown .... *Phanerotoma* sp. **[Figs. 493, 494]**

17' Not as above 18

18(17') Fore wing with reduced venation; antenna 18-segmented, brownish except yellow rounded pedicel, flagellum in male twice longer than wide and a little longer than wide in female except apical one; shiny mesoscutum and scutellum flattened viewed laterally; propodeum transverse, coarsely punctated with strong basal carina in anterior three-fourths; first abdominal tergite constricted in the smooth subbasal one-third and rugulose in the wider apical two-thirds; legs all yellow except black to brownish basal half of coxa III; ovipositor short, approximately half of tarsus III length .... *Cotesia sesamiae* Cameron **[Figs. 495–497]**

18' Not as above, with more than 6 closed cells 19

19(18') Fore wing without bands or spots in both sexes; second segment of radius distinctly longer than first or than the first intercubitus; temple slightly wider than the diameter of ocellar triangle; midanterior half of mesoscutum with a black band; lateral margins of propodeum hairy; tergites I and II of abdomen black medially, tergite I sculptured submarginally with a midhump posteriorly; ocelli in a black triangle; mandibles touching when closed with a concave cavity above it; antennal base closer to the compound eyes than to each other in both sexes; female ovipositor very long........... *Bracon* sp. **[Figs. 498–501]**

19' Fore wing with 1 or 3 brownish black bands; hind wings with or without a band 20

20(19') Hind wing uniformly light brown in apical one-half; fore wing with 2-3 transversely broad bands in apical one-half interrupted by transparent areas from middle of stigma, first cubital stretch to base of second brachial cell and middle of radial cell extended to second intercubitus; tergite I with longitudinal row of pits sublaterally, 2nd tergite coarsely punctate with an inverted V-shaped pit, 3rd tergite onwards each with a transverse row of pits anteriorly; bases of antennae closer to the compound eyes than to each other ....*Stenobracon deesae* (Cameron) **[Figs. 502, 503]**

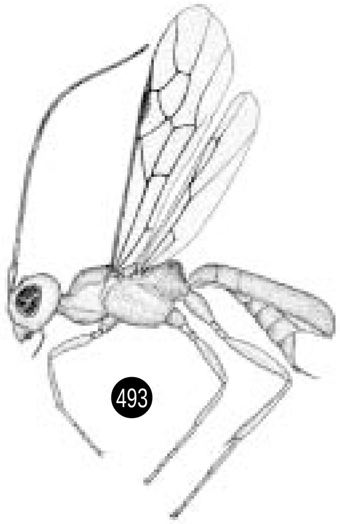
20' Hind wing without light brown band; fore wing with an apical light brown band almost reaching the second intercubitus, second segment of radius about as long as the first segment, 3rd segment away from wing apex; tergites I and II dorsally coarse with longitudinal sublateral pits; distance between toruli almost as long as distance to the eyes; female ovipositor very long, about twice length of abdomen .... *Habrobracon* sp. **[Figs. 504, 505]**

Section III: Spiders

Selected spiders

1 Fangs of chelicerae parallel to the midline and to each other when closed; all 8 eyes in a small tubercle, anterior median eye (AME) the largest and lateral (LEs) oblique converging anteriorly and posteriorly 2

1' Fangs of chelicerae close towards the midline, not parallel to each other; eyes not on a tubercle, arranged differently... 4



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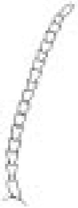
Figs. 493–494. *Phanerotoma* sp., lateral view (493; 7.4X) and frontal view2 of head (494; 15.5X).

495



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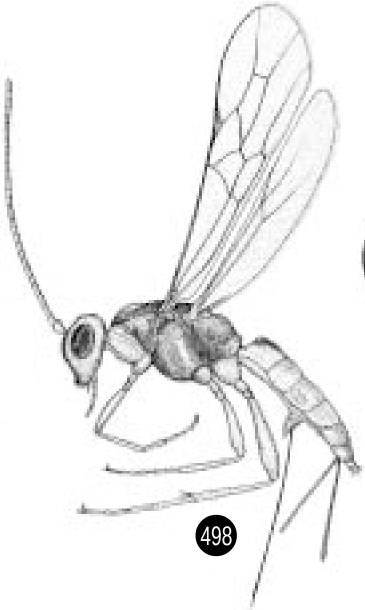
Figs. 495–497. *Cotesia sesamiae* Cameron, fore wing (495; 21.7X), antenna of female (496; 21.7X) and male (497; 21.7X).



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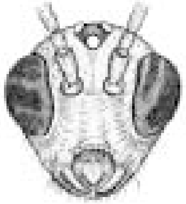

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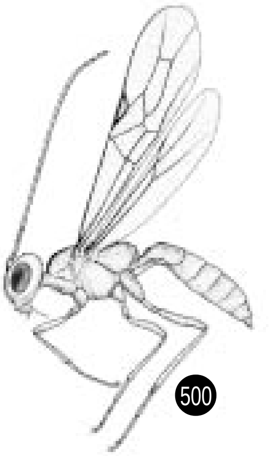

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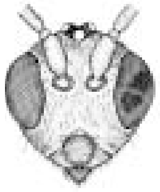

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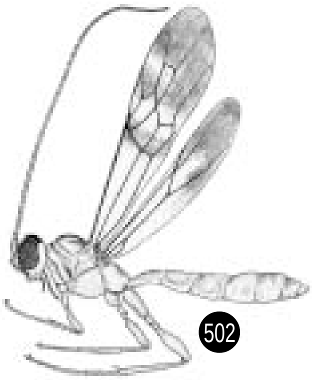
Figs. 498–501. *Bracon* sp., female lateral view (498; 9.5X) and frontal view of head (499; 33.3X), male lateral view (500; 10.3X) and frontal view of head (501; 34X).



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Figs. 502–503. *Stenobracon deesae* (Cameron), lateral view (502; 5.7X) and frontal view of head (503; 18X).

2(1) Basal inner half of pedipalp's coxa and apical one-half of labium with cuspules; legs uniformly covered with thin and slender spines, trichobothria present in the tibiae, metatarsi and tarsi; metatarsus I with a single apicoventral spine; dorsum of all tarsi with short clubbed spines and ventral scopulae divided by 2–3 longitudinal rows of setae; tarsi with ungual tufts and superior claws weakly toothed; clypeus narrow; anterior eye row procurved; thoracic fovea transverse and straight; body length 9.5 mm [Family **Theraphosidae**] .... *Plesiophrictus* sp. **[Figs. 506, 507]**

2' Coxa of pedipalp and labium without cuspules; legs with prominent ventral spines in the tibiae and metatarsi; ventral scopulae of tarsi not divided by spines or setae, ungual tuft absent and superior claws strongly toothed; thoracic fovea procurved; posterior spinnerets very long [Family **Dipluridae**] 3

3(2') Carapace brown, as long as combined length of patella and tibia of leg IV; tibia of pedipalp with sparse setae ventrally and a prolateral spine; combined length of bulb and embolus 1.6 times longer than tarsus; bulb rounded basally; embolus relatively long, curved tip projected to outside; sternum, labium, maxillae and legs brown to light brown; body length 8.2 mm .... *Macrothele* sp. A **[Figs. 508, 509]**

3' Carapace black, longer than combined length of patella and tibia of leg IV; tibia of pedipalp with dense setae ventrally and without prolateral spine; combined length of bulb and embolus 1.45 times longer than tarsus; bulb slightly pointed basally; embolus long and relatively straight towards apex; sternum, labium, maxillae and legs dark reddish brown to black; body length 11.2 mm .... *Macrothele* sp. B **[Figs. 510, 511]**

4(1') Three-clawed hunting or orb-weaving spiders 5

4' Two-clawed spiders 44

5(4) Three-clawed hunting spiders. 6

5' Three-clawed orb-weaving spiders 22

6(5) Trochanter with a notch 7

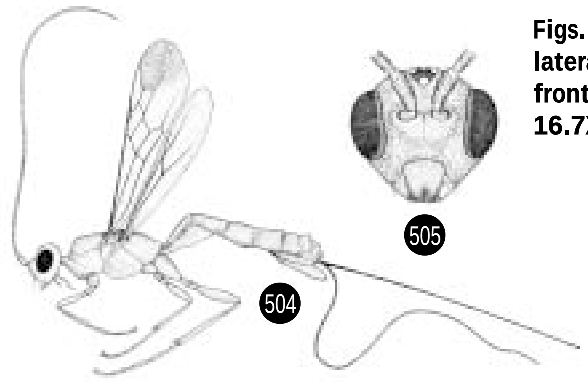
6' Trochanter normal, without a notch 19

7(6) Posterior eye row recurved; posterior median eyes (PME) less than three times one anterior median eye (AME) diameter; male palpus with a tibial apophysis [Family **Pisauridae**] 8

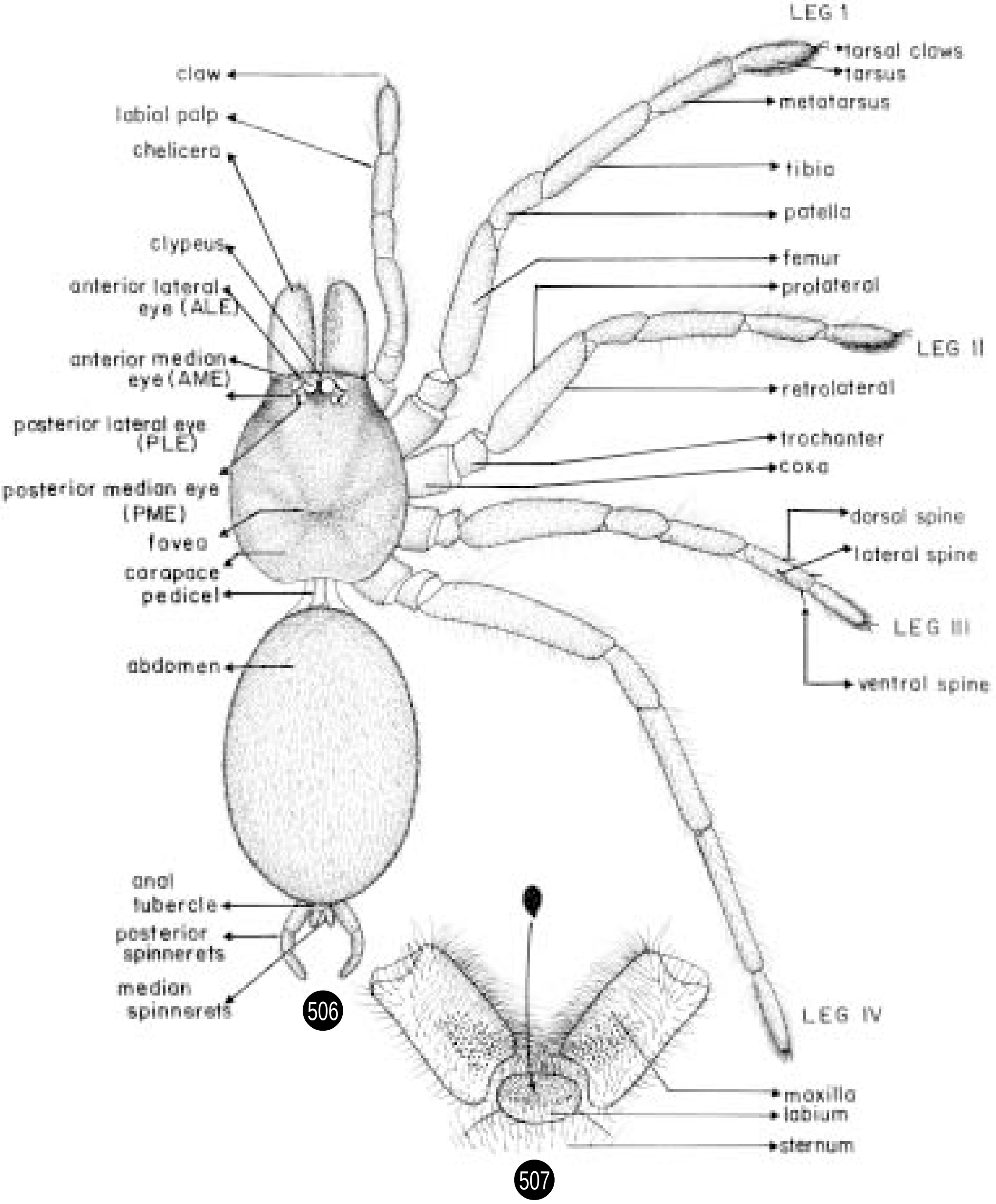
7' Posterior eye row strongly recurved forming a rectangle; posterior median eye at least three times or more than one anterior median eye diameter; male palpus without tibial apophysis [Family **Lycosidae**] 10

8(7) Chelicera with 3 retromarginal teeth 9

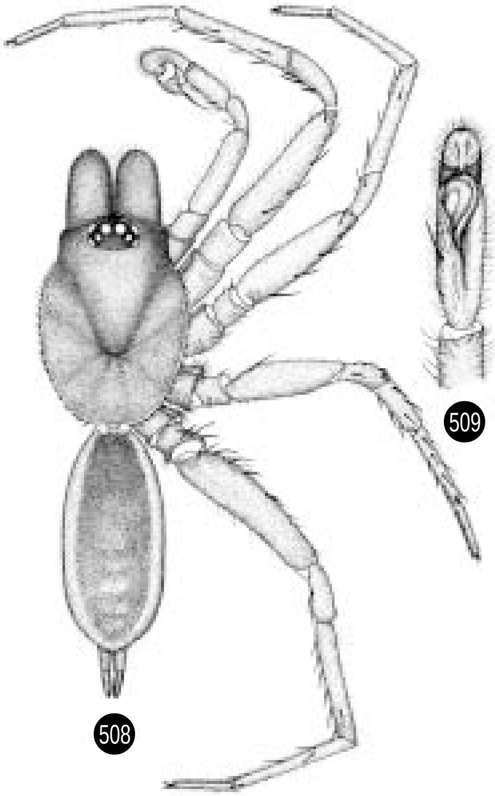
8' Chelicera with 4–5 teeth; abdomen gray mottled with white spots; male cephalothorax prominently wider than abdomen and equally wide in female; retrolateral apophysis long and acute (left pedipalp) with a sub-basal tooth, with a small apical hook in the right pedipalp; median apophysis curved downwards apically; embolus short, slightly passes terminal apophysis; female epigynum with a short apically rounded median septum and widely concave lateral epigynal margin; body length 9 mm ..... *Dolomedes* sp. **[Figs. 512–515]**



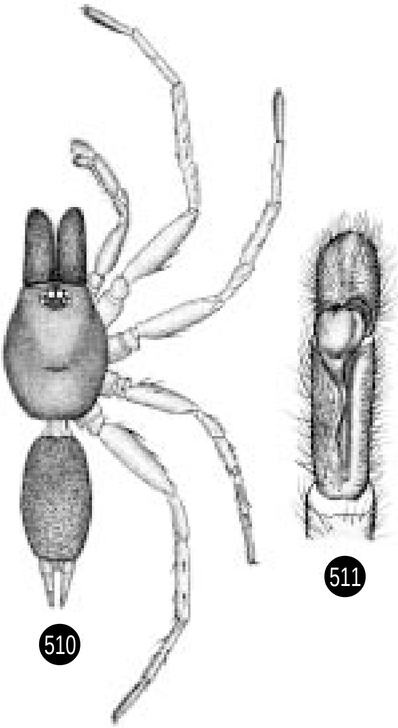
Figs. 504–505. ***Habrobracon*** **sp., lateral view (504; 5.5X) and frontal view of head (505; 16.7X).**



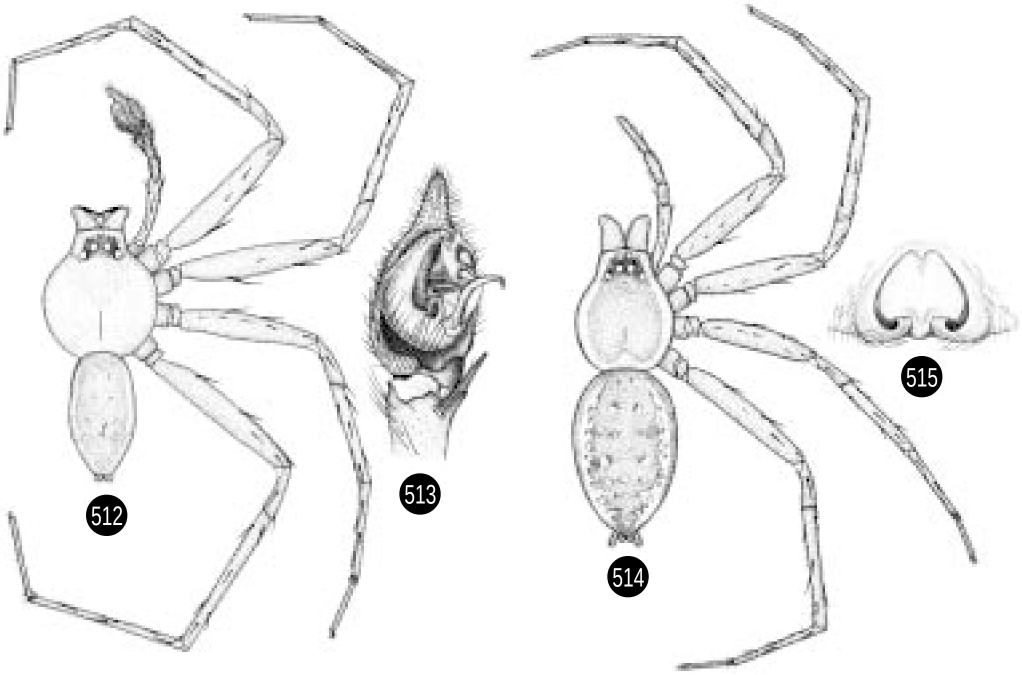
Figs. 506–507. ***Plesiophrictus*** **sp., dorsal view (506; 7.6X) and cuspules in the labium and maxillae (507; 13.5X).**



Figs. 508–509. *Macrothele* sp. A, dorsal view (508; 7.07X) and ventral view of pedipalp's tarsus (509; 8X).



Figs. 510–511. *Macrothele* sp. B, dorsal view (510; 3.3X) and ventral view of pedipalp's tarsus (511; 9.5X).



Figs. 512–515. *Dolomedes* sp., male dorsal view (512; 3.56X) and ventral view of cymbium (513; 16.1x), and female dorsal view (514; 4.11X) and epigynum (515; 30X).

9(8) Male; abdomen ovoid, twice longer than broad; retrolateral apophysis dark brown, short and robust, apical tip curved downwards and located at midlength of tibia; venter of tibia with a broadly flat apically rounded yellow flange anteriorly and 7–8 long black hairs at about midlength; embolus coiled counterclockwise, long and emanates posteriorly; median apophysis widely bifurcate; cephalothorax yellow, slightly longer than wide; legs moderately long; body length 6.5 mm .... *Pisaurina* sp. **[Figs. 516, 517]**

9' Female; epigynum with a strongly convex anterior hood on top of a pair of double laterally concave plates, posterior margin notched medially; cephalothorax uniformly brown, one-fifth longer than wide; legs long and slender; body length 6.7–7.0 mm .... *Pisaurina* sp. **[Figs. 518, 519]**

10(7') Posterior spinnerets diverging, prominently longer than the anterior pair with conical apical segment; sternum with a median longitudinal band; cymbium shortly elongate, pointed distally and slightly notched proximally, lateral side with 2 long spines; embolus emanates at "12 o'clock", very short, thin, and upcurved; body length 7.8 mm .... *Hippasa* sp. **[Figs. 520, 521]**

10' Posterior spinnerets slightly longer than anterior, distal segment not conical; sternum without median longitudinal band 11

11(10') Metatarsus IV as long as or longer than tibia IV + patella IV; sides of carapace vertical anteriorly; median apophysis of male pedipalp not excavated dorsally; transverse portion of median septum of female epigynum not curved anteriorly 12

11' Metatarsus IV shorter than combined length of tibia IV and patella IV; sides of carapace slanting seen anteriorly; median apophysis of male and epigynum of female different 13

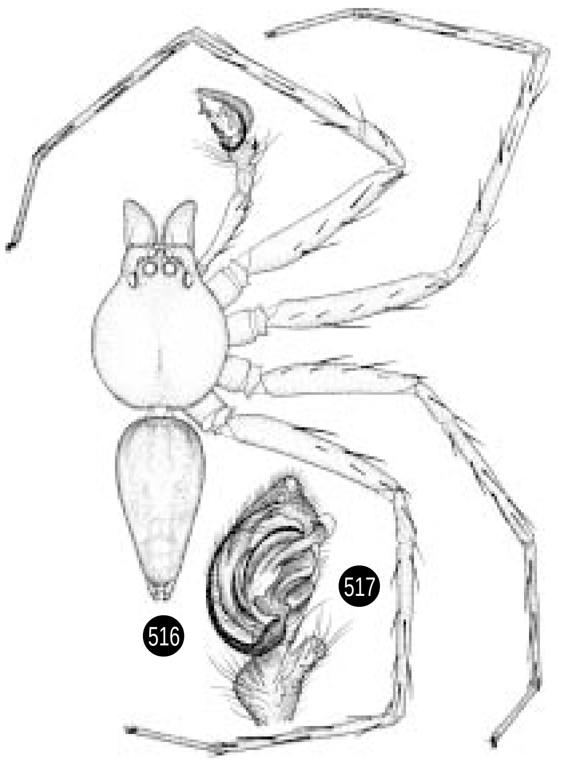
12(11) Carapace brown; legs with alternating yellow and brown bands; tibia IV with 5–6 ventral spines; retrolateral spines weak with middle spine higher than its prolateral pair; female: median septum broad apically, slightly concave midapically; male: cymbium without apical spine, one-third longer than tibia; median apophysis longer (b) than wide (a), a/b = 0.6, apex hooked downwards; body length 5–7 mm .... *Pardosa injucunda* (O.P.-Cambridge) **[Figs. 522–525]**

12' Carapace black; legs yellow brown, coxae I–II black and III–IV yellow, femora I and II black with yellow apices; tibia IV with 6 ventral spines, midprolateral spine higher than its pair; cymbium with 2 strong apical spines; 1.5 times longer than tibia, median apophysis .... *Pardosa* sp. **[Figs. 526, 527]**

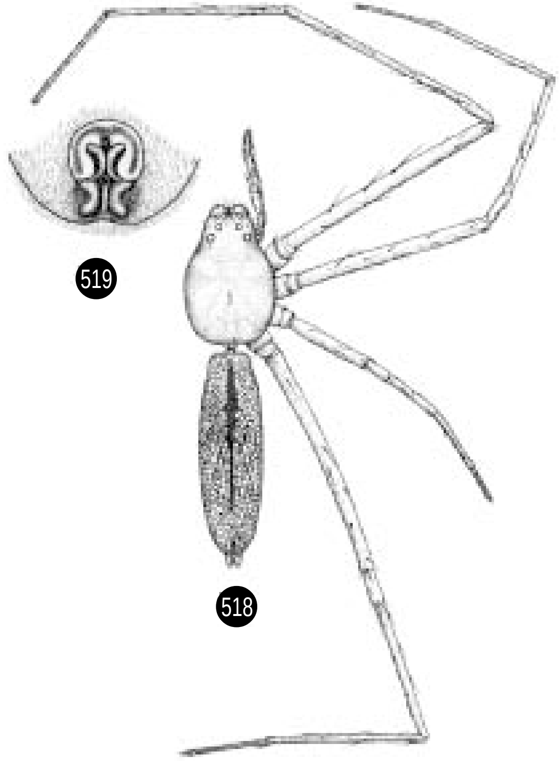
13(11') Leg III longer than leg I; brown carapace with about 10–12 fan-like yellow striae emanating from the fovea; abdomen ovoid with a pair of yellow bands surrounding the cardiac area and 2–3 transversely convex yellow band in posterior one-half; legs brown with dark brown bands; epigynum with a bell-shaped hood and a thin T-shaped median septum; body length 14 mm .... *Ocyale atalanta* Auduoin **[Figs. 528, 529]**

13' Leg III shorter than leg I 14

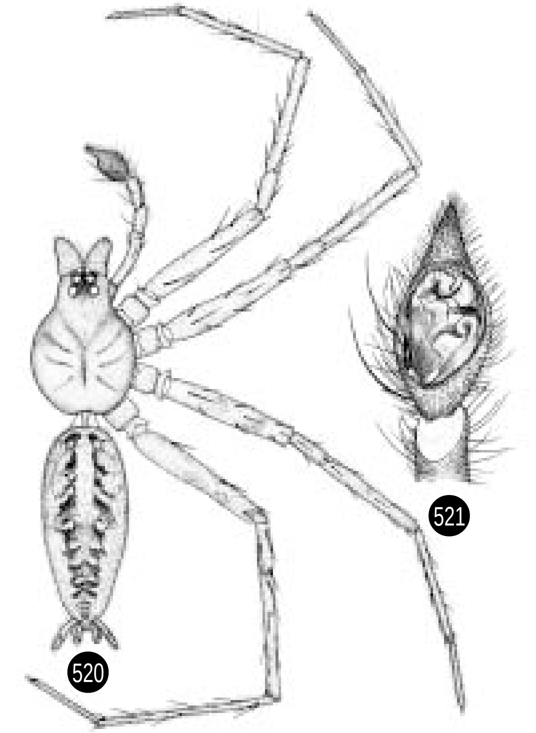
14(13') Tibia IV with 2 dorsal equally robust spines; chelicera with 3 retromarginal teeth; carapace without paired longitudinal marks distal to fovea; dorsal spines on tibia IV equally stout; epigynum with a pair of obliquely elongate



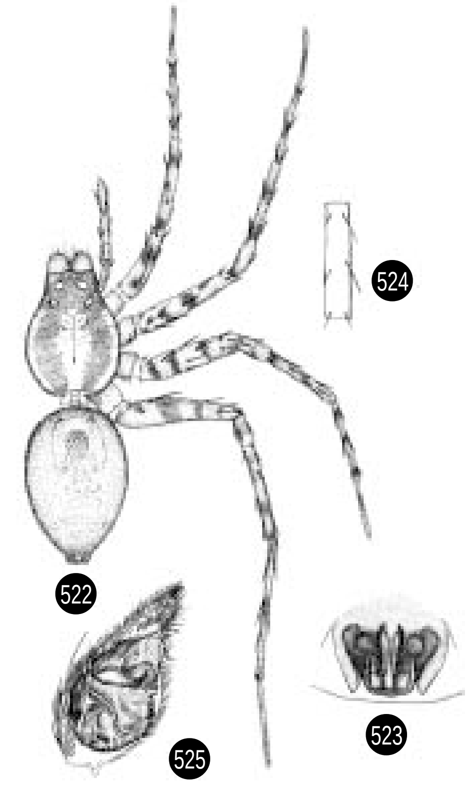
Figs. 516–517. *Pisaurina* sp., male dorsal view (516; 6.92X) and ventrolateral view of cymbium (517; 17X).



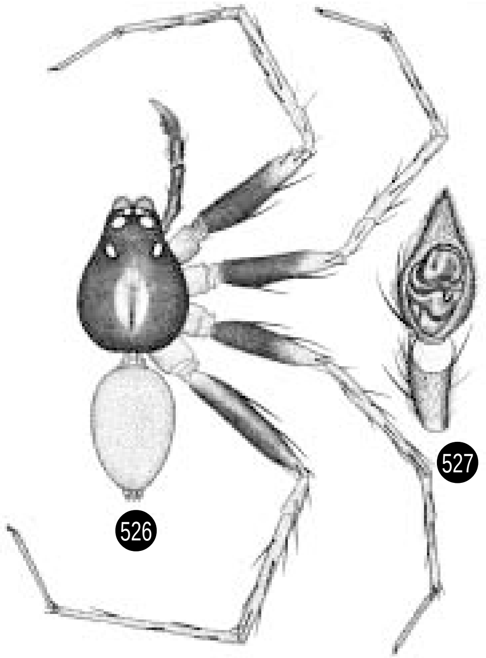
Figs. 518–519. *Pisaurina* sp., female dorsal view (518; 6.56X) and epigynum (519; 17.5X).



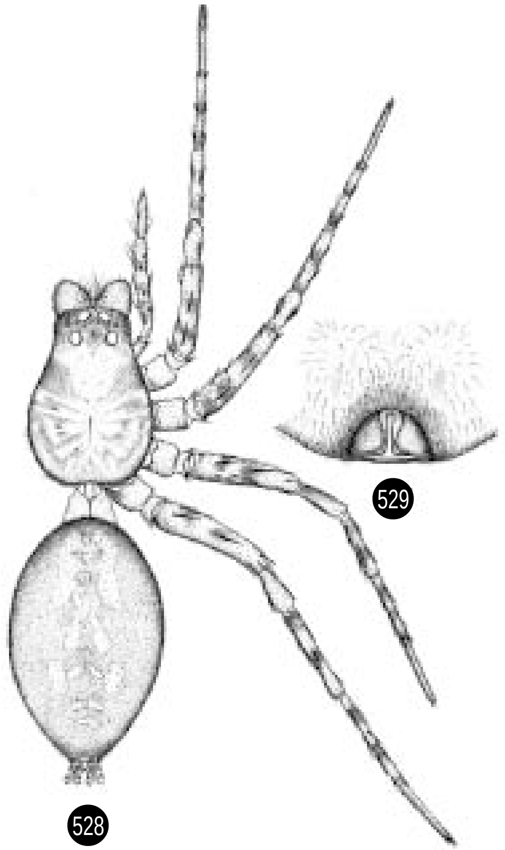
Figs. 520–521. *Hippasa* sp., male dorsal view (520; 6.02X) and palp (521; 13.6X).



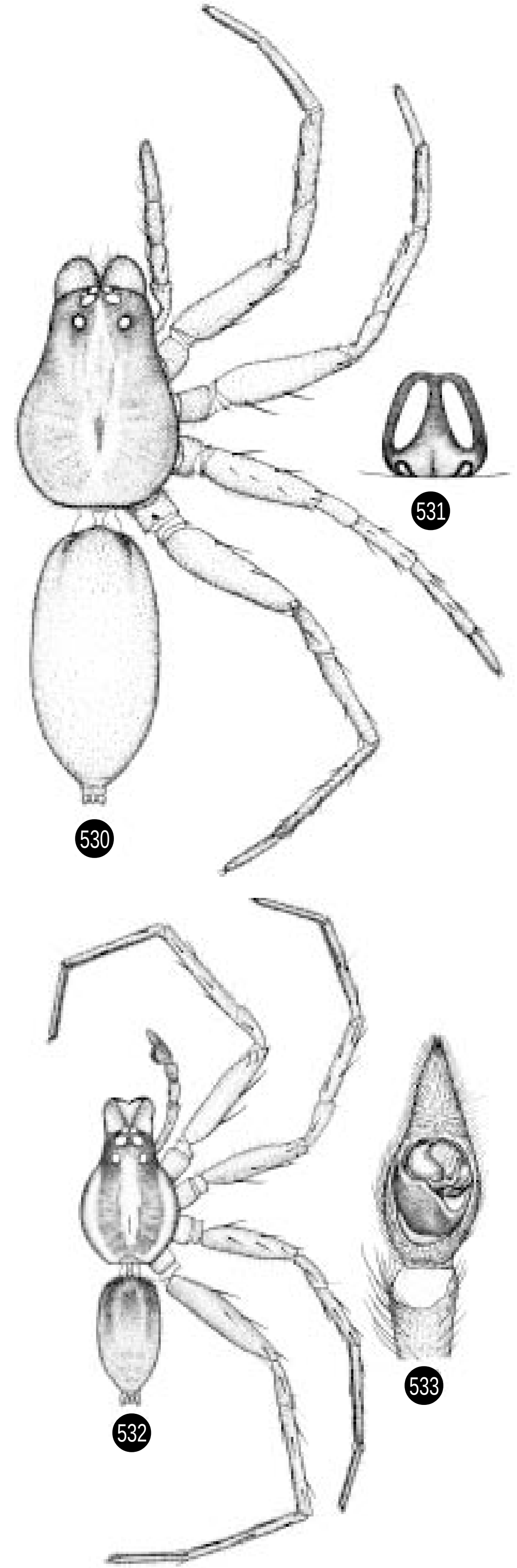
Figs. 522–525. *Pardosa injucunda* (O.P.-Cambridge), female dorsal view (522; 6.33X), epigynum (523; 28X), ventral view of tibia IV (524; 0.5X), and male palp (525; 23X).



Figs. 526–527. ***Pardosa*** **sp., male dorsal view (526; 7.3X) and male palp (527; 21X).**



Figs. 528–529. ***Ocyale atalanta*** **Auduoin, female dorsal view (528; 4.28X) and epigynum (529; 25X).**



Figs. 530–533. ***Lycosa*** **sp., female dorsal view (530; 6.31X) and epigynum (531; 28X), male dorsal view (532; 3.38X) and male palp (533; 14.38X).**

orifices, median septum large; cymbium acute apically with 2 large spines; median apophysis tooth prominently developed; tegulum large; abdominal venter of abdomen uniformly grayish brown to black; body length 9.5–13 mm .... *Lycosa* sp. **[Figs. 530–533]**

14’ Tibia IV with a proximal spine thin and more drawn out than the distal one, sometimes reduced to a bristle 15

15(14’) Carapace glabrous; tarsus I with a dorsobasal bristle 16

15’ Carapace hairy; tarsus I without a dorsobasal bristle 17

16(15) Carapace with a yellow median longitudinal band dagger-shaped posteriorly; abdomen black anteriorly with 4–5 double concave or wavy transverse yellow bands below midlength, venter yellow with gray V-band; pedipalp brown; cymbium pointed apically with an apical and 6 subapical spines, 1.5 times longer than tibia; median apophysis with a sharp tip, ratio of height and length = 0.77; body length 10.5 mm .... *Arctosa* sp. A **[Figs. 534, 535]**

16’ Carapace reddish brown to dark reddish brown; abdomen ovoid with evenly scattered whitish spots, venter grayish yellow without band; epigynum dome-shaped with a pair of apically diverging orifices; cymbium almost two times longer than tibia, apically pointed, a large spine present at tip; median apophysis transverse, narrows distally and curved downwards; tegulum small; body length 6–8 mm .... *Arctosa* sp. B **[Figs. 536–539]**

17(15’) Tibia I with one prolateral spine; femora I and II with broad gray longitudinal bands retrolaterally and prolaterally in III and IV; median septum with a narrow median and thin apical plate, ratio of height and apical width = 0.64; hood base widely separated; body length 7.5 mm .... *Trochosa* sp. A **[Figs. 540, 541]**

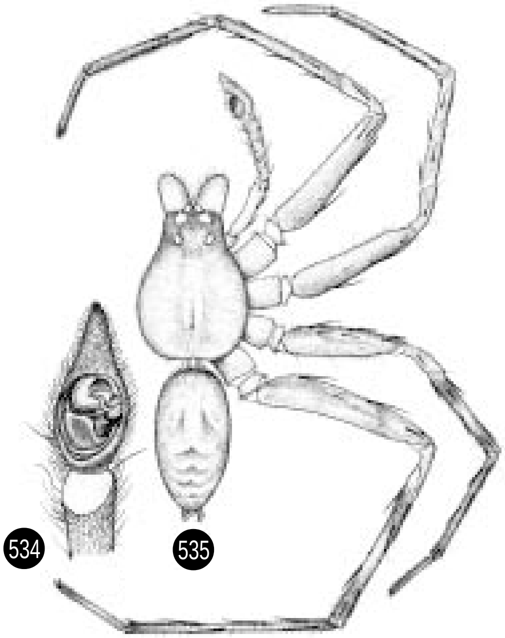
17’ Tibia II with two prolateral spines 18

18(17’) Legs yellowish brown with gray and yellow bands; median septum slender, relatively broad with thick anterior plate; cymbium moderately short distally with stout apical spine and two smaller ones dorsally, base protruded basally; subtegulum at “7 o’clock,” embolus short with a small base; duct parallel to margin of cymbium, C-shaped proximally; femur of pedipalp with a dense mat of black hairs; body length 8–10 mm............ *Trochosa* sp. B **[Figs. 542–544]**

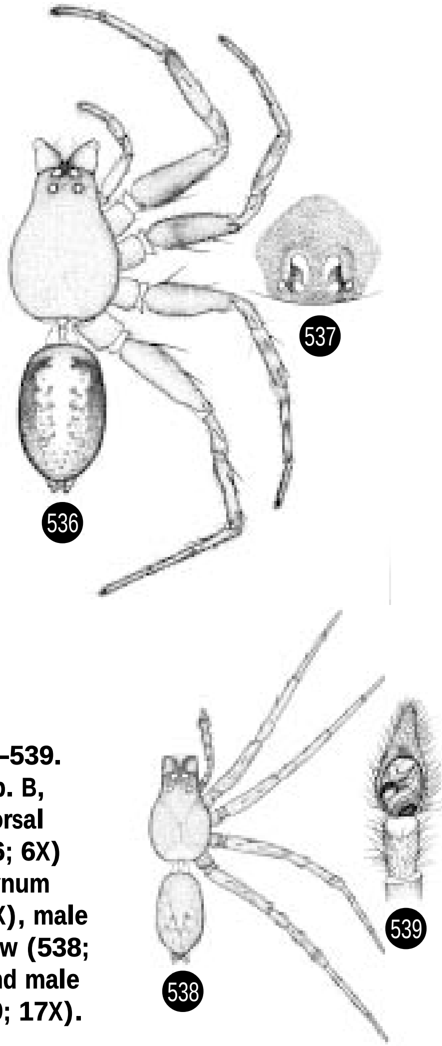
18’ Legs uniformly yellow without bands; cymbium slender distally without apical spines, base not protruded basally; subtegulum at “6 o’clock”; embolus with a large base; duct sigmoid; femur of pedipalp without a dense mat of black hairs; body length 5.5 mm .... *Trochosa* sp. C **[Figs. 545, 546]**

19(6’) Green lynx spiders; face vertical; anterior lateral eyes (ALE) the largest, anterior median eyes the smallest; posterior eye row procurved forming a hexagonal arrangement to ALE; cephalic area parallel-sided; abdomen more than 4 times longer than wide; long and slender legs with long spines; body length 6.5 mm long [Family **Oxyopidae**] .... *Peucetia* sp. **[Fig. 547]**

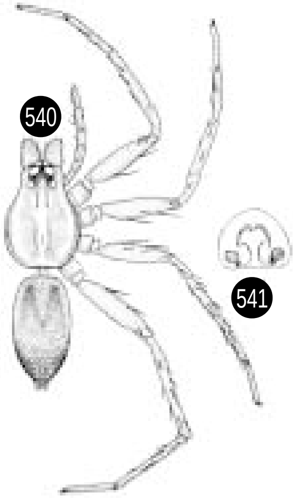
19’ Not as above, eye arrangement never hexagonal 20



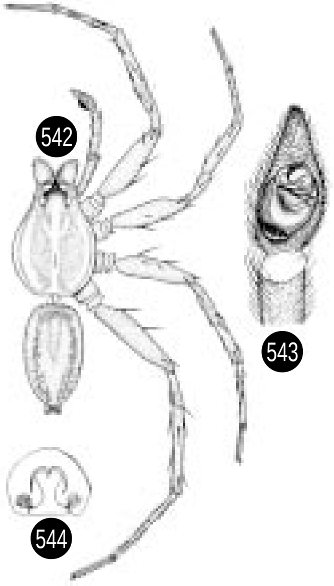
Figs. 534–535. *Arctosa* sp. A, male palp (534; 34X) and male dorsal view (535; 3.90X).



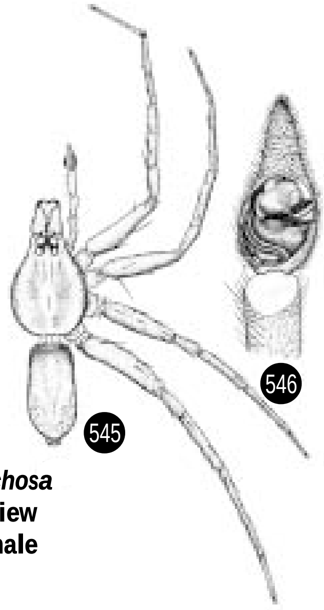
Figs. 536–539. *Arctosa* sp. B, female dorsal view (536; 6X) and epigynum (537; 30X), male dorsal view (538; 3.42X) and male palp (539; 17X).



Figs. 540–541. *Trochosa* sp A, female dorsal view (540; 3.87X) and epigynum (541; 13.3X).



Figs. 542–544. *Trochosa* sp. B, male dorsal view (542; 3.33X), male palp (543; 18.2X), and female epigynum (544; 10X).



Figs. 545–546. *Trochosa* sp. C, male dorsal view (545; 5.09X) and male palp (546; 23.3X).

20(19’) Patella of leg I prominently elongated, as long as or longer than tibiae; metatarsus I shorter than tarsus I; all legs not spinous; scopulae present in tibia and metatarsus of leg I; femur I greatly enlarged dorsally; carapace slightly ovoid, not strongly rounded posteriorly; anterior eye row recurved and posterior eye row procurved; tibia of pedipalp slightly enlarged, without spines or lateral processes; median apophysis hook-shaped borne at the apex of the large tegulum covering the cymbium in ventral view; body reddish with yellow abdomen, length 4.5 mm [Family **Palpimanidae**] ...... *Anisaedus* sp. **[Fig. 548]**

20’ Leg I normal without ventral scopulae in the tibia and metatarsus; all legs spinous, metatarsus I longer than tarsus I; femur I not enlarged; endites strongly converging without serrula; promargin of chelicera without teeth; anterior pair of spinnerets robust [Family **Zodariidae**] 21

21(20’) Tibia IV with 4 dorsal spines; abdominal dorsum with distinct white spots and bands; epigynum simple with a pair of small vertical orifices; pedicel almost parallel-sided; embolus emanates at “6 o’clock,” base small and rounded projected posterolaterally; tegular apophysis without teeth, sigmoid; tibial apophysis moderately slender; body length 6–7.5 mm .... *Mallinella nyikae* (Pocock) **[Figs. 549–552]**

21’ Tibia IV with 3 dorsal spines; abdominal dorsum without white spots and bands; second segment of pedicel distinctly wider than first segment; embolus with a large and widely transverse base, emanates at “5 o’clock;” tegular apophysis broad, base with a narrow fold; tibial apophysis moderately robust; body length 7.5–9 mm .... *Mallinella kibonotensis* Bosmans and van Hove **[Figs. 553, 554]**

22(5’) Tarsus IV with 6–10 serrated bristles forming a tarsal comb; black abdomen round dorsally with 3 pairs of white spots anterolaterally, mediolaterally, and posteriorly; carapace brown; legs yellowish brown with brown femora I–IV; epigynum with a pair of large orifices separated by a narrow septum; body length 2.20 mm long [Family **Theridiidae**] .... *Steatoda erigoniformis* Simon **[Figs. 555–557]**

22’ Tarsus IV without serrated bristles 23

23(22’) Chelicerae, abdomen and legs all long; maxillae longer than wide; epigynum simple; paracymbium elongate [Family **Tetragnathidae**] 24

23’ Without the combination of above characters 28

24(23) Posterior tip of abdomen pointed; spinnerets almost at midventer of abdomen in both sexes; posterior eye row strongly recurved; male: auxillary tooth slightly bifurcate distally; fang without cusp; paracymbium rounded apically with a swollen structure at midlength; conductor with 2–3 pleats basally; female: apical and subapical tooth of chelicera widely separated; epigynum laterally indented at midlength; body length 12–16.5 mm .... *Tetragnatha javana* (Thorell) **[Figs. 558–562]**

24’ Without the combination of above characters 25

25(24’) Apicoventral part of chelicera with a large tooth 26

25’ Not as above 27

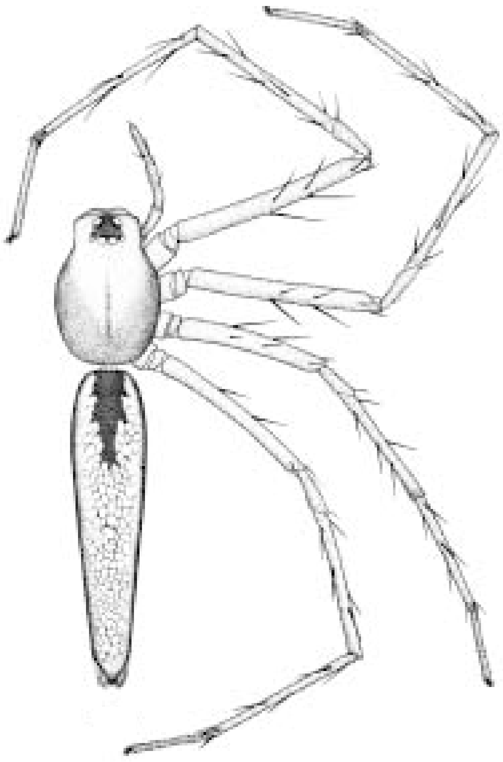


Fig. 547. *Peucetia* sp., female dorsal view (9.54X).

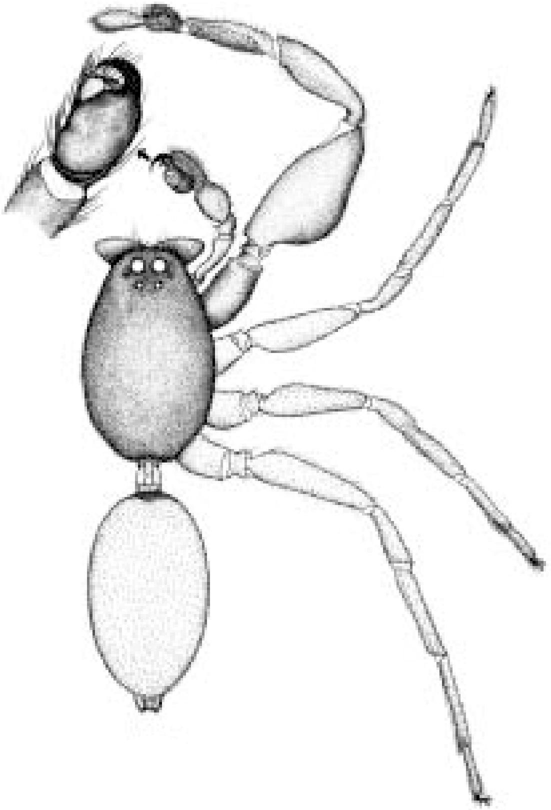
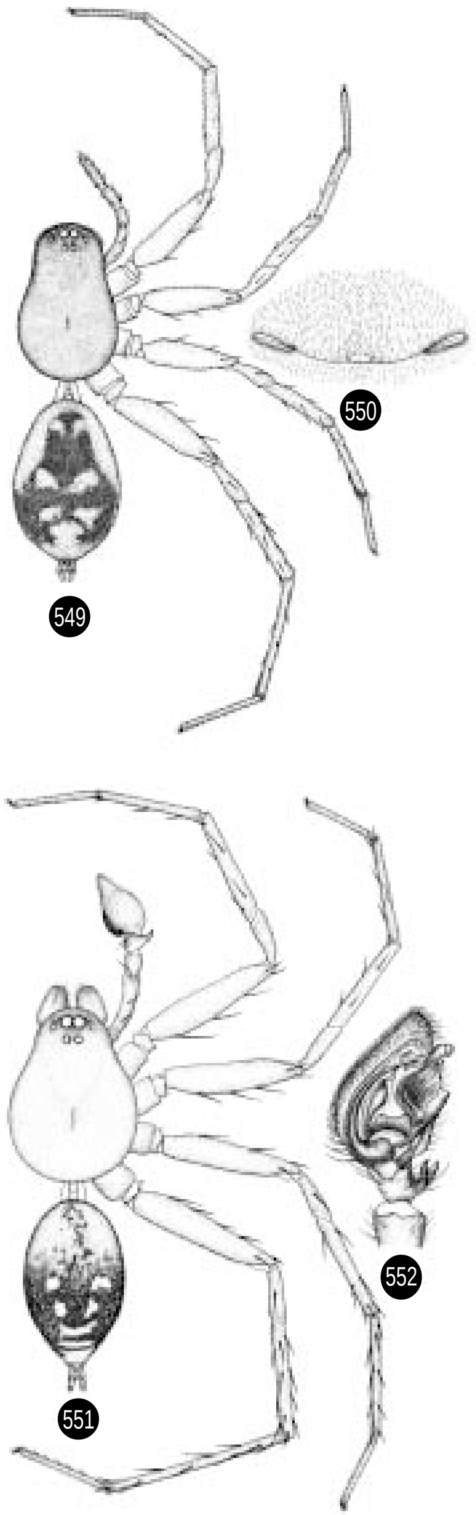
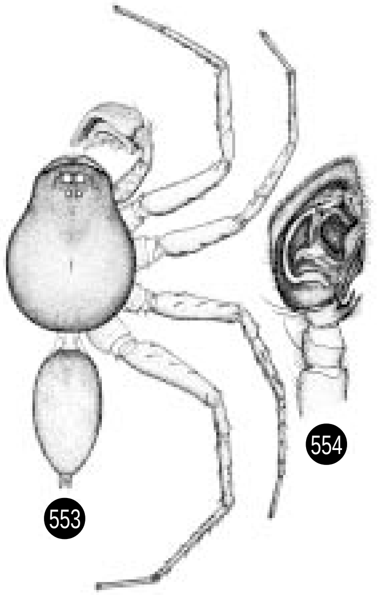


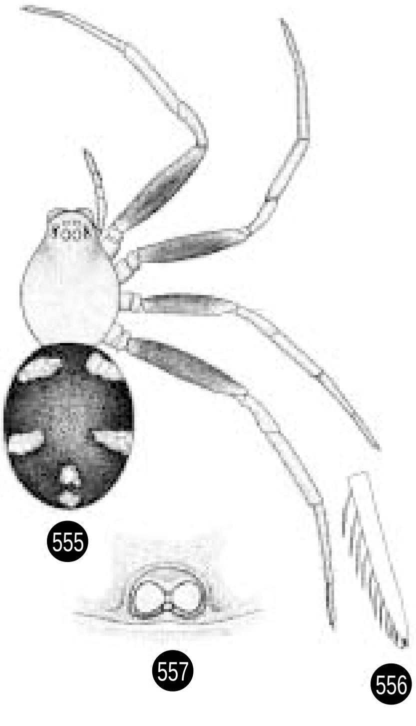
Fig. 548. *Anisaedus* sp., male dorsal view (13.11X).



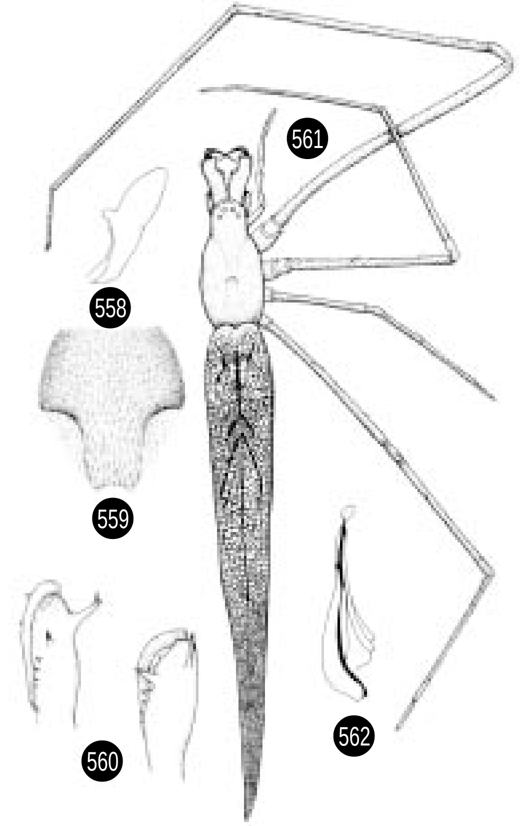
Figs. 549–552. *Mallinella nyikae* (Pocock), female dorsal view (549; 6.52X), epigynum (550; 12.7X), male dorsal view (551; 6.96X), and male palp retrolateral view (552; 12X).



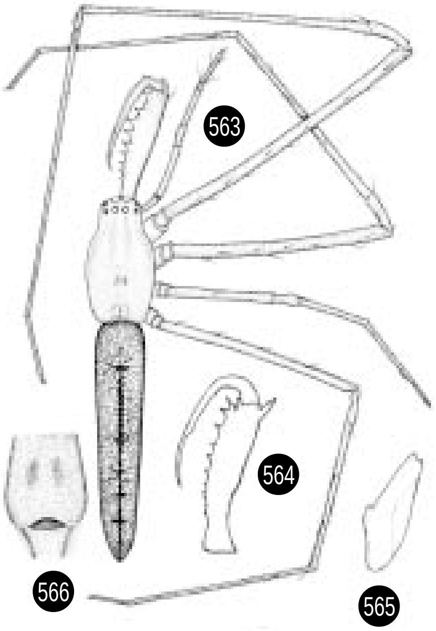
Figs. 553–554. ***Mallinella kibonotensis*** **Bosmans and van Hove, male dorsal view (553; 4.84X) and male palp retrolateral view (554; 12.8X).**



Figs. 555–557. ***Steatoda erigoniformis*** **Simon, female dorsal view (555; 17.72X), tarsus IV with serrated bristles (556; 30.7X), and epigynum (557; 50X).**



Figs. 558–562. ***Tetragnatha javana*** **(Thorell), paracymbium (558; 40X), female epigynum (559; 12.4X), male retrolateral, and dorsal views of chelicerae (560; 12X), female dorsal view (561; 5.8X), and conductor (562; 48X).**



Figs. 563–566. ***Tetragnatha boydi*** **Cambridge, female dorsal view (563; 4.9X), dorsal view of male right chelicera (564; 8.2X), paracymbium (565; 17X), and female epigynum (566; 14.5X).**

26(25) Fang of chelicera with a subbasal outer tooth and an inner tooth; auxillary tooth unevenly bifurcate; tooth and slant tooth almost together; apex of paracymbium notched, broadest below midlength; distal portion of conductor and embolus hooked downwards; apical ventral tooth of chelicera small; epigynum moderately long with a deeply convex anterior opening and a pair of elongate brown bands in the middle; body length 10 mm .... *Tetragnatha boydi* Cambridge **[Figs. 563–566]**

26’ Fang of chelicera without teeth in the outer and inner sides, divided at midlength forming a small cusp; apical promarginal tooth widely separated from the smaller second tooth; epigynum with a penis-like mark posteriorly, apex straight to slightly convex; body length 11 mm .... *Tetragnatha* sp. **[Figs. 567, 568]**

27(25’) Chelicera one-third shorter than carapace; tip of abdomen rounded; male: promargin with 7 teeth and 10 retromarginal teeth; auxillary tooth rounded apically, obliquely projected forward; tegulum almost vertical and very large; paracymbium shoe-like, rounded apically; conductor and embolus without subapical notch near apex of cymbium; female: 7–8 teeth in both promargin and retromargin; epigynum short, posterior margin straight; body length 7 mm .... *Tetragnatha jaculator* Tullgren **[Figs. 569–572]**

27’ Chelicera as long as carapace; tip of abdomen moderately pointed; male: promargin with 9 teeth and 11 in the retromargin; tegulum transverse, moderately large, occupies barely one-half of cymbium; paracymbium bifurcate apically; conductor with a subapical notch; female: promargin with 10-11 promarginal and 9-10 retromarginal teeth; epigynum with a hat-like opening, deep notch in anterior and concave in posterior margin; body length 8 mm .... *Tetragnatha nitens* (Auduoin) **[Figs. 573–576]**

28(23’) Femur IV with 2 longitudinal rows of 28 trichobothria parallel to each other in the prolateral side, dorsally with 15 and ventrally with 13; both eye rows recurved; chelicerae with rudimentary boss; abdomen shortly elongate with a pair of black spots anteriorly and 2 pairs posteriorly; epigastric plates without transverse furrows; epigynum with a moderately narrow and parallel-sided median septum; body length 6.8 mm long [Family **Metidae**] .... *Leucauge* sp. **[Figs. 577, 578]**

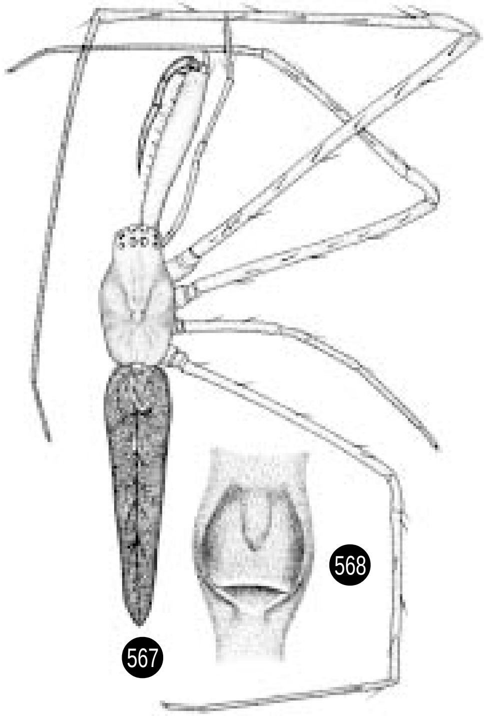
28’ Femur IV without rows of trichobothria; chelicerae with well-developed boss; abdominal shape and color variable; epigastric furrow straight; tarsi with prominent auxillary foot claws [Family **Araneidae**] 29

29(28’) Abdomen hard, dorsally flattened with numerous spots and lateral spines; carapace with parallel-sided cephalic and nearly straight anterior area viewed dorsally 30

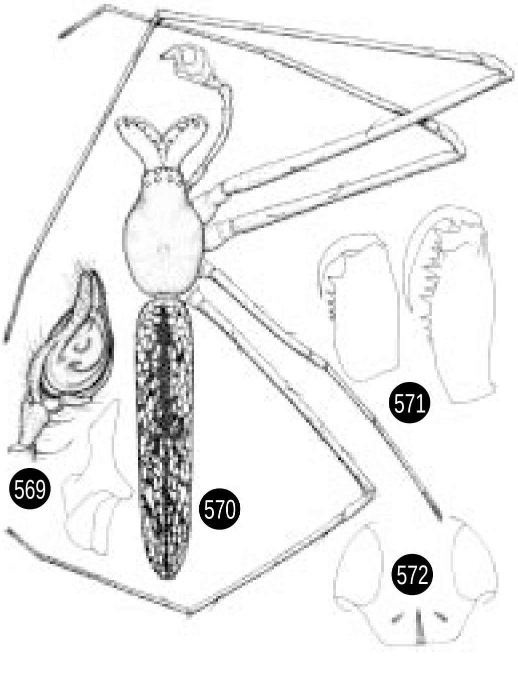
29’ Without the combination of above characters 31

30(29) Abdomen bears 6 spines with 2 short humeral pointed laterad and 4 long submedian and posterior spines all projected posteriorly, dorsum with 19 submarginal and 4 median subspherical spots; scape of epigynum straight apically............................. *Gasteracantha curvispina* Guerin **[Figs. 579, 580]**

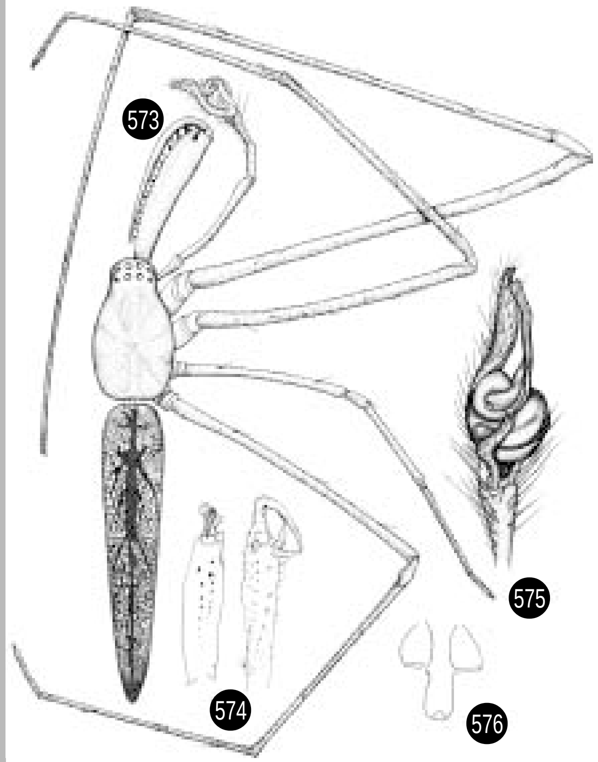
30’ Abdomen with 4 short spines, submedian spine absent, dorsum with 17 ovoid and 4 moderately large subspherical spots in the submargin and median areas, respectively; apex of scape strongly rounded .... *Isoxya mucronata* (Walckenaer) **[Figs. 581, 582]**



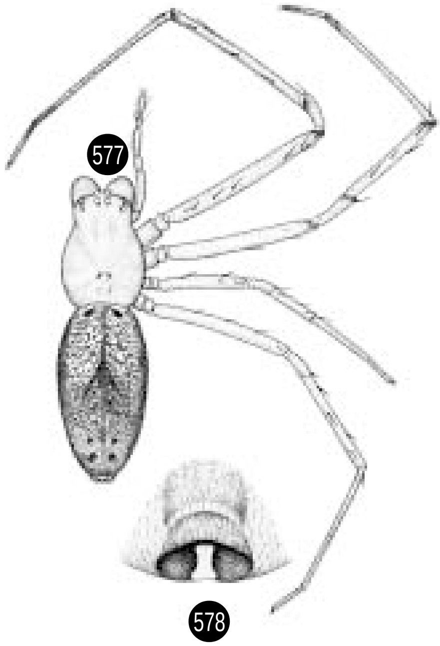
Figs. 567–568. ***Tetragnatha*** **sp., female dorsal view (567; 4.82X) and epigynum (568; 11.2X).**



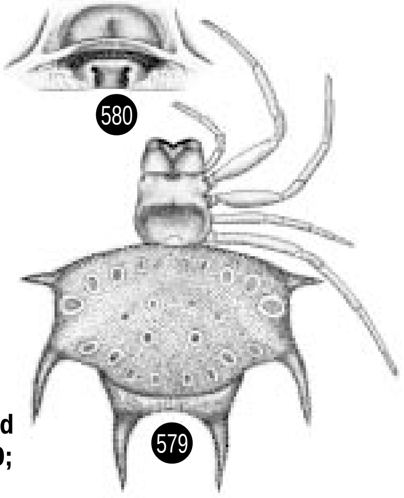
Figs. 569–572. ***Tetragnatha jaculator*** **Tullgren, retrolateral view of male palp with close-up of paracymbium (569; 16.6X), male dorsal view (570; 7.9X), dorsal view of male (right) and female (left) chelicerae (571; 13.1X), and female epigynum (572; 30X).**



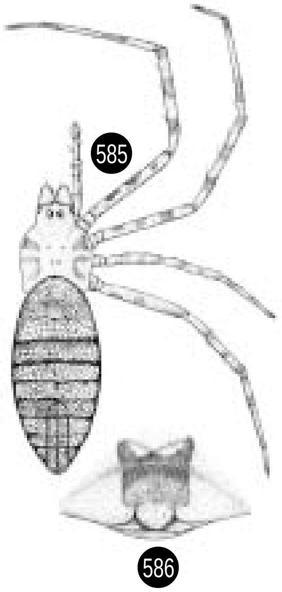
Figs. 573–576. ***Tetragnatha nitens*** **(Auduoin), male dorsal view (573; 7.38X), inner lateral view of male (left) and female (right) chelicera (574; 7X), ventral view of male palp (575; 18.5X), and female epigynum (576; 20X).**



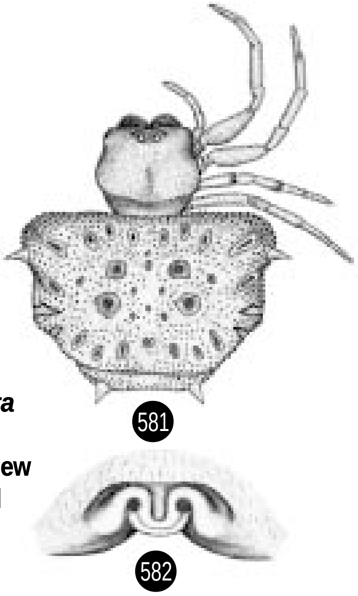
Figs. 577–578. ***Leucauge*** **sp., female dorsal view (577; 5.59X) and epigynum (578; 30X).**



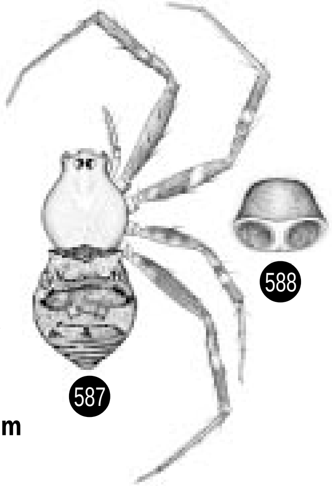
Figs. 579–580. ***Gasteracantha curvispina*** **Guerin, female dorsal view (579; 5.2X) and epigynum (580; 40X).**



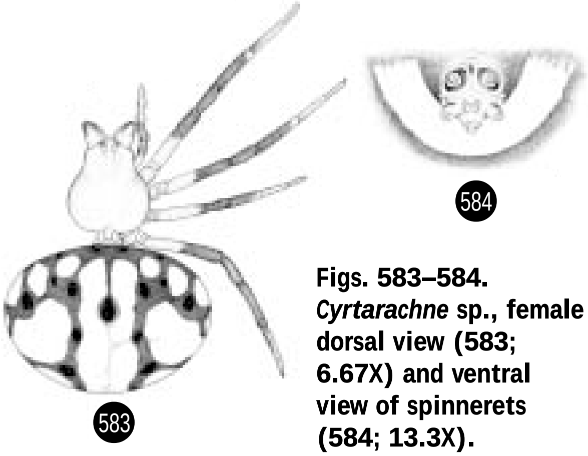
Figs. 585–586. ***Argiope trifasciata*** **(Forskal), female dorsal view (585; 4.38X) and epigynum (586; 20X).**



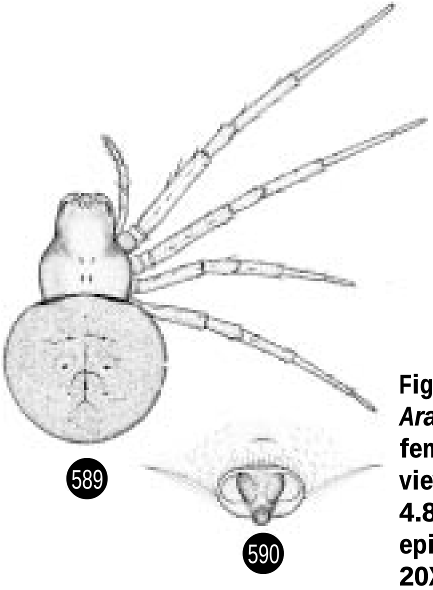
Figs. 581–582. ***Isoxya mucronata*** **(Walckenaer), female dorsal view (581; 5.8X) and epigynum (582; 40X).**



Figs. 587–588. ***Argiope flavipalpis*** **(Lucas), female dorsal view (587; 5.6X) and epigynum (588; 33X).**



Figs. 583–584. ***Cyrtarachne*** **sp., female dorsal view (583; 6.67X) and ventral view of spinnerets (584; 13.3X).**



Figs. 589–590. ***Araniella*** **sp., female dorsal view (589; 4.85X) and epigynum (590; 20X).**

31(29’) Abdomen with leathery integument, strongly convex dorsally and transversely ovoid; color pattern black and yellow with 4 black spots anteriorly, 9 medially in 2–3 transverse rows and 2 posteriorly; anterior spinnerets widely separated basally; body length 6 mm .... *Cyrtarachne* sp. **[Figs. 583, 584]**

31’ Without the combination of above characters 32

32(31’) Posterior eye row strongly procurved; anterior lateral eyes smaller than the posterior lateral eyes 33

32’ Posterior eye row straight or recurved; lateral eyes of equal size 34

33(32) Abdomen elongate, 2.2 times longer than wide, silvery white with 7 pale yellow transverse bands; carapace with 3 pale brownish gray sublateral bands; legs with alternating brown and yellow bands; apex of the developing median septum strongly rounded; subadult body length 8 mm .... *Argiope trifasciata* (Forskal) **[Figs. 585, 586]**

33’ Abdomen subglobular with a truncate brown anterior margin, a broad subanterior yellow transverse band and a narrowly submedian band; carapace yellow to yellowish brown; legs brown with yellow bands in femur II, at almost midlength of tibiae II and III and base of tibia IV; epigynum with a pair of slightly oblique orifices separated by a relatively narrow median septum; body length 5 mm .... *Argiope flavipalpis* (Lucas) **[Figs. 587, 588]**

34(32’) Abdomen subspherical, whitish green except black anterior margin; carapace brown with 2 pairs of dark brown spots along thoracic foveal area; epigynum with a small apically blunt scape, orifices subspherical, body length 6.8 mm ... . *Araniella* sp. **[Figs. 589, 590]**

34’ Not as above 35

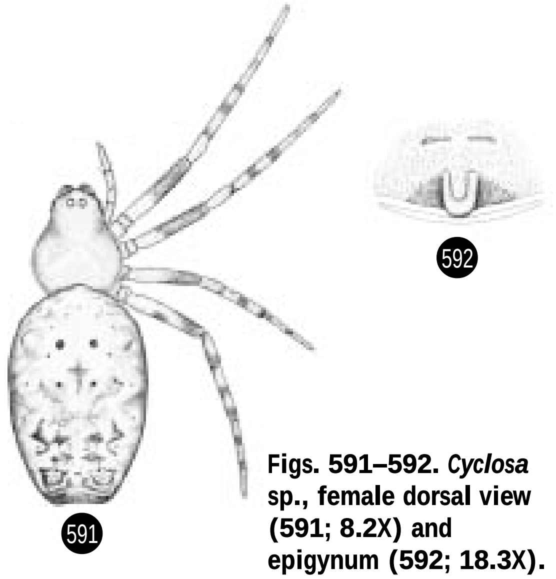
35(34’) Abdomen truncate posteriorly, undulated anteriorly, paired humps present near the shoulder and posterior ends; posterior one-half of abdomen mottled dark brown; carapace brown with short white fine hairs; apical two-thirds of femora I and II dark brown with yellow base; tibiae and tarsi with alternating yellow and dark brown bands; epigynum with a prominent tongue-like scape; body length 5 mm; female .... *Cyclosa* sp. **[Figs. 591, 592]**

35’ Abdomen rounded posteriorly 36

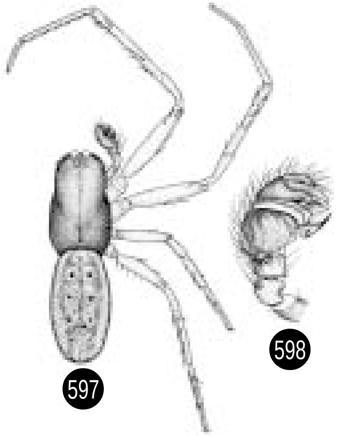
36(35’) Abdomen with 8 dorsal spots in 2 longitudinal rows 37

36’ Abdomen without paired dorsal spots in 2 longitudinal rows 38

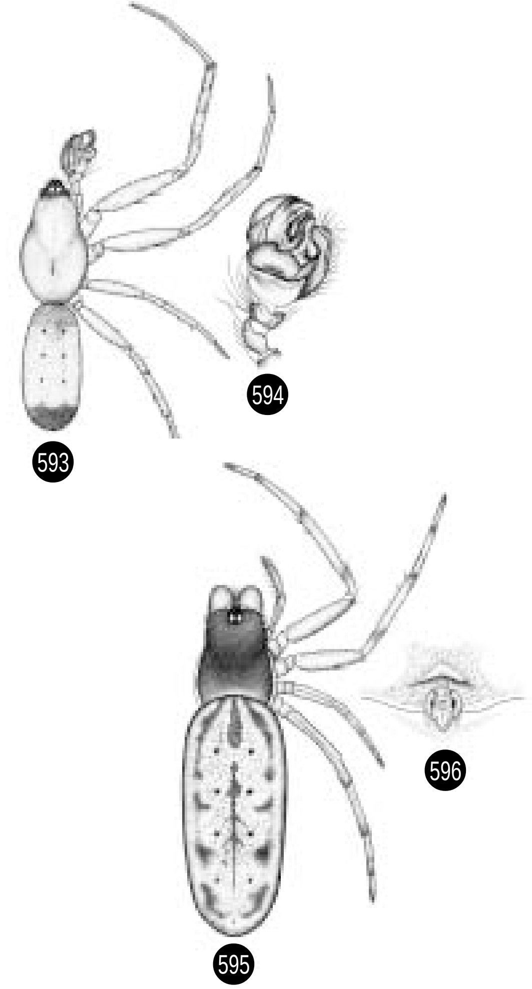
37(36) Spinnerets closer to midlength of abdomen than to posterior end; metatarsus I with 0-3 ventral spines; male: tibia I with 7 (1-2-2-2) and femur IV with no ventral spines; femur of pedipalp without dorsal spines; patella with 2 moderately weak spines; tibia with a tubercle in ventral view; paracymbium rounded apically; median apophysis small, slightly longer than wide with a minute tooth basally; terminal apophysis large with a short and sharply pointed tip; female: carapace white laterally; apices of leg segments light brown to gray; tibia I with 4 (0-2-2) ventral spines; abdominal venter with a pair of parallel elongate white bands; scape prominently tongue-like, broader subdistally and narrower proximally; body length 3.5–6.5 mm .... *Singa* sp. **[Figs. 593–596]**



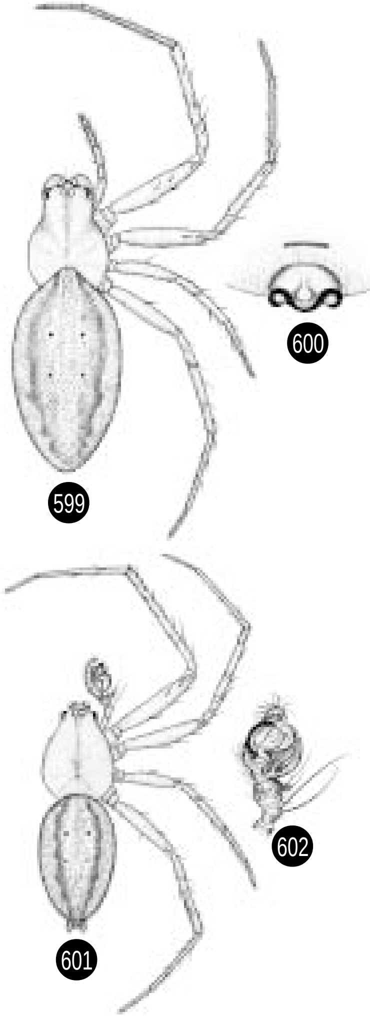
Figs. 591–592. *Cyclosa* sp., female dorsal view (591; 8.2X) and epigynum (592; 18.3X).



Figs. 597–598. *Singafrotypa acanthopus* Simon, male dorsal view (597; 4.2X) and retrolateral view of palp (598; 13.3X).



Figs. 593–596. *Singa* sp., male dorsal view (593; 6.6X), male palp (594; 21X), female dorsal view (595; 3.6X), and epigynum (596; 33X).



Figs. 599–602. *Larinia* sp., female dorsal view (599; 3.8X), epigynum (600; 2.9X), male dorsal view (601; 4.9X), and retrolateral view of palp (602; 15.8X).

37’ Spinnerets closer to posterior end of abdomen than to midlength; metatarsus I with 10 strong ventral spines; tibia I with 11 ventral and 2 prolateral spines; femur IV with 6 ventral spines; femur of pedipalp with 2 strong apicodorsal spines; patella with 3 stout spines dorsally; tibia rectangular with a small posteroventral tooth and moderately thick set of bristles; paracymbium very distinct, slightly swollen apically; median apophysis well developed, 3 times longer than wide with a bifurcate tooth basally; terminal apophysis relatively large with a blunt tooth; abdominal venter with 2 globular white spots; body length 6.7 mm .... *Singafrotypa acanthopus* Simon **[Figs. 597, 598]**

38(36’) Median ocular quad wider in front than behind; abdomen pointed midanteriorly and posteriorly in the female and both rounded in male; epigynal orifice very prominent; median septum strongly rounded apically with a very broad base; a transverse black band present anterior of the epigynal margin; male pedipalp with two very long spines in patella; both sexes with two moderately broad longitudinal light brown to gray subdorsal bands enclosing 2–3 pairs of brown spots in two longitudinal rows; body length 9–11 mm................................. .... *Larinia* sp. **[Figs. 599–602]**

38’ Without the combination of above characters; coxa I of male with a posteroventral spur 39

39(38’) Abdomen yellowish green with 3–5 pairs of small brown dots arranged longitudinally in two rows; tibia of pedipalp with inner process lined with 8–9 long white hairs; cymbium yellow with a deep concave cut on one side; patella with two long hairs not on the same place; body length 4.7 mm .... *Neoscona blondeli* (Simon) **[Figs. 603, 604]**

39’ Abdomen not yellowish green, without paired small brown dots; promargin of tibial palp without long white hairs 40

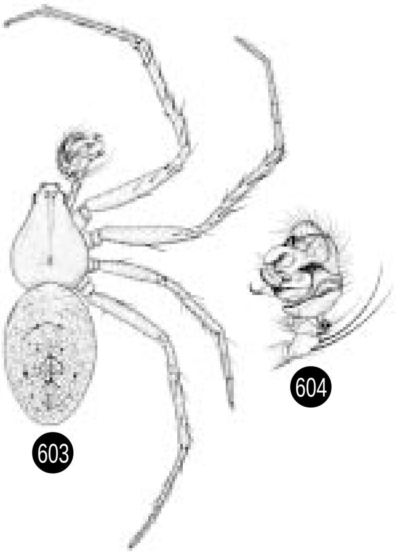
40(39’) Abdomen with a pair of light brown submedian longitudinally wavy or undulated bands and a median white band; carapace usually with a median and sublateral longitudinal reddish brown bands 41

40’ Not as above 42

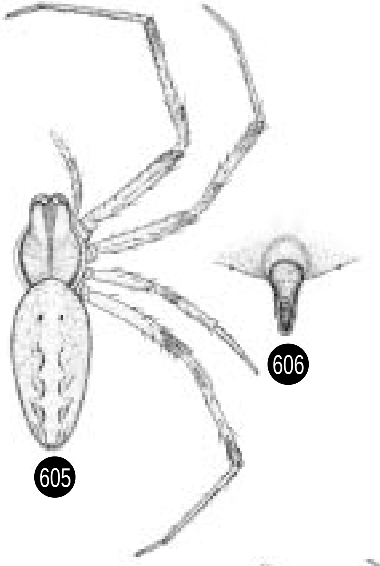
41(40) Undulated and concave light brown band prominent in posterior one-half of abdomen; oblongate abdomen wider in anterior one-third; carapace with three distinct reddish brown longitudinal bands; scape of epigynum long, basally broad and slightly enlarged subapically; patella of male pedipalp with two equally long and widely separated spines; median apophysis bifurcate apically; tegulum very large, oblique in position, body length 9.5–12 mm .... *Neoscona theisi theisiella* (Tullgren) **[Figs. 605–608]**

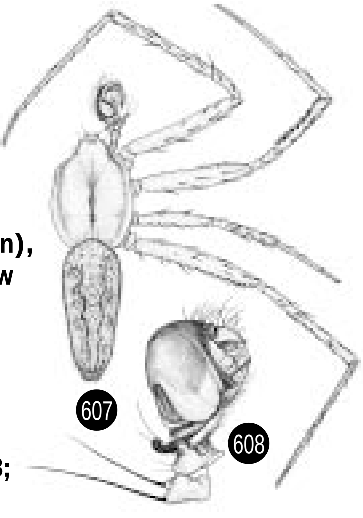
41’ Margins of abdominal bands zigzag or serrated; abdomen widest medially; carapace without dark reddish brown longitudinal bands; scape of epigynum short, truncate apically in line to the posterior epigynal margin; moderately large orifices opening right on the posterior epigynal margins; hat-like hood below the anterior epigynal margins; body length 6.8–7.0 mm .... *Kilima conspersa* Grasshoff **[Figs. 609, 610]**

42(40’) Abdomen globular with a pair of widely zigzag brown longitudinal bands dorsally in female; carapace dark reddish brown to almost black, widest along posterior one-third; femur dark brown except yellow basal one-fourth; epigynum prominently circular with a small triangular scape, sharply pointed tip of scape reaches the posterior epigynal margin; male abdomen elongate,

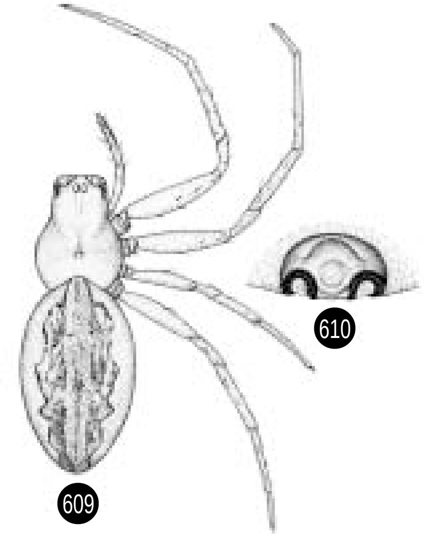


Figs. 603–604. *Neoscona blondeli* (Simon), male dorsal view (603; 6.81X) and retrolateral view of palp (604; 18X).

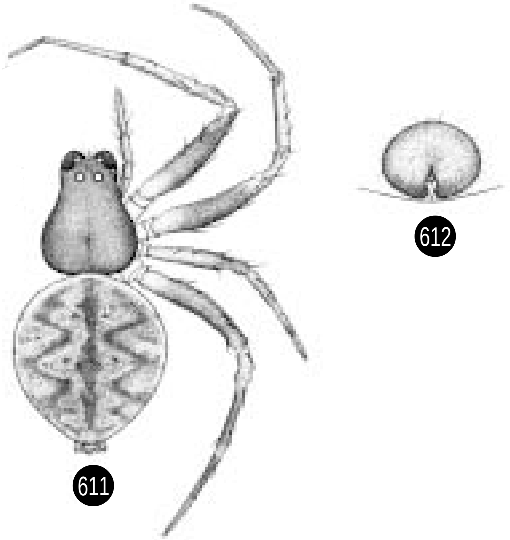


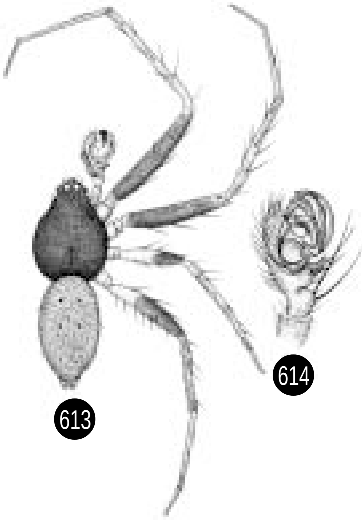


Figs. 605–608. *Neoscona theisi theisiella* (Tullgren), female dorsal view (605; 3.16X), epigynum (606; 10X), male dorsal view (607; 3.1X), and retrolateral view of palp (608; 12.5X).



Figs. 609–610. *Kilima conspersa* Grasshoff, female dorsal view (609; 5.65X) and epigynum (610; 30X).





Figs. 611–614. *Araneus ethiospissa* Simon, female dorsal view (611; 6.91X), epigynum (612; 40X), male dorsal view (613; 4X), and retrolateral view of palp (614; 21X).

yellow brown with 4 pairs of brown dots dorsally; femora I and II black, III and IV black except yellow basal one-half; pedipalp with a dark reddish brown patella and tibia, femur yellowish brown; tibia with 7–8 long retrolateral hairs in a transverse row, ventral part triangularly pointed; body length 4–7 mm ....*Araneus ethiospissa* Simon **[Figs. 611–614]**

42’ Abdomen and carapace without such characters 43

43(42’) Abdomen with a pair of black spots posteriorly and 4 pairs of light brown median bands interrupted in the middle; legs uniformly yellow, tibia I with only one prolateral spine; scape pointed apically and beyond the posterior epigynal margin; body length 3.5 mm.............*Araneus* sp. A **[Figs. 615, 616]**

43’ Abdomen with a dark brown median band in posterior one-half; tibia of pedipalp with a short bluntly rounded inner process lined with 6–8 long white hairs; cymbium brown, apex rounded without a deep cut on one side; patella with two long hairs parallel to each other; body length 4 mm ....*Araneus* sp. B **[Figs. 617, 618]**

44(4’) Legs I and II laterigrade, usually with crab-like appearance 45

44’ Legs prograde 53

45(44) Leg I slightly longer and thicker than III and IV, II longer than I, scopulae and claw tufts present; body setae soft; both eye rows recurved, not on a tubercle; posterior eyes equidistant from each other; cephalic margin truncate anteriorly; ovoid abdomen pointed posteriorly; tegulum of pedipalp large with a short coiled embolus on its anterior end; tibia with a long dorsal spine; epigynum with a large opening, spermathecae converging towards the posterior epigynal margin and bulbous anteriorly; body length 5–7 mm [Family **Philodromidae**] ....*Philodromus* sp. **[Figs. 619–622]**

45’ Legs I and II much thicker and longer than III and IV; legs without scopulae or claw tufts [Family **Thomisidae**] 46

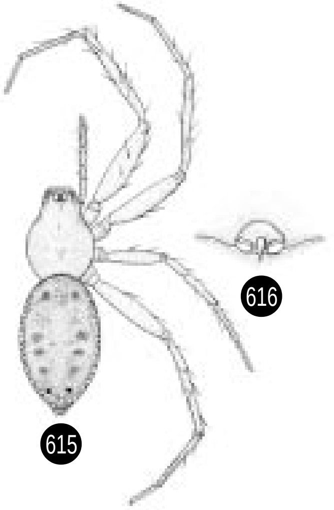
46(45’) Abdomen prominently long, wrinkled and tapers posteriorly, produced like a tail well beyond the spinnerets; epigynum inverted V to horseshoe-shaped with a transverse mark in the middle; immature with unwrinkled posterior abdomen and pale horseshoe-shaped band in the epigynum region; body length 11 mm... *Monaeses* sp. **[Figs. 623, 624]**

46’ Not as above 47

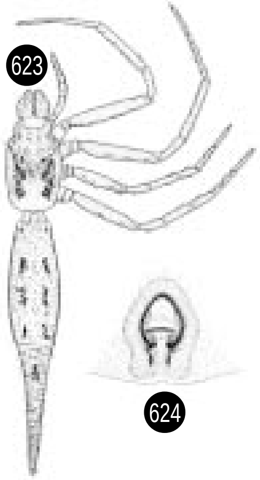
47(46’) Abdomen widened posteriorly with posterolateral humps; eyes on tubercles... 48

47’ Abdomen long with lateral corrugations; eyes on a carina......................... 49

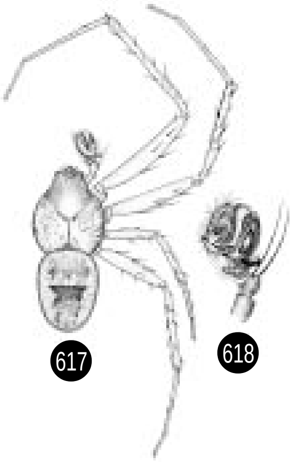
48(47) Carapace with a broad dark reddish brown longitudinal band on both lateral sides, margins serrated; abdomen yellowish brown and serrated laterally; legs commonly reddish brown except yellow metatarsus, tarsus and base of femur II, basal two-thirds of femora III and IV and basal one-half of tibia IV; embolus counter-clockwise; retrolateral tibial apophysis pointed beyond tutacular apophysis; body length 2.5 mm.. .... *Thomisus spiculosus* Pocock **[Figs. 625, 626]**



Figs. 615–616. *Araneus* sp. A, female dorsal view (615; 8.2X) and epigynum (616; 25X).

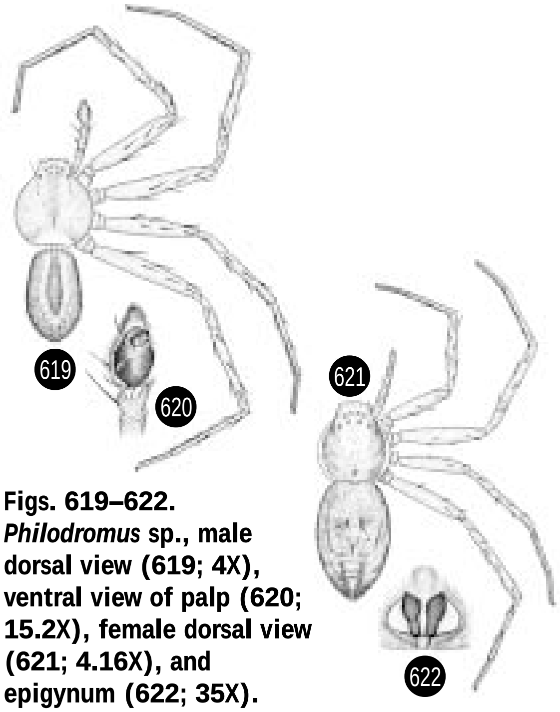


Figs. 623–624. *Monaeses* sp., female dorsal view (623; 4.09X) and epigynum (624; 40X).

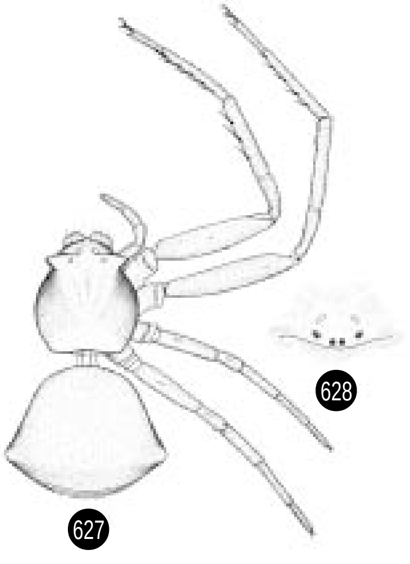


Figs. 617–618. *Araneus* sp. B, male dorsal view (617; 5.5X) and retrolateral view of palp (618; 15X).

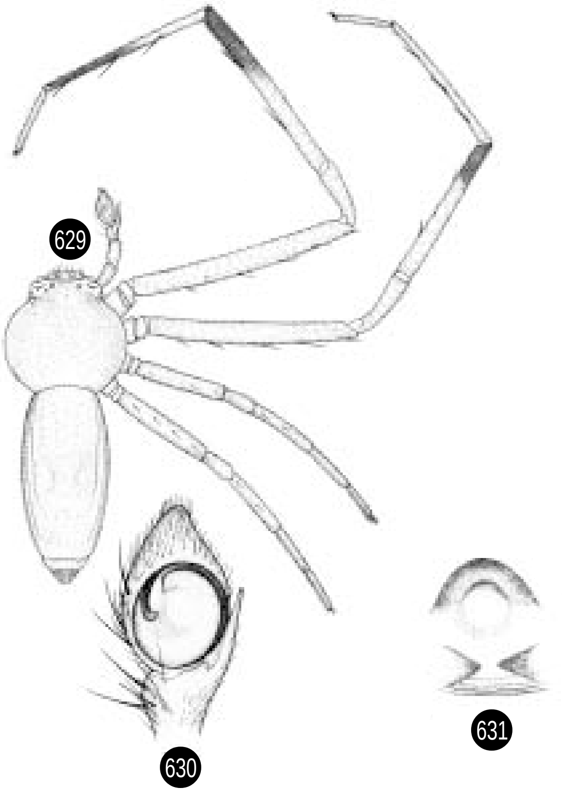
Figs. 625–626. *Thomisus spiculosus* Pocock, male dorsal view (625; 8.8X) and ventral view of palp (626; 23.75X).



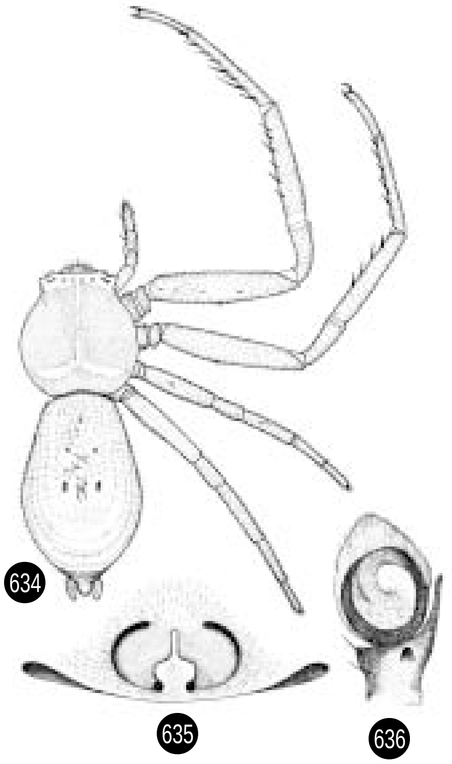
Figs. 619–622. *Philodromus* sp., male dorsal view (619; 4X), ventral view of palp (620; 15.2X), female dorsal view (621; 4.16X), and epigynum (622; 35X).



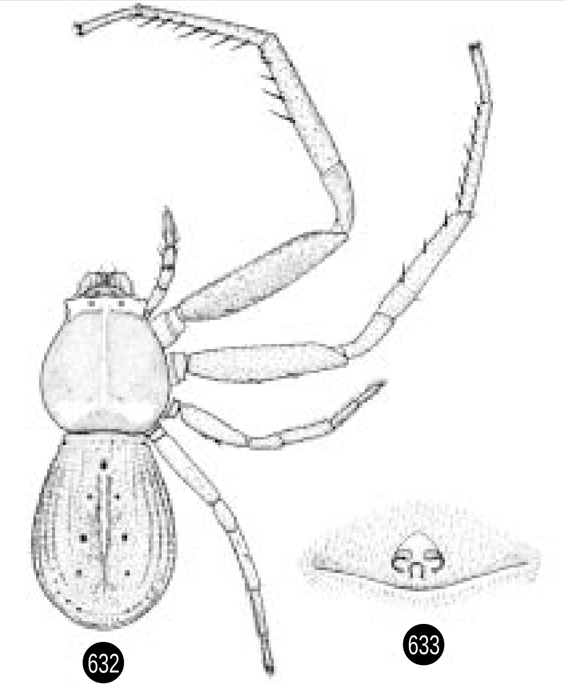
Figs. 627–628. *Thomisus* sp., female dorsal view (627; 7.56X) and epigynum (628; 30X).



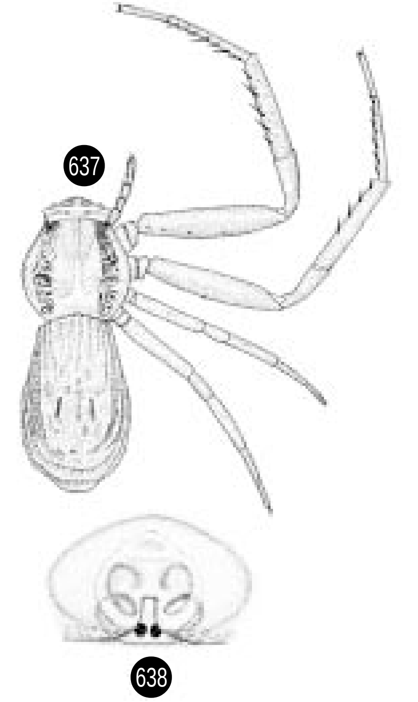
Figs. 629–631. ***Runcinia carae*** **Dippenaar-Schoeman, male dorsal view (629; 10.25X), ventral view of palp (630; 44.3X), and female epigynum (631; 62X).**



Figs. 634–636. ***Runcinia affinis*** **Simon, female dorsal view (634; 7.45X), epigynum (635; 76.9X) and ventral view of palp (636; 46X).**



Figs. 632–633. ***Runcinia*** **sp., female dorsal view (632; 7.5X) and epigynum (633; 61X) .**



Figs. 637–638. ***Runcinia lateralis*** **(Koch), female dorsal view (637; 6.8X) and epigynum (638; 83X).**

48’ Carapace yellowish brown, lateral margins smooth; abdomen creamy white without lateral serrations; legs uniformly yellowish brown; epigynum of subadult female with a pair of small openings on the midposterior epigynal margin and two pairs of spots anterolaterally; body length 4.5 mm .... *Thomisus* sp**. [Figs. 627, 628]**

49(47’) Carapace without submedian longitudinal reddish brown bands 50

49’ Carapace with very distinct longitudinal reddish brown bands 52

50(49) Apical one-half of tibia I and metatarsus I and apical one-fourth of tibia II dark reddish brown; carapace strongly rounded laterally; abdomen elongate with 4–6 transverse constrictions on the narrowed posterior and 2–3 longitudinal constrictions laterally; pedipalp with a long apically pointed retrolateral tibial apophysis (RTA); ventrolateral tibial apophysis (VTA) hook-like; embolus clockwise emanates at “7 o’clock,” epigynum with a central orifice, anteriorly with a transparent hood and median area with arrow-like elevated ridges; body length 4 mm .... *Runcinia carae* Dippenaar-Schoeman **[Figs. 629–631]**

50’ Not as above; carapace with an inverted white T-band 51

51(50’) White T-band broad in the thoracic area; abdomen rounded posteriorly, median area with 3 pairs of brown spots, tibia I with 9–11 ventral spines; epigynum subtriangular with a small U-shaped opening and a pair of spermathecae on its top; body length 6 mm .... *Runcinia* sp. **[Figs. 632, 633]**

51’ White T-band narrow in the thoracic area; abdomen pointed anteriorly with 2 pairs of brown spots medially; tibia I with 8–9 ventral spines; epigynum with a fork-shaped opening and heavily sclerotized laterally convex margins; RTA slender, slightly rounded apically; VTA short and truncate, body length 5.5 mm .... *Runcinia affinis* Simon **[Figs. 634–636]**

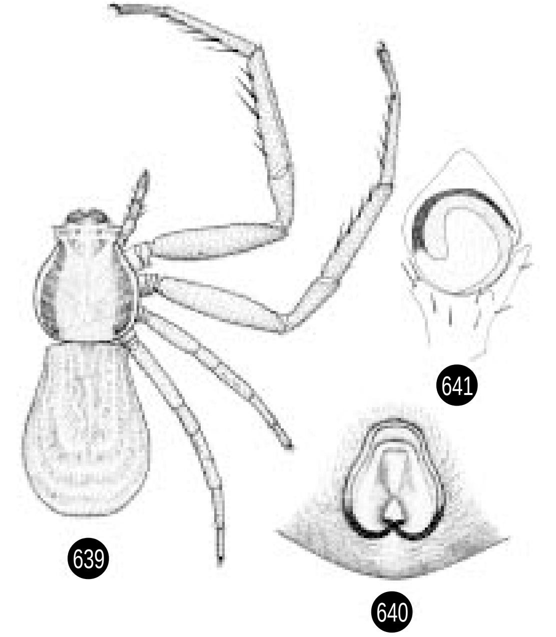
52(49’) Abdomen narrowly rounded posteriorly, median pair of dark brown elongate band present; metatarsus I with 14 ventral spines; epigynum transversely ovoid with a U-shaped opening; body length 5.7 mm .... *Runcinia lateralis* (Koch) **[Figs. 637, 638]**

52’ Abdomen broadly rounded to slightly truncate posteriorly, median area without elongated dark brown bands; metatarsus I with 10 ventral spines; epigynum pear-shaped with a triangular opening; RTA robust, subapically reduced and tip moderately pointed; VTA short and widely truncate; inner lateral side prominently developed with 2 long spines; body length 4.2 mm .... *Runcinia aethiops* (Simon) **[Figs. 639–641]**

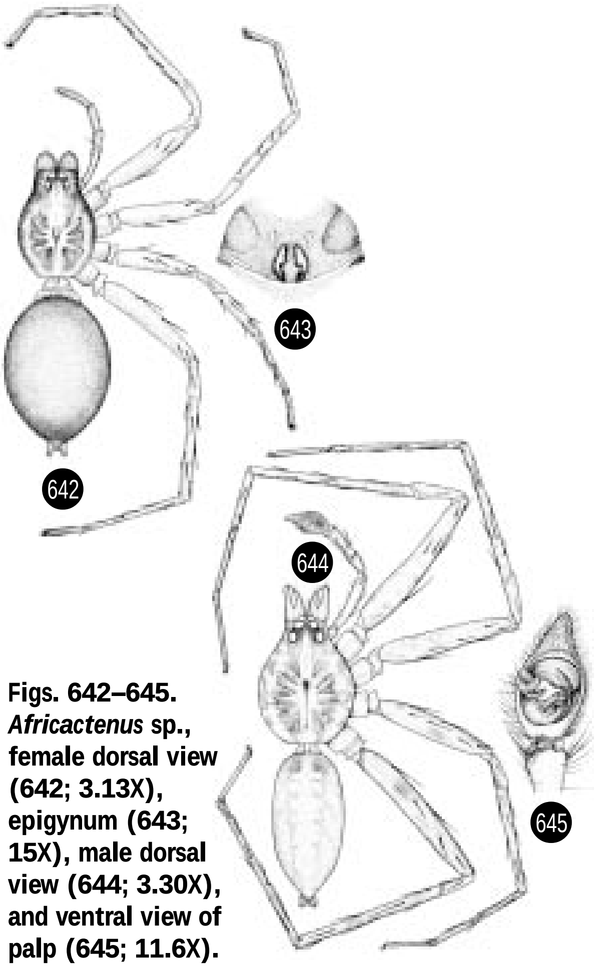
53(44’) Eyes in 3 rows 54

53’ Eyes in 2 rows 62

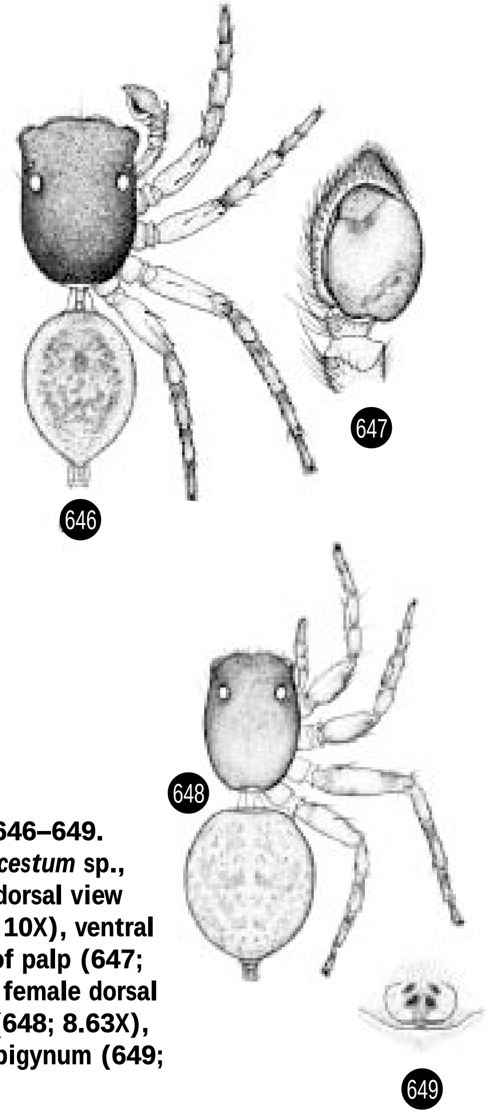
54(53) Eyes in 3 rows of 2, 4, and 2; carapace with finger-like striae radiating from the dagger-like thoracic groove, dark brown submedian and submarginal longitudinal bands distinct; abdomen dark to yellowish brown, ovoid or oblongate; tibia I with 10 ventral spines and metatarsus I with 6 ventral spines; epigynum with a pair of sickle-shaped lateral openings enclosing an



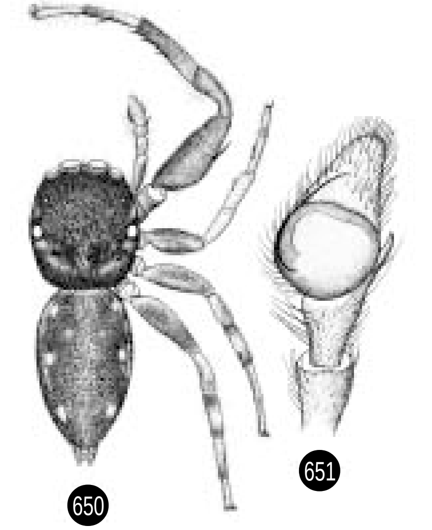
Figs. 639–641. ***Runcinia aethiops*** **(Simon), female dorsal view (639; 9.76X), epigynum (640; 46X), and ventral view of male palp (641; 50X).**



Figs. 642–645. ***Africactenus*** **sp., female dorsal view (642; 3.13X), epigynum (643; 15X), male dorsal view (644; 3.30X), and ventral view of palp (645; 11.6X).**



Figs. 646–649. ***Habrocestum*** **sp., male dorsal view (646; 10X), ventral view of palp (647; 31X), female dorsal view (648; 8.63X), and epigynum (649; 20X).**



Figs. 650–651. ***Bianor*** **sp., male dorsal view (650; 12.67X) and ventral view of palp (651; 42X).**

anchor-like scape with a truncate apex; femur of pedipalp as long as combined length of patella and tibia; embolus thin and sickle-shaped; VTA short and truncate apically; body length 9–14 mm [Family **Ctenidae**] .... *Africactenus* sp. **[Figs. 642–645]**

54’ Eyes arranged in 3 rows of 4, 2, and 2; anterior median eyes very large, twice or more as large as anterior lateral eyes; posterior median eyes very small [Family **Salticidae**] 55

55(54’) Posterior median eyes (PME) very close to the posterior lateral eyes (PLE); anterior lateral eyes slightly projected outwards; dark reddish brown carapace subrectangular and distinctly sloped posteriorly; abdomen globular to ovoid, brownish gray; male pedipalp with a very large tegulum; epigynum with a very short scape; body length 4–5.5 mm............ *Habrocestum* sp**. [Figs. 646–649]**

55’ PME not very close to PLE, often closer to anterior lateral eyes or in between the lateral eyes 56

56(55’) Carapace and abdomen dark reddish brown with white patches in the thoracic area posterior of posterad lateral eyes and 6 pairs of white submarginal spots in the abdomen; leg I prominently larger than other legs; tibia I with 6 pairs of ventral spines and 2 pairs in metatarsus I; retrolateral tibial apophysis not beyond apex of tegulum; embolus clockwise emanating from the midlateral side of tegulum; body length 3 mm .... *Bianor* sp. **[Figs. 650, 651]**

56’ Not as above 57

57(56’) Cephalothorax with a pale yellow T-band behind the posterior lateral eyes; PME slightly closer to PLE than to anterior lateral eyes; abdomen brown with at least five yellow transverse bands in posterior one-half, venter yellow with a brown spot posteriorly; chelicera with one retromarginal tooth; tibia I with 3 pairs of ventral spines; epigynum with a pair of oblique openings; body length 8 mm ....*Plexippus* sp. **[Figs. 652, 653]**

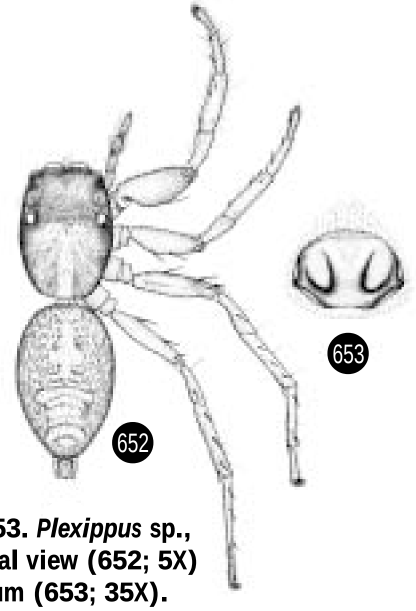
57’ Not as above 58

58(57’) Carapace light brown; broadest across posterior lateral eyes and narrowed posteriorly; abdomen elongate with prominent markings; femur I enlarged; tibia I with at least 4 pairs of ventral spines all in the anterior two-thirds of its length 59

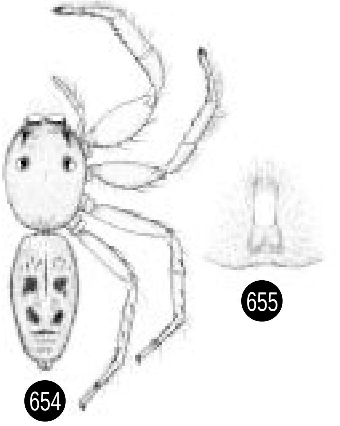
58’ Carapace black 61

59(58) Abdomen yellowish brown with 2 pairs of black median spots and 3 dark brown transverse stripes posteriorly; carapace yellow except black eye margins; femur I moderately enlarged with relatively thick black hairs ventrally similar to femur II; tibia I with 4 prolateroventral and 3 retrolateroventral spines; epigynum with a short, vertically elongate orifice; body length 7 mm............. .... *Thyene* sp. A **[Figs. 654, 655]**

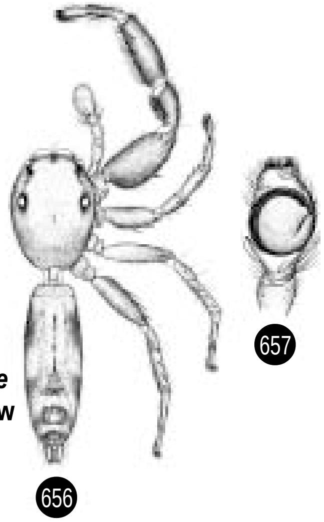
59’ Not as above 60



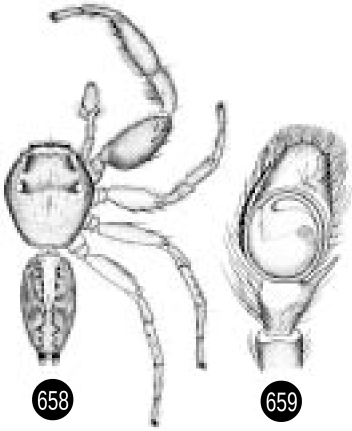
Figs 652–653. ***Plexippus*** **sp., female dorsal view (652; 5X) and epigynum (653; 35X).**



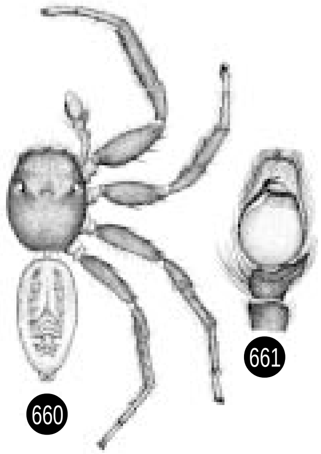
Figs. 654–655. ***Thyene*** **sp. A, female dorsal view (654; 5X) and epigynum (655; 27.5X).**



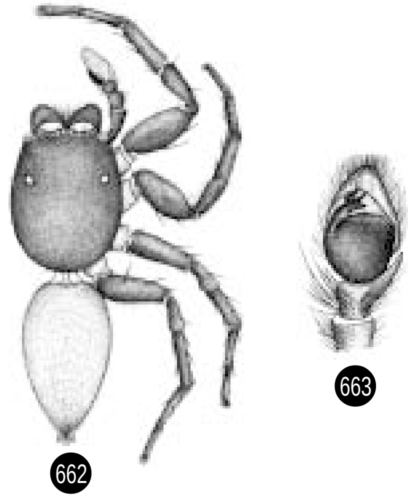
Figs. 656–657. ***Thyene*** **sp. B, male dorsal view (656; 5.71X) and ventral view of palp (657; 20X).**



Figs. 658–659. ***Thyene inflata*** **(Gerstacker), male dorsal view (658; 5.58X) and ventral view of palp (659; 23.3X).**



Figs. 660–661. ***Pachypoessa plebeja*** **L. Koch, male dorsal view (660; 4.77X) and ventral view of palp (661; 15X).**



Figs. 662–663. ***Pachypoessa*** **sp., male dorsal view (662; 4.82X) and ventral view of palp (663; 13.1X).**

60(59') Abdomen with 4 yellow transverse bands located anteriorly, medially and two posteriorly enclosing a small triangular yellow area; posterior spinnerets black; leg I very large compared to legs II, III, and IV; tibia I with thick scopulae, as long as combined length of metatarsus I and tarsus I; cymbium moderately truncate apically, tegular ledge at posterior one-half of tegulum; retrolateral tibial apophysis at approximately posterior one-third of tegular ledge; body length 6 mm .... *Thyene* sp. B **[Figs. 656, 657]**

60' Abdomen with a pair of brown longitudinal slightly zigzag band enclosing a yellow median band; posterior spinnerets black basally and yellow apically; leg I similar in shape to *Thyene* sp.; tibia I shorter than combined length of metatarsus I and tarsus I; cymbium apically rounded; tegular ledge in anterior one-half of tegulum; retrolateral tibial apophysis slightly curved at midlength; body length 5.2 mm .... *Thyene inflata* (Gerstacker) **[Figs. 658, 659]**

61(58') Abdomen yellowish gray with a pair of brownish longitudinal submedian bands in anterior one-half and a series of alternating yellow and brown inverted V-stripes in posterior one-half; legs dark reddish brown except yellow tarsi; midventral spines of metatarsus I long reaching base of apical pair; pedipalp dark reddish brown except whitish yellow cymbium; retrolateral tibial apophysis shortly pointed, curved towards the broad base, tegulum strongly rounded basally and slightly truncate anteriorly; apex of cymbium broadly rounded; body length 6.5 mm ....
.... *Pachypoessa plebeja* L. Koch **[Figs. 660, 661]**

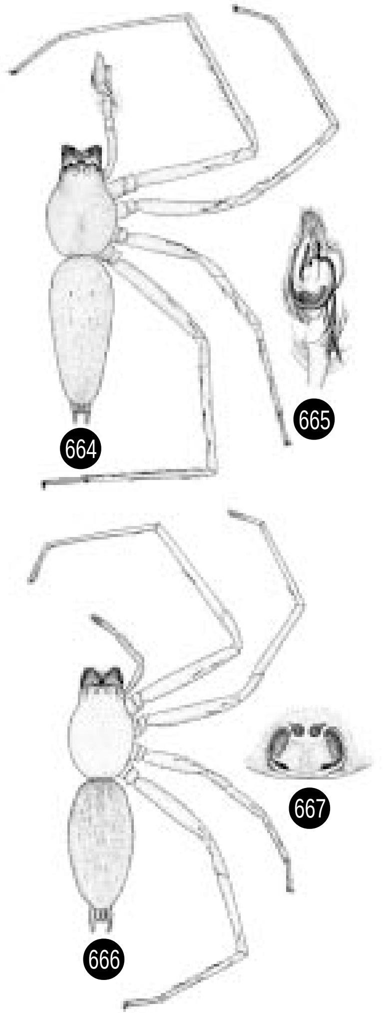
61' Abdomen brownish yellow with yellowish and broadly U-shaped transverse bands in posterior two-thirds; legs more robust than in *P. plebeja*; midventral spines of metatarsus I short not reaching apical ventral spines; cymbium whitish and narrowly rounded apically; retrolateral tibial apophysis moderately long with a sharply pointed apex; tegulum narrowly rounded basally and moderately convex anteriorly; embolus acutely pointed with a broad base; body length 8.5 mm .... *Pachypoessa* sp. **[Figs. 662, 663]**

62(53') Eyes homogenous; anterior spinnerets conical and contiguous [Families **Clubionidae** and **Corinnidae**] 63

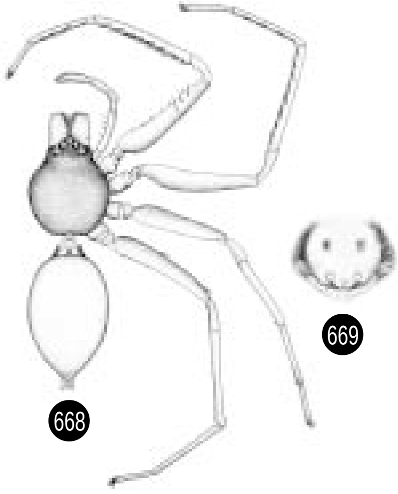
62' Eye heterogenous, anterior median eyes dark; anterior spinnerets cylindrical [Family **Gnaphosidae**] 67

63(62) Leg I longer than IV; thoracic groove absent; abdomen without a dense cluster of long curved erect hairs at the anterior end; posterior spinnerets prominently longer than the anterior pair; cymbium of male palpus with a strong basal spur; epigynum with a wide opening and spermathecae at the anterior end of the opening; body length 8–11 mm [Family **Clubionidae]** ....
....*Cheiracanthium* sp. **[Figs. 664–667]**

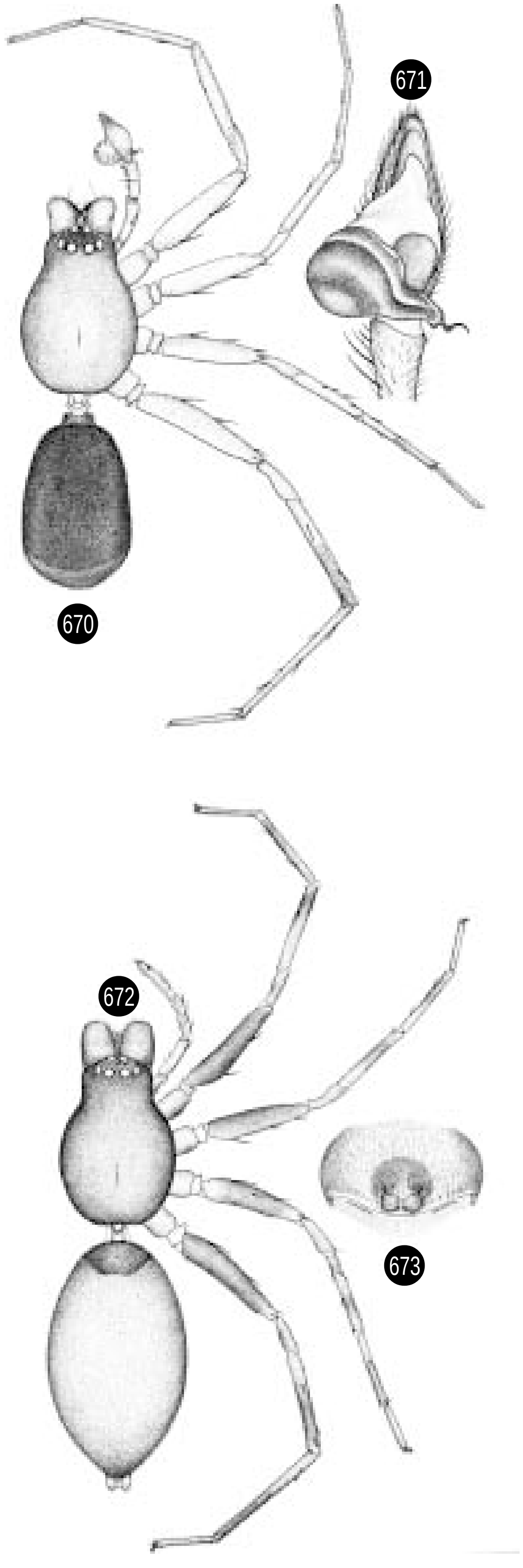
63' Leg IV longer than leg I [Family **Corinnidae]** 64



Figs. 664–667. *Cheiracanthium* sp., male dorsal view (664; 3.47X), ventral view of palp (665; 6X), female dorsal view (666; 3.26X), and epigynum (667; 16.7X).



Figs. 668–669. *Phrurotimpus* sp., female dorsal view (668; 5.52X) and epigynum (669; 20X).



Figs. 670–673. *Castianeira* sp. A, male dorsal view (670; 10.2X), ventral view of palp (671; 31.8X), female dorsal view (672; 9.3X), and epigynum (673; 17.5X).

64(63') Tibia I with 9 pairs of ventral spines and metatarsus I has 4 pairs; femur I with 3 dorsal macrosetae; legs III and IV without ventral spines; anterior median eyes large; carapace dark red similar to the pedipalps, legs, labium, maxillae, sternum, and the anteroventral scutum; epigynum with a pair of spermathecae slightly above posterior epigynal margin; body length 5.8 mm .... *Phrurotimpus* sp. **[Figs. 668, 669]**

64' Not as above, commonly with a notch in trochanter IV in distal margin; anterior end of abdomen without long curved erect hairs.......................... 65

65(64') Dorsal dark reddish brown scutum of abdomen almost entire; carapace pale reddish brown with thoracic area slightly higher than the cephalic; legs yellowish brown except reddish brown apical one-half of tibia IV; tibia I with 2 pairs of ventral spines; cymbium as long as combined length of femur and patella, apex slightly curved downwards or scoop-like with 5 spines; double coiled embolus short; female similar to male except for a very narrow anterodorsal scutum; reddish apical one-half of tibiae and metatarsi; epigynum with the copulatory openings between spermathecae.. *Castianeira* sp. A **[Figs. 670–673]**

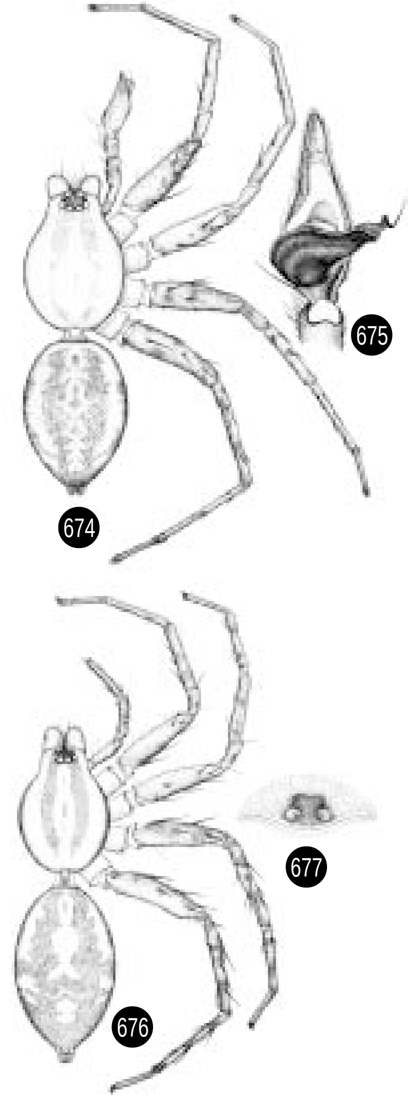
65' Not as above; abdominal marks distinct 66

66(65') Abdominal markings longitudinal and carapace bands parallel to each other; legs with numerous gray spots usually at bases of spines in the femora; embolus thin, twisted twice and rest in a relatively long apical chamber of the cymbium; epigynum simple with a pair of single-coiled copulatory openings; body length 6.5–7.2 mm ....*Castianeira* sp. B **[Figs. 674–677]**

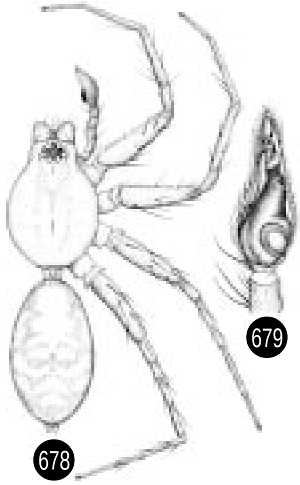
66' Abdominal markings longitudinal in apical one-half and transverse in posterior one-half; legs with slight gray markings; bases of femoral spines unmarked; apex of cymbium with a short receptable for the moderately thick embolus; body length 6.8 mm ....*Castianeira* sp. C **[Figs. 678, 679]**

67(62') Carapace and legs uniformly black; abdomen grayish with a black V-band anterodorsally; posterior median eyes oblique towards each other; embolus transverse on the anterior of the tegulum; body length 5.8 mm... *Zelotes* sp. **[Figs. 680, 681]**

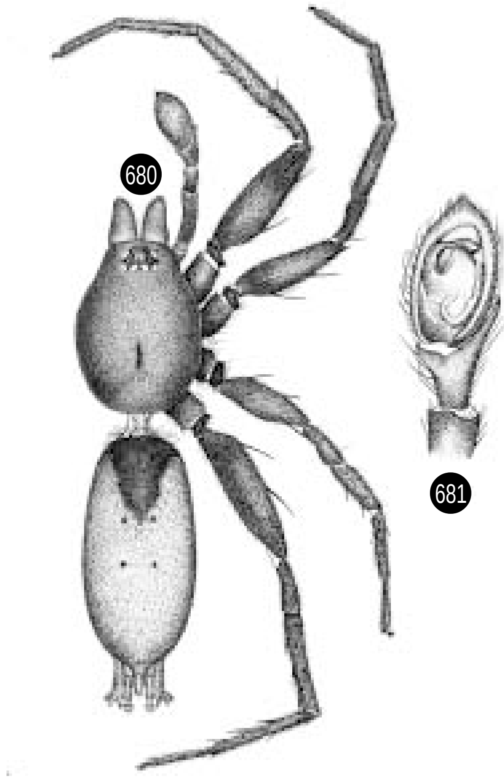
67' Carapace yellowish brown with a mat of grayish stripes becoming a network towards the posterior eyes; abdomen uniformly gray; posterior median eyes oblique diverging anteriorly; epigynum with a V-shape opening and a pair of dangling bell-like spermathecae towards the posterior epigynal margin; body length 5 mm...*Setaphis* sp. **[Figs. 682, 683]**



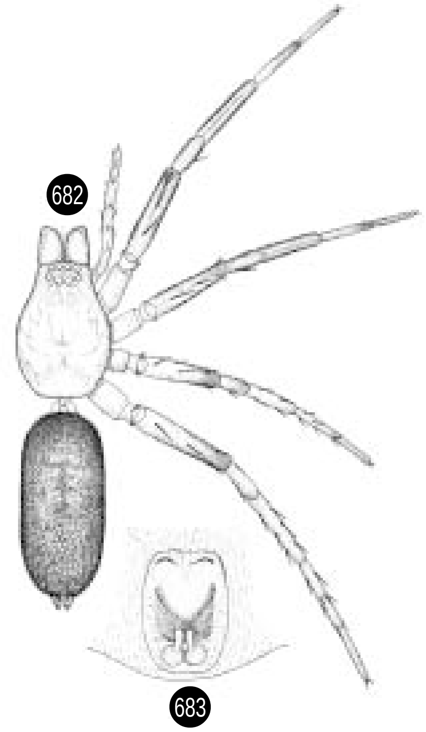
Figs. 674–677. *Castianeira* sp. B, male dorsal view (674; 6X), ventral view of palp (675; 17.3X), female dorsal view (676; 5.83X), and epigynum (677; 33X).



Figs. 678–679. *Castianeira* sp. C, male dorsal view (678; 5.59X) and ventral view of palp (679; 11.2X).



Figs. 680–681. *Zelotes* sp., male dorsal view (680; 9.66X) and ventral view of palp (681; 26.9X).



Figs. 682–683. *Setaphis* sp., female dorsal view (682; 8.8X) and epigynum (683; 32X).

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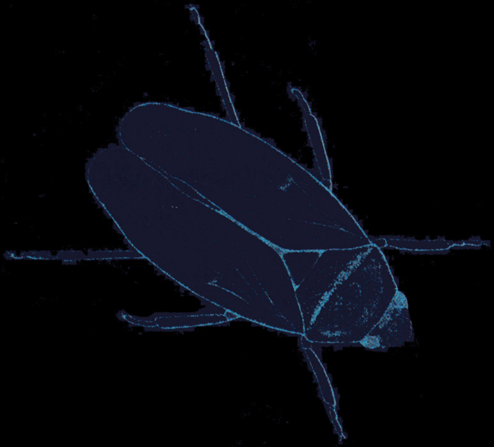

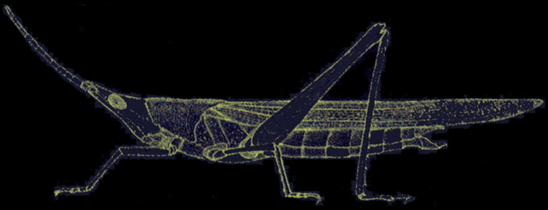

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