The parasitoids of the African white rice borer, *Maliarpha separatella* Ragonot (Lepidoptera: Pyralidae)

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Abstract

A key is provided for the recognition of the hymenopterous parasitoids of the African white rice borer, *Maliarpha separatella* Ragonot, a pest of rice in Africa and Madagascar. Five species are described as new: Braconidae: *Chelonus maudae* Huddleston, *Rhaconotus carinatus* Polaszek; Ichneumonidae: *Pristomerus bullis* Fitton, *Pristomerus caris* Fitton, *Venturia jordanae* Fitton. The following synonyms are proposed: *Goniozus indicus* Muesebeck, *G. natalensis* Gordh and *G. procerae* Risbec are synonymized with *Goniozus indicus* Ashmead. *Phanerotoma major* Brues is synonymized with *Phanerotoma saussurei* Kohl. Lectotypes are designated for *Goniozus procerae* Risbec, *Rhaconotus scirpophagae* Wilkinson and *Garouella ovicida* Risbec. The known distributions, biologies and alternative hosts of each parasitoid are provided, and their use as biological control agents or components of integrated pest management programmes are discussed.

Introduction

Maliarpha separatella Ragonot, commonly called the African white rice borer, is known almost exclusively as a pest of cultivated rice (*Oryza sativa* and *O. glaberrima*). It also occurs on the wild rices *O. longistaminata* and *O. punctata* (Brenière *et al.*, 1962). Apart from *Oryza* spp. it has been reported only from the wild grasses *Andropogon tectorum* and *Echinochloa holubii* (Anon., 1970, 1977).

Maliarpha separatella is distributed throughout sub-saharan Africa and Madagascar, and published records from outside these regions (Martin, 1958; CIE, 1970; Sandhu

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& Chander, 1975, Li, 1985) are of doubtful validity. However, there remain several problems concerning the genus *Maliarpha*. Taxonomic studies show that in West Africa two *Maliarpha* spp. may be present, the pan-African (and Madagascan) *M. separatella*, and a second species, possibly undescribed. The possible existence of a second *Maliarpha* sp. in West Africa was suggested by Viette (in Etienne, 1977), more recently by M. Shaffer (pers. comm.), and by studies of sex pheromones (Cork *et al.*, 1991). The most recent taxonomic treatment of *Maliarpha* by Martin (1958) is rather cursory and needs careful reassessment in order to establish exactly which species are present, their status and distribution. The biology and ecology of *M. separatella* have been thoroughly reviewed by Brenière *et al* (1962), Appert (1970), Pollet (1981), Ho *et al.* (1983) and Bianchi *et al.* (1990). It is unlikely that any of these studies concern a species other than *M. separatella* itself.

The impact of *M. separatella* on rice yield is difficult to assess because damage to the plant only rarely results in the appearance of 'dead hearts' or 'white heads', which are the most apparent signs of damage by other stem-boring species. Some assessments of yield loss have been undertaken (Pollet, 1981; Ho *et al.*, 1983; Akinsola, 1984; Ho, 1986; Anon., 1989; Baumgärtner *et al.*, 1990; Bianchi *et al.*, in press), but remain neglected for most African and Madagascan rice agroecosystems. As a major pest *M. separatella* is therefore something of a borderline case, but its importance may increase with the intensification of rice production. Control using chemical insecticides has been thoroughly investigated, but is not widely practised because of the high costs involved (Akinsola & Agyen-Sampong, 1984). Alternative methods are currently being developed, and biological control represents the most economically efficient and ecologically least harmful prevention method.

Biological control of rice stem borers through the introduction of exotic parasitoids has been attempted previously in Madagascar (Appert *et al.*, 1969; Appert, 1970, 1971; Anon., 1975) and Senegal (Roudeillac, 1972, Vercambre, 1977a), as well as in several parts of Asia. In Madagascar parasitoids were usually introduced either from East Africa or from India with the primary intention of controlling stem borers in sugarcane or maize monocultures (Appert *et al.*, 1969; Betbeder-Matibet, 1971). In most cases field testing and release of parasitoids against *M. separatella* were carried out incidentally during other biological control projects, and with natural enemies that probably were not well adapted to *M. separatella*. Often, species were used which had never been reared from *M. separatella*, either from the field or in the laboratory.

Until now there has been no thorough investigation of the natural enemy complex of *M. separatella*. In order to attempt to fill this gap a new research programme was initiated to complete previous surveys in different African and Madagascan rice agroecosystems (Bousses & Rahalivavololona, 1990; Bianchi *et al.*, 1991). These surveys have revealed a large complex of parasitoids associated with this pest, and in order to facilitate correct identification of these parasitoids, and to provide access to information concerning their biology, the current study was initiated.

Methods

Field work was conducted in Cameroon, Ivory Coast, Kenya, Madagascar, Senegal and Tanzania. Wherever possible, upland, irrigated and flooded rice ecosystems were investigated. Rice stems were collected and dissected for larvae or pupae of *M separatella* and egg masses were collected from leaves Parasitoids were reared by placing the excised part of the plant containing the apparently parasitized borer larva, pupa or eggs in a small plastic vial kept at 25°C. After parasitoid emergence head capsules of host larvae were examined to confirm the host's identity. Egg masses of *M. separatella* are distinctive and easily recognizable, even when parasitized (Brenière *et al.*, 1969, figs 12–14).

The most important previous surveys of *M. separatella* parasitoids were carried out in Ghana (Scheibelreiter, 1972; Agyen-Sampong, 1977) Ivory Coast (Pollet, 1981), Madagascar (Appert, 1973), Senegal (Roudeillac, 1972; Etienne, 1987) and Sierra Leone (Jordan, 1966; Agyen-Sampong, 1980), and a largely successful attempt was made to retrieve all voucher specimens from these surveys. Reared specimens from various insect collections in Europe and Africa were also examined, and this resulted in the discovery that many published records of parasitoids have been based on misidentifications. Six species, belonging to different genera, examined during the current survey were each represented by between one and three specimens only. Positive identification of these as either previously described species or species new to science was not possible, and they have therefore each been designated 'species A' Material examined is listed only for species newly described and those designated 'species A'. For previously described species it can be assumed that all material currently present in the collections of the BMNH, MNHN and WAU has been examined. Specimens of *all* the species in this study are deposited in the collections of The Natural History Museum, London, UK. All abbreviations can be found under Acknowledgments.

Unpublished reports cited in this paper are deposited in the library of the Department of Entomology, Wageningen Agricultural University, The Netherlands.

Key to the parasitoids of *M. separatella*, males and females

The following key is designed to be used for specimens examined with a stereo binocular ('dissecting') microscope at magnifications of up to at least ×60 For the correct identification of some species it is necessary to make slide preparations of certain parts of the body for subsequent examination with a compound microscope at higher magnifications. The range of morphological diversity of *M. separatella* parasitoids extends from relatively large species (up to 10 mm), such as some Ichneumonidae, down to Trichogrammatidae (less than 1 mm), and includes groups from the section Aculeata (Bethylidae) and Parasitica (remaining families). For specimen preparation and morphological terminology the user is therefore referred to Gauld & Bolton (1988) or Borror *et al.* (1989).

This key is designed *exclusively* for the identification of specimens which are known to have been reared from *M. separatella*. Many of the genera mentioned in this study contain groups of closely related species which attack stem borer pests in Africa and Madagascar. Some of these species attack hosts whose ecology may be very similar to that of *M. separatella*, but are not, as yet, known from *M separatella*. For this reason it is important that the host is correctly

Table 1 Checklist of *Maliarpha separatella* parasitoids

Genus/species	Family	Subfamily	Page reference
Amauromorpha sp. A	Ichneumonidae	Phygadeuontinae	p 84
Bracon testaceorufatus	Braconidae	Braconinae	p 77
Chelonus maudae	Braconidae	Cheloninae	p 78
Cotesia ruficrus	Braconidae	Microgastrinae	p 80
Elasmus sp. A	Elasmidae		p 81
Eurytoma oryzivora	Eurytomidae	Eurytominae	p 82
Goniozus indicus	Bethylidae	Bethylinae	p 68
Lathromeris ovicida	Trichogrammatidae		p 85
Macroneura sp A	Eupelmidae		p 82
Mesobraconoides psolopterus	Braconidae	Braconinae	p 78
Norbanus sp. A	Pteromalidae	Pteromalinae	p 84
Phanerotoma saussurei	Braconidae	Cheloninae	p 79
Pristomerus africator	Ichneumonidae	Cremastinae	p 83
Pristomerus bullis	Ichneumonidae	Cremastinae	p 83
Pristomerus caris	Ichneumonidae	Cremastinae	p 83
Psilochalcis soudanensis	Chalcididae		p 81
Rhaconotus carinatus	Braconidae	Doryctinae	p 79
Rhaconotus scirpophagae	Braconidae	Doryctinae	p 80
Telenomus bini	Scelionidae	Telenominae	p 85
Temelucha sp. A	Ichneumonidae	Cremastinae	p 83
Tetrastichomyia sp. A	Eulophidae	Tetrastichinae	p 81
Tropobracon antennatus	Braconidae	Braconinae	p 78
Vadonina ?nimbipennis	Ichneumonidae	Phygadeuontinae	p 84
Venturia jordanae	Ichneumonidae	Campopleginae	p 82

identified. Reference to the diagnosis or description contained in each species treatment is essential. It is hoped that the authors have succeeded in excluding the possibility of misidentifications by providing diagnoses for previously described species and complete descriptions for new species. In doubtful cases, specimens may be sent to the first author for checking.

In addition to the species known to have been reared from *M. separatella*, two additional species have been included in the key for reasons given below: Ceraphronidae· *Aphanogmus fijiensis* (Ferrière) and Ichneumonidae: Pimplinae *Itoplectis naranyae* (Ashmead).

1. Fore wing without closed cells, or brachypterous (figs 11–14) 2
- Fore wing with at least one closed cell (figs 15–17, 33, 34, 44–46, 65) 11
2. Tarsi 3-segmented; antennae with fewer than 8 segments (excluding anelli, fig. 10). Fore wing as in fig. 11 .... *Lathromeris ovicida*
- Tarsi 4- or 5-segmented; antennae with more than 8 segments 3
3. Pronotum reaching tegulae (fig. 1); prepectus (see fig. 2) absent 4
- Pronotum not reaching tegulae, prepectus present between pronotum and tegula (fig. 2) 5
4. Stigmal vein distinctly curved, fore wing venation as in fig. 12 (hyperparasitoids, emerging from coccoons) .... *Aphanogmus fijiensis*
- Fore wing venation different, stigmal vein straight (fig. 13); (egg parasitoids) .... *Telenomus bini*
5. Tarsi 4-segmented 6
- Tarsi 5-segmented 7
6. Hind coxa greatly expanded and flattened (fig. 3) .... *Elasmus* sp. A
- Hind coxa not greatly expanded and flattened .... *Tetrastichomyia* sp. A
7. Hind femur greatly expanded and toothed (fig. 4) .... *Psilochalcis soudanensis*
- Hind femur not greatly expanded or toothed 8
8. Mesopleuron forming a strongly convex shield (fig. 5), brachypterous species .... *Macroneura* sp. A (♀♀)
- Mesopleuron different 9
9. Pronotom rectangular in dorsal view, with coarse punctures (fig. 6) .... *Eurytoma oryzivora*
- Pronotum different 10
10. Notauli incomplete (fig. 8). Antenna 12-segmented (♀), consisting of scape, pedicel, 2 small ring segments, a 6-segmented funicle and a rather obscurely 2-segmented club with a point (fig. 9), ♂ unknown, antennae may be 12- or 13-segmented .... *Norbanus* sp. A
- Notauli complete. Antenna 12-segmented, consisting of scape, pedicel, a single ring segment, 6-segmented funicle and three segmented club without a point .... *Macroneura* sp. A ♂♂
11. Hind wing without veins, fore wing venation as in fig. 15; propodeum as in fig. 81 .... *Goniozus indicus*
- Hind wing with veins, fore wing venation and propodeum different 12
12. Fore wing with a single recurrent vein (that is, 2m-cu absent; figs 16, 17, 33) first cubital cell almost always separated from the discoidal cell by a vein (Braconidae, except *Chelonus*, fig. 34) 13
- Fore wing with two recurrent veins (that is, 2m-cu present; figs 44–46, 65); first cubital cell always fused with the discoidal cell (Ichneumonidae) 20
13. Hypoclypeal depression present, deep and wide (fig. 24) 14
- Hypoclypeal depression absent 18
14. Posterior flange of propleuron absent; first metasomal tergite coarsely rugose (figs 19, 21). Fore tibia without a row of pegs or thick spines.. 15

- Posterior flange of propleuron present (figs 28, 31); first metasomal tergite longitudinally striate (figs 29, 32) Fore tibia with a row of pegs or thick spines 17

15. Wings strongly infumate (darkened) .... *Mesobraconoides psolopterus*
- Wings largely hyaline (clear) 16

16 Mesosoma entirely orange. Antennae elongate, about 1.25× the body length (excluding ovipositor). Mesoscutum with fine, reticulate sculpture (fig. 20) .... *Tropobracon antennatus*
- Mesosoma with some brown or black markings. Antennae shorter, about equal to, or less than, the body length (excluding ovipositor). Mesoscutum smooth, shining (fig. 18) .... *Bracon testaceorufatus*

17. Pterostigma uniformly pale (fig. 16). Head and mesosoma with dense setae (figs 25, 27, 28) .... *Rhaconotus scirpophagae*
- Pterostigma dark (fig. 17) at least in its anterior half. Head and mesosoma less densely setose (figs 26, 30, 31) .... *Rhaconotus carinatus*

18. Tergites 1–3 of metasoma immovably joined (figs 23, 35) and forming a carapace. Vein SR1 present and enclosing a marginal cell (fig. 34) 19
- Tergites 1–3 of metasoma articulating, not forming a carapace. Vein SR1 absent, and fore wing venation as in fig. 33 .... *Cotesia ruficrus*

19. Body entirely yellow. Tergites of metasoma clearly distinguishable (fig. 23) .... *Phanerotoma saussurei*
- Body largely dark. Metasoma forming an undivided carapace .... *Chelonus maudae*

20. Segment 1 of the metasoma rather wide, with the spiracles on the anterior half (fig. 39). Edge of eye strongly indented opposite antennal socket (fig. 38) .... *Itoplectis naranyae*
- Segment 1 of the metasoma more slender (fig. 40), with the spiracles on the posterior half (fig. 42). Edge of eye at most only weakly sinuate opposite antennal socket (fig. 41) 21

21. Fore wing with pterostigma long and slender (fig. 44–46). Tergite 2 of metasoma granulate or punctate 22
- Fore wing with pterostigma broad and triangular (fig. 65). Tergite 2 of metasoma very finely, longitudinally aciculate (figs 73–75) 24

22. Clypeus not distinctly separated from face, the two together forming a continuous, weakly convex surface (fig. 66). Fore wing with areolet (absent in a few aberrant specimens) petiolate (2rs-m and 3rs-m arising together from Rs) (fig. 44) .... *Venturia jordanae*
- Clypeus separated from face, clypeus and face each forming a distinct, curved surface (figs 67, 68). Fore wing with areolet present and almost quadrate (the sections of Rs and M between 2rs-m and 3rs-m almost equal in length) (fig. 46) or areolet absent (fig. 45) 23

23. Fore wing with areolet present, although 3rs-m weakly or not pigmented (fig. 46). Frons with a differentiated trans-striate area above the antennal socket (fig. 67) .... *Vadonina ?nimbipennis*
- Fore wing with areolet absent (fig. 45), although the position which 3rs-m would occupy may be indicated by the configuration of Rs and M. Frons without a differentiated area (although it is less punctate) above the antennal sockets (fig. 68) .... *Amauromorpha* sp. A

24. Tergite 2 of metasoma without thyridia. Hind femur of males and females without a tooth on the ventral surface .... *Temelucha* sp A
- Tergite 2 of metasoma with thyridia (figs 73–75). Hind femur of males, but not of all females with a distinct tooth on the ventral surface (figs 62–64) 25

25. Eyes larger in proportion to size of head: face narrower (male fig. 49, female fig. 50), gena (in lateral view) narrower (male fig. 58, female fig. 55). Male with ocelli not quite touching eyes (fig. 60). Female with hind femur lacking a distinct tooth on ventral surface (fig. 61) .... *Pristomerus caris*
- Eyes smaller in proportion to size of head: face wider (male figs 47, 48, female figs 51, 52), gena (in lateral view) wider (male figs 56, 57, female figs 53, 54). Male with ocelli separated from eyes by more than 0.6 of their diameter (fig. 59). Female with hind femur with a distinct tooth on ventral surface (fig. 62) 26

26. Clypeus wider and less convex (male fig. 47, female fig. 51). Female with ovipositor shorter, less than 1.9 (the visible portion 1.3) times as long as the hind tibia. Male with hind femur stouter (fig. 63) [East Africa] .... *Pristomerus bullis*
- Clypeus narrower and more convex (male fig. 48, female fig. 52). Female with ovipositor longer, more than 2.3 (the visible portion 1.4) times as long as the hind tibia. Male with hind femur more slender (fig. 64) [West Africa] .... *Pristomerus africator*

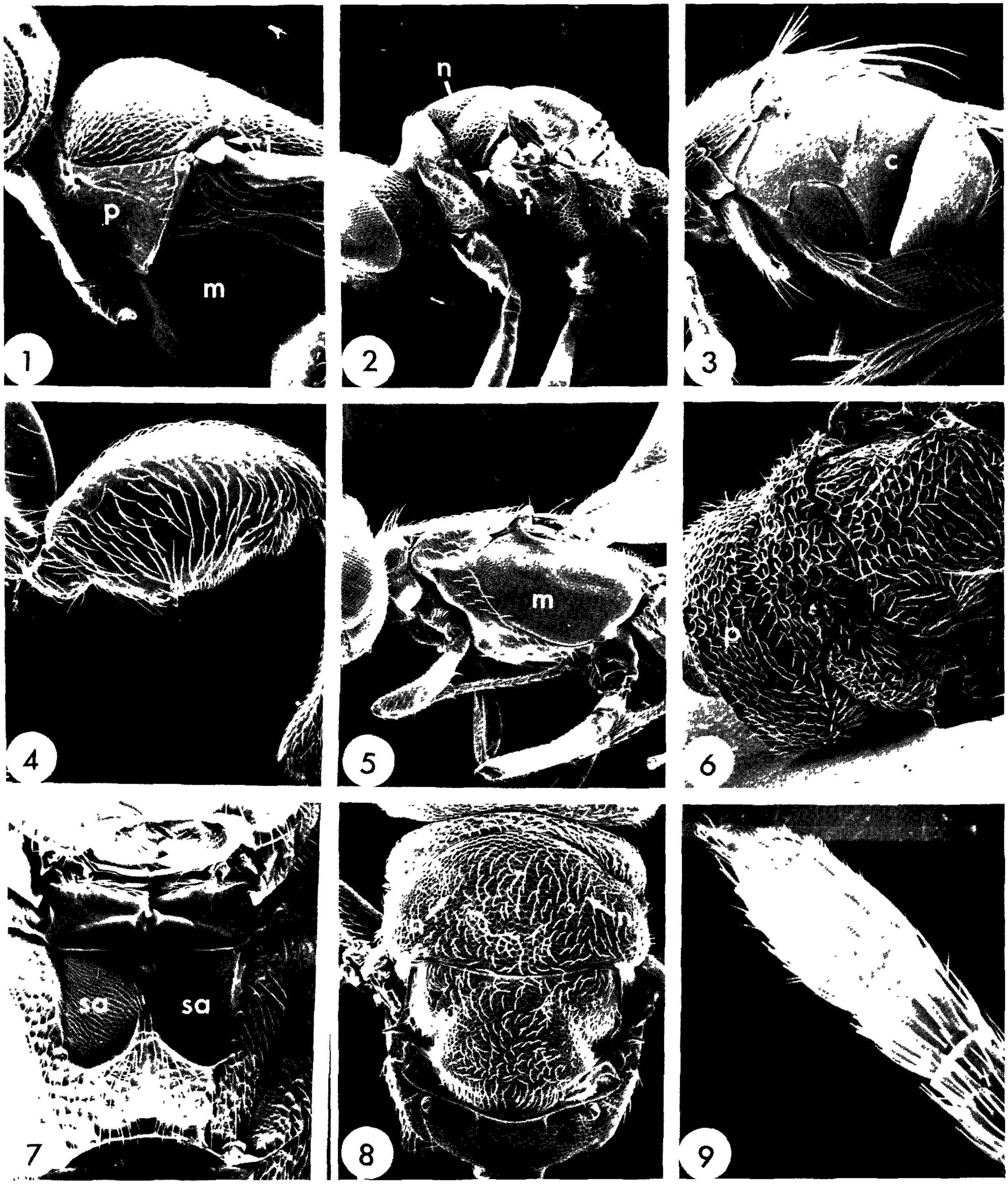
BETHYLIDAE

Goniozus indicus Ashmead

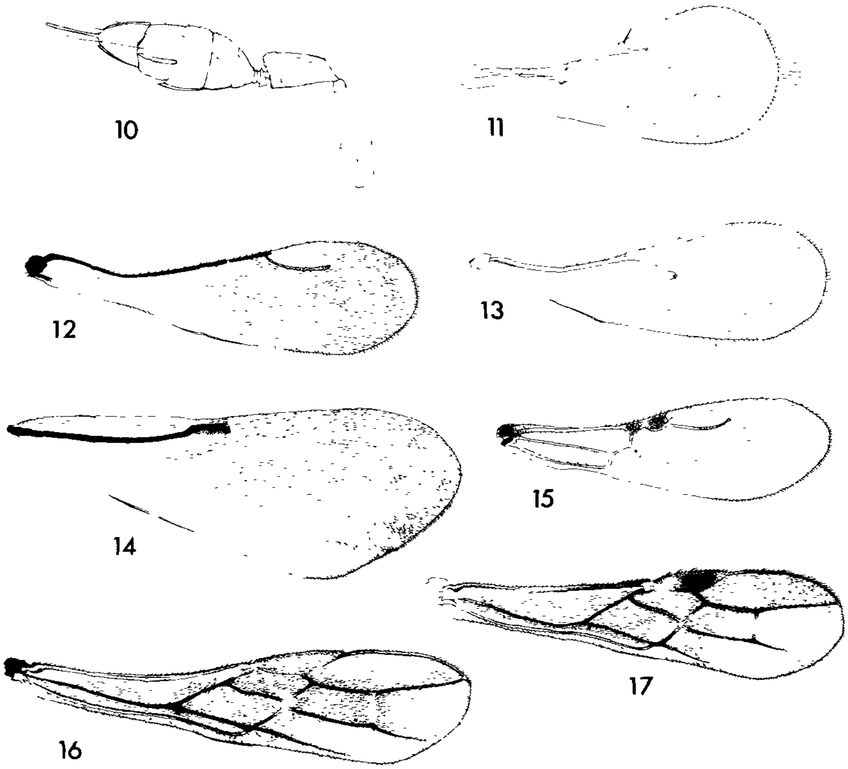
(figs 15, 78, 79, 81)

Goniozus indicus Ashmead, 1903: 2 Holotype ♀, India Calcutta [*ex Scirpophaga*] (USNM) [examined].
Goniozus indicus Muesebeck, 1940· 121. Holotype ♀, INDIA. Coimbatore V.26 36 (P. Israel) *ex Scirpophaga* on sugarcane (USNM) [examined] **syn. nov.**
Goniozus procerae Risbec, 1956b. 157 Lectotype ♀ (here designated), [CAMEROON] Garoua (Descamps 173) (MNHN) [examined] **syn. nov.**
Goniozus natalensis Gordh, 1986: 257 Holotype ♀, SOUTH AFRICA: Natal, Ngwavuma 20.xi 1982 (H. Hastings) *ex Eldana saccharina* (PPRI) [holotype not examined; paratypes examined] **syn. nov.**
Goniozus sp Descamps, 1956, Harris, 1962, Jordan, 1966, Appert, 1973; Agyen-Sampong, 1980; Agyen-Sampong & Fannah, 1987

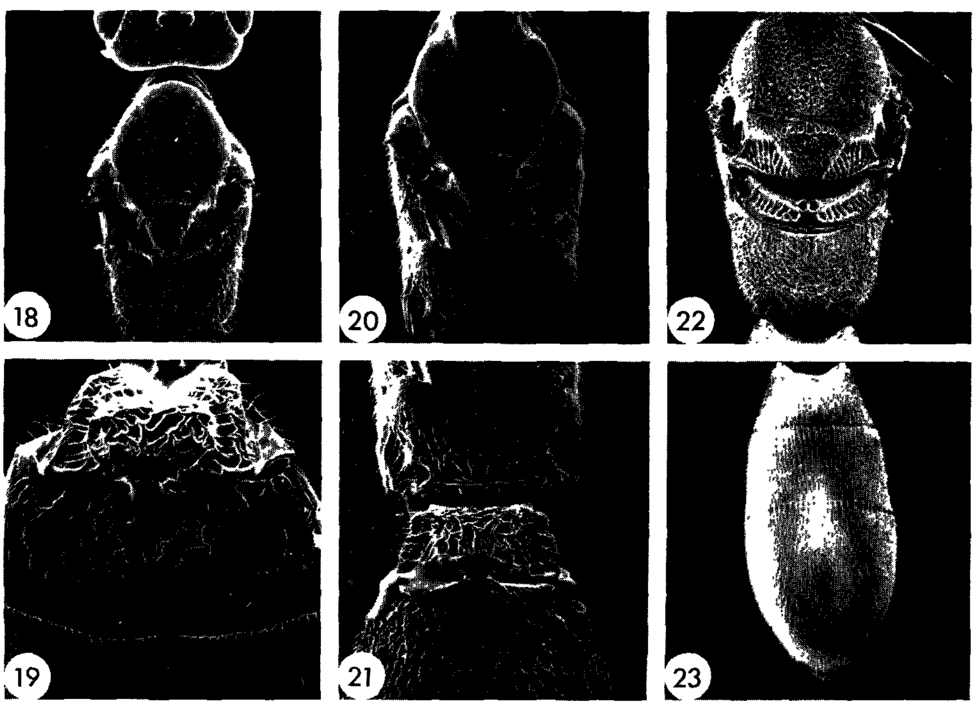
Diagnosis. Length 3.0–6.0 mm Entirely chestnut brown to black, with the following usually paler· antennae, all tibiae and tarsi, fore femora. Head prognathous as in all Bethylidae, body appreciably dorso-ventrally flattened. Head (♀) in dorsal view elongate, distance from the hind margin of the eyes to the posterior end of the head slightly greater than the maximum length of the eyes Ocelli forming an approximately equilateral triangle, separated from the posterior end of the head by about the maximum length of the ocellar triangle Clypeus evenly rounded, not pointed or truncate Sculpture of the head and body smooth, shining, with a few shallow punctures Fore femora enlarged. Fore wing typical for the genus (fig. 15), with both pterostigma and prostigma present, without a closed areolet Propodeum without any trace of a transverse carina separating the dorsal (horizontal) surface from the posterior (vertical) surface; with fine, reticulate sculpture apart from



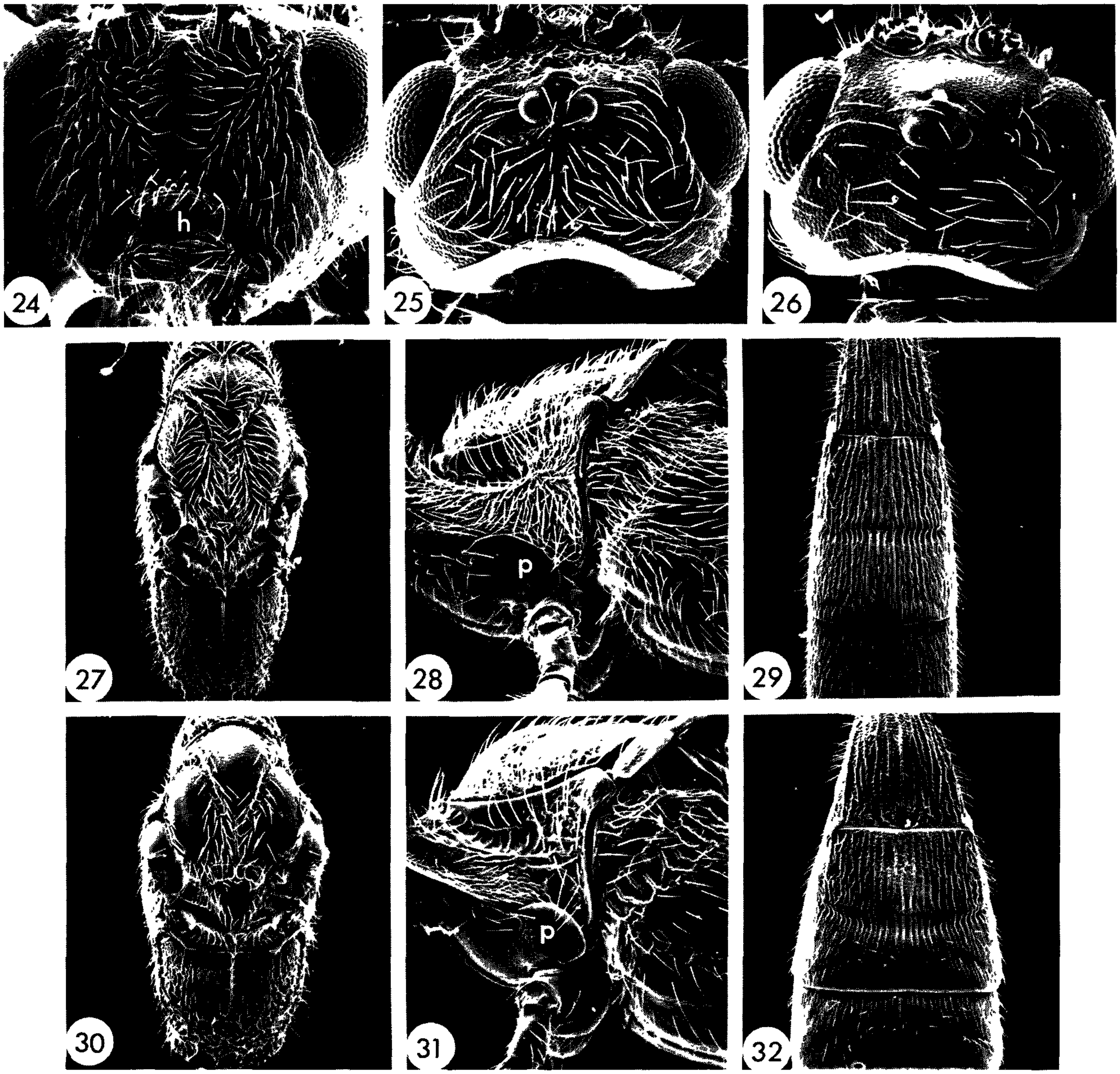
Figs 1–9. 1, *Aphanogmus fijiensis* mesosoma, lateral (m=mesopleuron, p=pronotum, t=tegula); 2, chalcidoid mesosoma, lateral (p=prontotum, t=tegula); 3, *Elasmus* sp. mesosoma, lateral (c=hind coxa); 4, *Psilochalcis sodanensis* hind femur; 5, eupelmid (♀) mesosoma, lateral (m=mesopleuron); 6, *Eurytoma oryzivora* mesosoma, dorsal (p=pronotum); 7, *E. oryzivora* mesosoma, ventral (sa=subpleural area); 8, *Norbanus* sp mesosoma, dorsal (n=notauli); 9, *Norbanus* sp (♀) antennal club



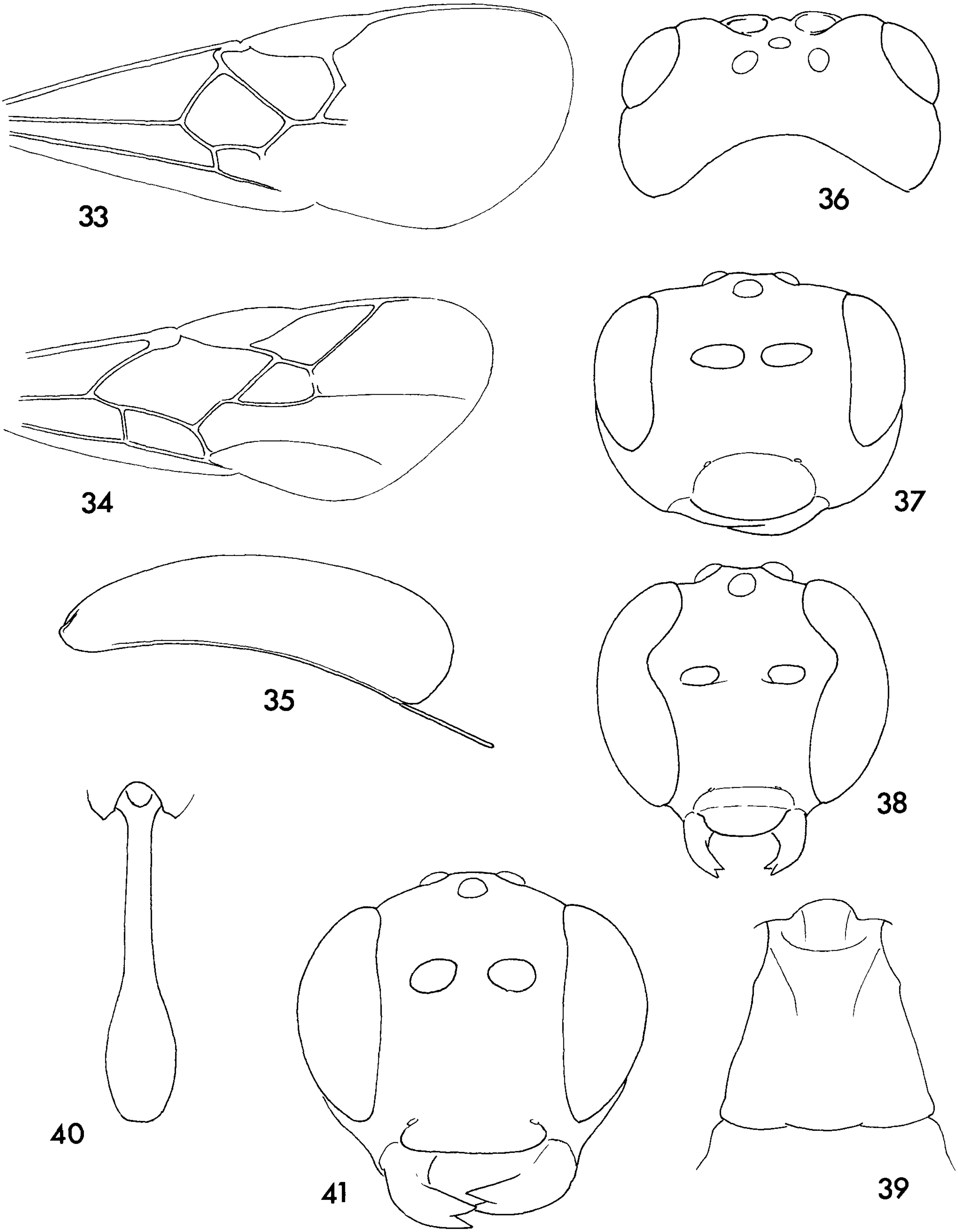
Figs 10–17. 10, *Lathromeris ovicida* antenna; 11, *L ovicida* fore wing; 12, *Aphanogmus fijiensis* fore wing; 13, *Telenomus bini* fore wing; 14, *Psilochalcis soudanensis* fore wing; 15, *Goniozus indicus* fore wing; 16, *Rhaconotus scirpophagae* fore wing; 17, *Rhaconotus carinatus* fore wing.



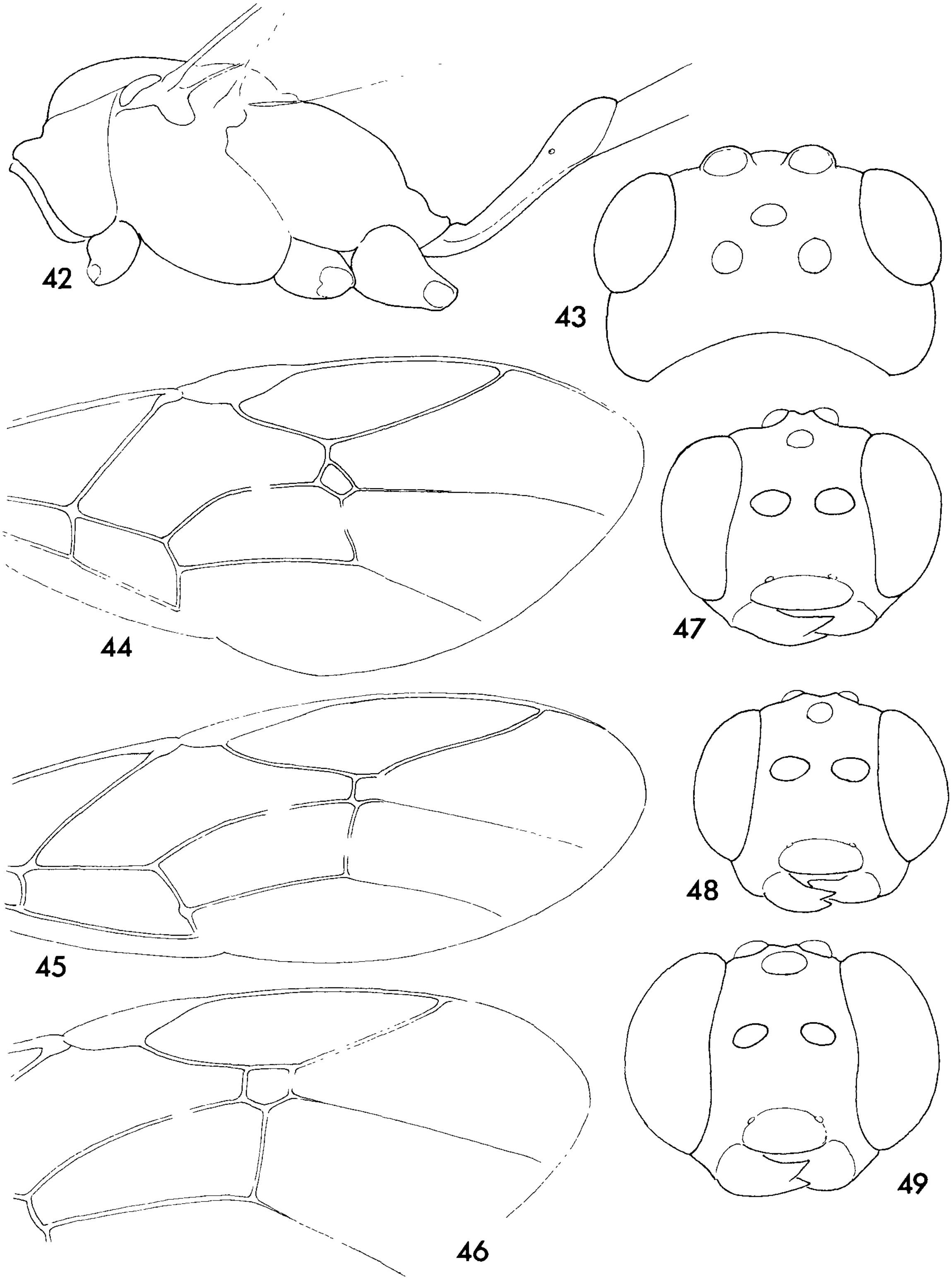
Figs 18–23. 18–19, *Bracon testaceorufatus*· 18, mesosoma, dorsal; 19, metasoma, basal tergites; 20–21, *Tropobracon antennatus*. 20, mesosoma, dorsal, 21, metasoma, basal tergites, 22–23, *Phanerotoma saussurei*· 22, mesosoma, dorsal; 23, metasoma, dorsal



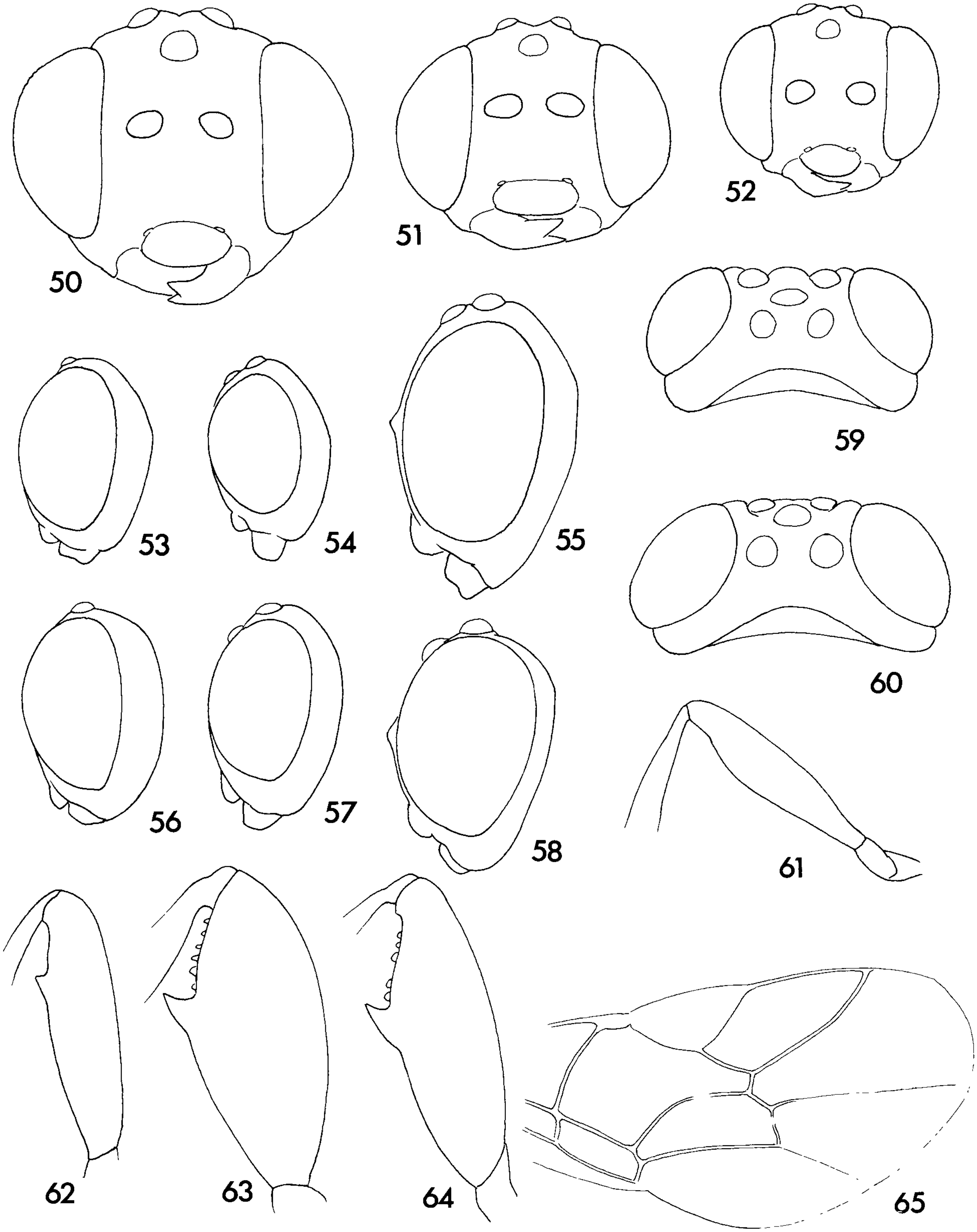
Figs 24–32. 24, *Rhaconotus* sp head, anterior (h=hypoclypeal depression), 25, *Rhaconotus scirpophagae* head, dorsal, 26, *R. carinatus* head, dorsal; 27–29, *R scirpophagae*. 27, mesosoma, dorsal, 28, mesosoma, lateral; 29, metasoma, basal tergites; 30–32, *R carinatus*. 30, mesosoma, dorsal; 31, mesosoma, lateral; 32, metasoma, basal tergites.



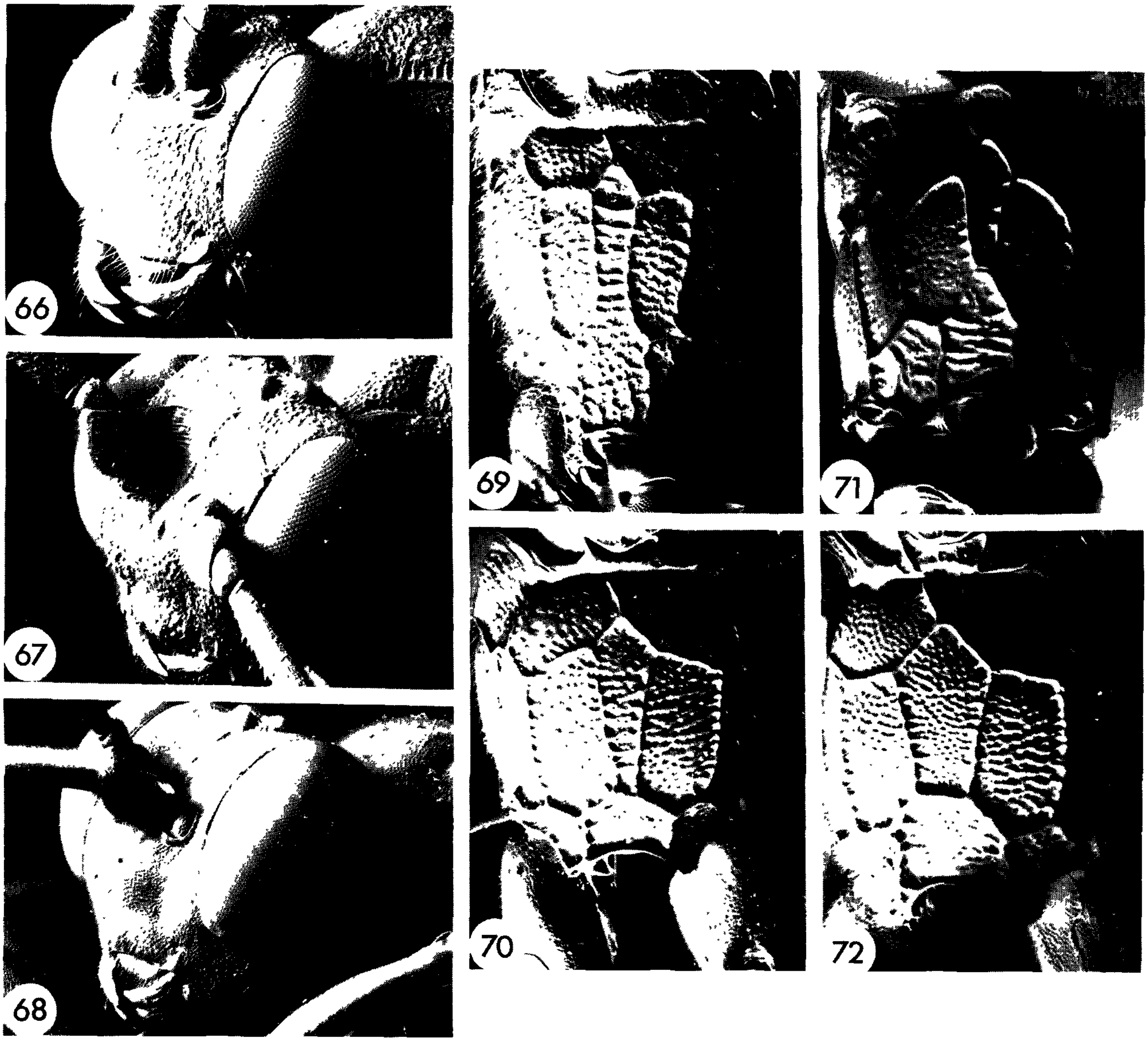
Figs 33–41. 33, *Cotesia ruficrus* fore wing; 34–37, *Chelonus maudae*: 34, fore wing; 35, metasoma, lateral; 36, head, dorsal; 37, head, anterior; 38–39, *Itoplectis naranyae*: 38, head, anterior; 39, metasoma, tergite I, 40–41, *Venturia jordanae*: 40, metasoma, tergite I, 41, head, anterior.



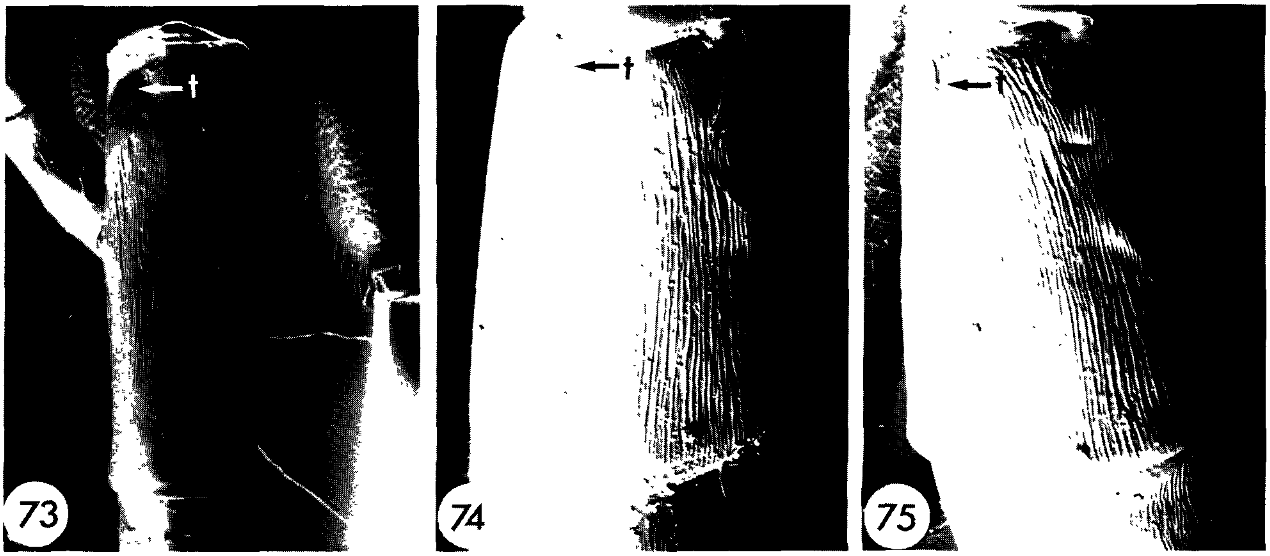
Figs 42–49. 42–44, *Venturia jordanae*: 42, mesosoma, lateral 43, head, dorsal; 44, fore wing; 45, *Amauromorpha* sp. A fore wing; 46, *Vadonina ?nimbipennis* fore wing, 47, *Pristomeris bullis* (♂) head, anterior; 48, *P. africator* (♂) head, anterior; 49, *P. caris* (♂) head, anterior.



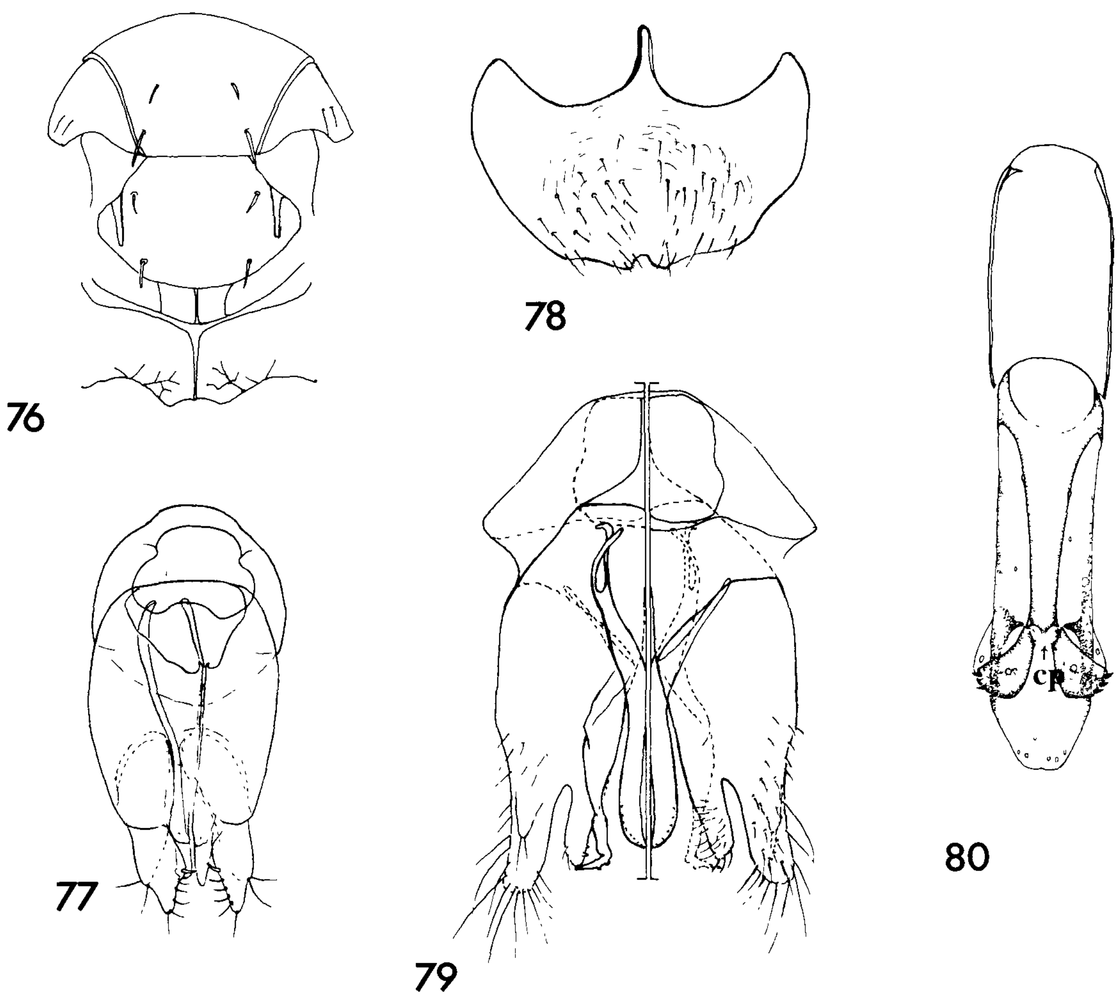
Figs 50–65. 50, *Pristomerus caris* (♀) head, anterior; 51, *P. bullis* (♀) head, anterior; 52, *P. africator* (♀) head, anterior; 53, *P bullis* (♀) head, lateral; 54, *P. africator* (♀) head, lateral, 55, *P. caris* (♀) head, lateral; 56, *P. bullis* (♂) head, lateral; 57, *P africator* (♂) head, lateral, 58, *P caris* (♂) head, lateral; 59, *P. bullis* (♂) head, dorsal, 60, *P. caris* (♂) head, dorsal; 61, *P. caris* (♀) hind femur, 62, *P. bullis* (♀) hind femur; 63, *P bullis* (♂) hind femur; 64, *P. africator* (♂) hind femur; 65, *P. caris* fore wing



Figs 66–72 66, *Venturia jordanae* head; 67, *Vadonina ? nimbipennis* head; 68, *Amauromorpha* sp A head; 69, *Venturia jordanae* propodeum; 70, *Pristomerus bullis* propodeum; 71, *P caris* propodeum; 72, *P. africator* propodeum.



Figs 73–75. 73, *Pristomerus caris* tergite 2; 74, *P. bullis* tergite 2; 75, *P. africator* tergite 2



Figs 76–80. 76, *Tetrastichomyia* sp. A mesosoma, dorsal; 77, *Aphanogmus fijiensis* (♂) genitalia (from Dessart, 1971); 78–79, *Goniozus indicus* (♂): 78, subgenital plate; 79, genitalia, 80, *Telenomus bini* (♂) genitalia.

Fig 81. *Goniozus indicus* propodeum, dorsal.

a smooth, triangular area tapering antero-posteriorly on the dorsal surface (fig. 81) Genitalia and sub genital plate of male as in figs 78, 79

Alternative hosts. Pyralidae *Chilo infuscatellus* Snellen, *C. partellus* (Swinhoe), *C. sacchariphagus* (Bojer), *C. suppressalis* (Walker) (laboratory host), *C. zacconius* Bleszynski, *Chilo* sp., *Coniesta ignefusalis* (Hampson), *Corcyra cephalonica* (Stainton) (laboratory host), *Diatraea centrella* Moeschler, *D lineolata* (Walker), *Eldana saccharina* (Walker), *Emmalocera depressella* (Swinhoe), *Scirpophaga excerptalis* (Walker), *S. incertulas* (Walker), *S nivella* (F.), *S. occidentella* (Walker), *Scirpophaga* sp. (see Biology, below).

Distribution All of sub-Saharan Africa, Mauritius and Madagascar. Asia· Bangladesh, India, Pakistan

Biology Like most *Goniozus*, a gregarious larval ectoparasitoid, usually attacking concealed larvae of Lepidoptera. Oviposition follows temporary anaesthesia, and is into the dorsum of the larva The biology of *G. indicus* (as *G procerae*) under laboratory conditions is given in detail by Ly (1976), Ndoye (1980) and Coquard (1987)

Gordh & Moczar (1990) list *Cryptophlebia carpophaga* (Walsingham) and *Cnaphalocrocis medinalis* (Guenée) among the hosts of *G. indicus* We have examined *Goniozus* specimens reared from *C. medinalis* and from *Cryptophlebia* sp., from India They are not *G indicus*, and these species seem unlikely to be (natural) hosts of *G. indicus*.

Remarks Type material of *G. indicus* Ashmead, *G. indicus* Muesebeck, *G. procerae* Risbec and *G. natalensis* Gordh was compared for this study Several hundred specimens of *G. indicus* from Africa and Asia were also examined No important differences were found, and these species are therefore here regarded as conspecific

The syntype series of *G procerae* consisted originally of 7♀ and 2♂ mounted on three microscope slides One female, on a slide with a partially dissected (by Risbec) male was clearly marked 'type' in Risbec's writing. This female has since been remounted on a card-point and is now labelled 'lectotype'. The following are now labelled as paralectotypes· the first slide previously containing the lectotype, now containing a remaining male (partially dissected); a second slide containing the genitalia of this male (used for Risbec's original figure) and two females; a third slide containing the genitalia (which are aberrant and asymmetrical) of the second male of the series, and five specimens (1♂, 4♀) mounted on two card squares. In the original description, nine females and two males were mentioned The remaining two females, if they ever existed, have not been located. Also in the original description, the hosts were mentioned as *'Adelpherupa* sp. et *Salurea* sp. (Pyralidae)' The type series is labelled (by Risbec) *'ex Proceras africana'* (=*Chilo zacconius*) No specimen was located in Risbec's collection with the names of the former genera, neither has any specimen ever been recorded from these hosts since the description. It seems highly probable that the names of these hosts were published in error.

A distinct species of *Goniozus* (*Parasierola*-group) is also widespread on lepidopterous cereal stem borers in Africa (Girling, 1977; Conlong & Graham, 1988), which Gordh (1986) suggested might be the same as *G. natalensis*. This species is known to us so far only in association with maize.

Goniozus indicus has been the subject of several studies in relation to biological control of the stem borer *E. saccharina* in South Africa (Conlong *et al.*, 1988; Graham & Conlong, 1988, as *G. natalensis*). It is also a well-known parasitoid of the millet stem borer *C. ignefusalis* in the West African Sahel (Ndoye, 1980; as *G. procerae*). *Goniozus indicus* was introduced into Madagascar (where it may well have already been present) from Senegal in 1973, for the attempted biological control of *M. separatella* (Appert, 1975), and into Réunion in 1972 (Betbeder-Matibet, 1977). *Goniozus indicus* was imported into Trinidad for the biological control of sugarcane borers in 1960. It successfully attacked two *Diatraea* species (see hosts, above), but it is not known whether it became established (Bennett, 1965).

BRACONIDAE: Braconinae

Bracon testaceorufatus Granger
(figs 18, 19)

Bracon testaceorufatus Granger, 1949· 71 Holotype ♀, MADAGASCAR. Bekily, (reg. sud de l'Ile) vii 1936 (A. Seyrig) (MNHN) [examined]. *Bracon testaceorufatus*· Brenière *et al.*, 1962; Appert, 1967, 1973, Anon, 1989.
Braconidae [sp. indet.] Tran, 1977.
Bracon quadratinotatus Granger· Bordat, 1979 (misidentification).

Diagnosis. Length 2.0–4.5 mm, excluding antennae and ovipositor sheaths. Deep orange-brown, with the following dark brown-black. antennae, stemmaticum, most of the wing venation, ovipositor sheaths, fifth tarsal segments; mesoscutum centrally, the sides varying from entirely without dark pigmentation to deeply pigmented; propodeum, first metasomal tergum, second metasomal tergum centrally and third and fourth terga broadly pigmented. Antenna (female) with 26–36 segments Head transverse, head and mesoscutum smooth and shining, notauli smooth, shallowly impressed. Propodeum coarsely sculptured, especially distally. Sculpture of first metasomal tergum, and second tergum centrally, strongly rugose (fig. 19). Male as female but habitus somewhat narrower, antennae with a few more segments and first metasomal tergum often paler than in female.

Alternative hosts. Pyralidae: *Chilo diffusilineus* (J. de Joannis), *C. zacconius*, *Chilo* sp., *Scirpophaga* sp.

Distribution. Cameroon, Côte d'Ivoire, Ghana, Kenya, Madagascar, Mali, Mauritania, Mozambique, Nigeria, Senegal, Tanzania, Uganda.

Biology. A gregarious larval ectoparasitoid (6–14 individuals per host) with an average fecundity of 25 eggs and a developmental time of 12 days. The larvae pupate within the rice stem, a few centimeters below the host's remains. Emergent adults leave the stem *via* the aperture made by the host larva. In Madagascar, at least part of the population undergoes larval diapause whereas the remainder is active throughout the year (Bianchi *et al*, 1991).

Remarks. In areas of Madagascar where this species was abundant it had no important role in regulating populations of *M. separatella* (Appert, 1967). During September and October 1989 *B testaceorufatus* was the most abundant parasitoid of *M. separatella* at Lac Alaotra, Madagascar (Anon., 1989) In Bouaké, Côte d'Ivoire, *B. testaceorufatus* was abundant on irrigated rice from May to June (Tran, 1977).

Mesobraconoides psolopterus (Wilkinson)

Mesobracon psolopterus Wilkinson, 1931: 394. Holotype ♀, SIERRA LEONE Njala, ex coffee branch borer, em. 4 xii.30 (E. Hargreaves) (BMNH) [examined].
Mesobraconoides psolopterus (Wilkinson): Sarhan & Quicke, 1990 221

Diagnosis. Length 6.0–7 0 mm. Antennae with about 55–60 flagellomeres, the median flagellomeres considerably longer than wide. Wings largely infumate, pterostigma yellow to orange, hind leg and metasoma largely orange to red.

Alternative hosts. Coleoptera Scolytidae *Xyleborus* sp.

Distribution Nigeria, Sierra Leone.

Biology Unknown, probably an ectoparasitoid, attacking the final larval instar of the host (Sarhan & Quicke, 1990).

Remarks The inclusion of this species is based on two published records of its attacking *M. separatella* in Sierra Leone (Sarhan & Quicke, 1990) No material reared from *M. separatella* was examined during the present study.

Tropobracon antennatus (Granger)
(figs 20, 21)

Habrobracon triangularis Szépligeti, 1911 405. Holotype ♀ [Kenya] Mombasa (Hildebrandt) (HMB) [examined].
Bracon antennatus Granger, 1949· 61. Replacement name for *H. triangularis* Szépligeti.
Tropobracon antennatus (Granger) Etienne, 1987
Habrobracon sp.. Risbec, 1950.
Mesobracon sp.: Ingram, 1958.
Shirakia sp.: Appert, 1973, Badawy, 1967, Jordan, 1966.

Diagnosis. Length 2.5–6 5 mm (excluding antennae and ovipositor sheaths). Body entirely deep orange except the following dark areas· antennae, stemmaticum, claws and base of fifth tarsal segment, ovipositor. Occasionally the triangle on T2 bordered with dark pigmentation which extends to a median longitudinal stripe the length of the metasoma. Pterostigma uniformly pale brown. Antenna with 50–65 segments Sculpture of mesosoma as in figure 20, mesoscutum with evident reticulate sculpture. Dorsally visible part of ovipositor+sheaths about half the length of the metasoma Male as female except for genitalic characters and the following. habitus narrower than in female and triangle on T2 usually complete at its apex.

Alternative hosts. Diptera: ?*Diopsis curva* Bertolini (Risbec, 1956a) Noctuidae: *Sesamia cretica* Lederer, *Sesamia* sp.; Pyralidae *Chilo zacconius*, *Chilo* sp.; *Coniesta ignefusalis*; *Scirpophaga* sp.

Distribution. Cameroon, Côte d'Ivoire, Kenya, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Togo, Uganda.

Biology. A gregarious larval parasitoid, *T. antennatus* is also known from stem borers of millet and wheat According to Jordan (1966) this species makes a small cocoon inside the stem on which its host has been feeding, usually an inch or so above the host's remains. The host record from Diptera. Diopsidae requires confirmation.

Remarks Three other closely related species of *Tropobracon* are known to attack lepidopterous cereal stem borers in the Palaeotropics. *Tropobracon antennatus* can be most easily distinguished from these by the reticulate sculpture of the mesoscutum (fig. 20). A key to *Tropobracon* spp. is provided by van Achterberg (1993).

In Madagascar, this species is uncommon on *M separatella* or other rice borers (P Bousses, pers comm.)

BRACONIDAE: Cheloninae

Chelonus maudae Huddleston *sp. n.*
(figs 34–37)

Description. Length 6–8 mm. Female· antenna with 28–29 segments, filiform; basal flagellar segment at least 3× as long as broad, each succeeding segment slightly shorter. Head strongly rounded behind eyes (fig. 36) Eye slightly longer than temple in dorsal view Frons strongly depressed behind antennae, coarsely rugose, sometimes reticulate. Vertex coarsely reticulate-rugose at sides but with strong transverse rugae medially, behind ocelli Ocelli moderately large, OO=2.0–2.5OD, almost on line. Eyes large, not protuberant Face at least twice as broad as high (fig. 37), only weakly convex, coarsely rugose with a reticulate element laterally. Clypeus distinctly narrower than face, moderately convex, densely, finely punctate; apical border produced but truncate medially Malar space marked by a band of fine rugulose sculpture. Mandibles large, moderately twisted. Thorax (mesosoma) rather depressed, in lateral view almost twice as long as high. Pronotum projecting distinctly in front of mesonotum, reticulate laterally, transversely striate dorsally. Notauli deeply impressed, foveolate Mesonotum generally coarsely reticulate-rugose except for small, smooth punctate areas laterally. Precoxal suture indistinguishable from the coarsely reticulate-rugose sculpture of the mesopleuron. Propodeum coarsely reticulate-rugose, divided by a strong transverse medial carina that is raised laterally into blunt dentate flanges. Carapace elongate, oval in dorsal view, ventral opening not reaching apex; posteroventrally strongly impressed medially Ovipositor long (at least half as long as carapace), narrow Hind coxa rugose dorsally, densely finely punctate ventrally

Colour black, but antennae brown; fore leg yellow except coxa and trochanter brown, mid leg brown except apex of femur, base of tibia and sometimes tarsus yellow, hind leg brown but always with a medial pale band on tibia, and often also base of tarsus yellow. Carapace with lateral pale areas anteriorly. Sternites and ovipositor sheaths brown, sometimes pale Male same as female except antennae 31-segmented, carapace more parallel-sided in dorsal view with smaller pale areas anterolaterally and no strong medial impression posteroventrally.

Material examined. Holotype ♀, SENEGAL: Djibelor, 15.x.1979 (J Etienne) [*ex* larva *Maliarpha separatella* on rice] (MNHN). Paratypes 3♂, 2♀, same data as holotype (BMNH, MNHN). 1♀ Senegal, Kagnout, 13.xi.1969 (B Vercambre) [ex *M. separatella*] (MNHN).

Alternative hosts. None known

Distribution. Senegal.

Biology. A solitary egg-larval endoparasitoid. Quartey (1975) referred to a 'genus near *Chelonus* ?sp' attacking *M. separatella* in Ghana which had a 7–29% parasitization rate. It is not unlikely that he was observing *C. maudae*, although we have not been able to recover the original material on which these observations were based.

Remarks *Chelonus maudae* is most closely related to *C. capensis* Cameron; the carapace of *C. capensis*, however, has a much shorter ventral opening and the posteroventral impressed part is therefore much longer. The temples of *C. capensis* are less strongly rounded and the sculpture on most parts of the body is less well developed

Phanerotoma saussurei Kohl
(figs 22, 23)

Phanerotoma saussurei Kohl, 1906: 125. Holotype ♀ (mistakenly given as ♂ in original description), MADAGASCAR· Tamatave (NMW) [examined].
Phanerotoma major Brues, 1926· 266. Holotype ♀, [KENYA] British East Africa: Masai Reserve (BMNH) [examined] **syn. n.**
Phanerotoma major: Jordan, 1966; Agyen-Sampong, 1980; Agyen-Sampong & Fannah, 1987
Phanerotoma saussurei: Appert, 1967
Phanerotoma sp: Etienne, 1987

Diagnosis. Length 6.0–8.0 mm. Entirely orange/brown; antennae, stemmaticum and occasionally the posterior metasoma brown, but otherwise without any distinct brown or black markings. Pterostigma uniformly orange. Body dorsoventrally flattened. Metasoma distinctly longer than mesosoma. Propodeum coarsely reticulate, without distinct carinae. Face with striate sculpture, tentorial pits deep. Reared always in association with rice stem borers.

Alternative hosts Pyralidae: *Chilo zacconius*, ?*Scirpophaga* sp.

Distribution Kenya, Madagascar, Mali, Senegal, Sierra Leone, Tanzania.

Biology A solitary egg-larval endoparasitoid, with a fecundity of 90 to 130 eggs. The life cycle is synchronized with that of its host, and death of the host occurs at the host's prepupal stage, with the emergence of the final instar parasitoid larva. Pupation occurs in the vicinity of the host remains within a bottle-shaped cocoon, about 14 mm long. Adult emergence occurs 12–14 days later (Bianchi *et al.*, 1991) In Madagascar this species is active throughout the year at Marovoay, from the end of December on the plateau but enters diapause at Lac Alaotra between July and October (Bianchi *et al.*, 1991).

Remarks. In the BMNH collection there are three specimens of *P. saussurei* labelled 'S.E. Asia, L. Caresche CIE A1745'. These specimens were part of a donation by Dr Caresche in 1971, which included many specimens from Cambodia and Vietnam, but it is doubtful whether the *Phanerotoma* specimens were collected from either of those countries. Dr Caresche was himself involved with classical biological control of stem borers in Madagascar in the 1960s, a more probable origin for these specimens. According to Appert (1967) *P. saussurei* was ineffective in controlling *M separatella* in Madagascar.

BRACONIDAE: Doryctinae

Rhaconotus carinatus Polaszek *sp. n.*
(figs 17, 26, 30–32)

Rhaconotus niger (Szépligeti)· Appert, 1967, 1973; Brenière *et al.*, 1962; Bianchi *et al.*, 1991 (misidentifications).
Rhaconotus nr *sudanensis* Wilkinson: Jordan, 1966.
Rhaconotus sp.. Etienne, 1987.
Rhaconotus nr *sciron* Nixon: Alam, 1992.

Diagnosis. Length 3.5–6.0 mm Apex of fifth metasomal tergum simple, not dentate or sinuate. T2+T3 of the metasoma with a single division (fig. 32). Fore wing with pterostigma dark (fig. 17), each antenna with about 30 segments. Mesoscutum with a median longitudinal carina posteriorly (fig. 30).

Description. Female with ground colour dark red/brown with the following dark brown/black· an ill-defined inverted triangle on the vertex, most of the mesoscutum, propodeum, lateral areas of metasomal terga and ovipositor. Head matt with fine reticulate sculpture, moderately setose, the setae directed posteriorly. Antenna with 28–33 segments. Mesoscutum as in figure 30, with reticulate sculpture except the median part posteriorly with an irregular, longitudinal carina having several short lateral branches. Only the notauli and edges of the mesoscutum with setae, the mid and side lobes of the mesoscutum asetose centrally. Propodeum as in figure 30, sculpture largely finely reticulate dorsally, with a central longitudinal carina and two shorter carinae laterally. Posteriorly sculpture becoming more rugose. Fore wing (fig. 17) with the pterostigma very distinctly infuscate. Metasoma with the fused T2+T3 divided by a single groove; the longitudinal striae on T2 continuing posteriorly across this groove into the anterior part of T3, without being interrupted by an irregular transverse carina (as in *R. sudanensis* Wilkinson). Dorsally visible part of ovipositor about 2/3 the length of the metasoma. Male largely as for female except for genitalia characters; habitus somewhat narrower.

Alternative hosts. Pyralidae: *Chilo zacconius.*

Distribution. Cameroon, Ghana, Madagascar, Nigeria, Senegal, Sierra Leone, Tanzania, Togo

Biology. A gregarious larval ectoparasitoid (6–27 individuals per host), with a fecundity of 10 to 30 eggs. Developmental time is about 20 days, and adult females show a preference for attacking fourth or fifth instar larval hosts. The cocoons are white and can be distinguished from those of *B. testaceorufatus* by being more closely aggregated and by the smoother texture of the silk. At Lac Alaotra this species undergoes a winter diapause to reappear during October (Bianchi *et al.*, 1991)

Material examined. Holotype ♀, Cameroon, near Santchou, Plaine de Mbo 250 km North Douala, i.1991, (G. Bianchi)/8 (BMNH). Paratypes (2♂ 28♀) same data as holotype (BMNH, MNHN, RMNH).

Remarks. Type material of those African and Asian *Rhaconotus* described by Granger, Nixon and Szépligeti which come at all close to *R. carinatus* has been examined.

Rhaconotus scirpophagae Wilkinson
(figs 16, 25, 27–29)

Rhaconotus scirpophagae Wilkinson, 1927. 34. Lectotype ♀ (here designated): INDIA: Pusa, Bihar 18.iii.1914 *'ex Scirpophaga auriflua* in sugar stem' (BMNH) [examined].
Rhaconotus sp nr *oryzae* Jordan, 1966.
Rhaconotus sp. Mathez, 1972
Rhaconotus sp nr *scirpophagae* Alam, 1992.

Diagnosis Length 4.0–7.0 mm Head and mesosoma densely hairy, the hairs on the mesosoma arranged as in figure 27. Hind margin of pronotum usually obscured by a ridge, mesosoma narrow, its sculpture and setation as in figure 27 T2+T3 of metasoma divided by a simple slightly curved groove. Antenna of female with more than 40 segments. Pterostigma uniformly pale, colouration and venation of fore wing as in figure 16

Alternative hosts Noctuidae: *Busseola fusca*, Pyralidae: *Chilo partellus*, *Chilo* sp., *Scirpophaga ?excerptalis*, *S. nivella*, *Scirpophaga* sp.

Distribution. Africa: Côte d'Ivoire, Ghana, Kenya, Nigeria, Senegal, Sierra Leone, Tanzania (Wilkinson, 1927). Asia. India, Java, Pakistan.

Biology. A gregarious larval ectoparasitoid.

Remarks. The holotype of *Rhaconotus caudatus* (Szépligeti) differs in very few respects from *R scirpophagae*, and may well be conspecific. We have refrained from synonymizing the two species pending a thorough taxonomic revision of *Rhaconotus* from the Old World tropics.

In addition to the two *Rhaconotus* species treated here, at least five other species are recorded as attacking other stem borer species in the Old World tropics These are the following: *R caulicola* Muesebeck, *R. oryzae* Wilkinson, *R. roslinensis* Lal, *R. schoenobivorus* (Rohwer) and *R. signipennis* (Walker).

Rhaconotus scirpophagae was described from *Scirpophaga auriflua* on sugarcane. *Scirpophaga auriflua* is a junior synonym of *S. nivella*, a rice stem borer. According to Lewvanich (1981), records of this species from sugarcane are probably misidentifications of *S. excerptalis*.

BRACONIDAE: Microgastrinae

Cotesia ruficrus (Haliday)
(fig. 33)

Microgaster ruficrus Haliday, 1834: 253 [Whereabouts of syntypes unknown]. For full synonymy see Nixon, 1974.

Diagnosis. Length 2 0–2 5 mm Ocelli in a high triangle. Antenna as long as body, the two preapical segments each about 1 7 × longer than wide. Mesoscutum shining, coarsely punctate Scutellum deeply and strongly punctate. Phragma of scutellum concealed by postscutellum. Hind coxae dull, rugose, Inner spur of hind tibia not reaching beyond middle of basitarsus. Tergite 2+3 highly polished distally to basal field, setae restricted almost to a single row in the middle, frequently double at the sides. Hypopygium short, roundly truncate at apex as seen in profile (Nixon, 1974). Colour: legs bright red/yellow, hind femur dark distally. Metasomal tergite 2+3 with yellow markings.

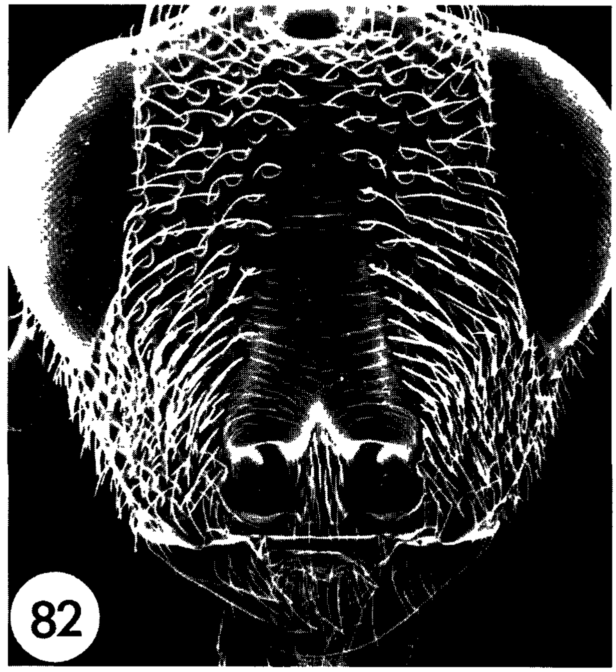


Fig 82. *Psilochalcis soudanensis* head, anterior

Alternative hosts. An extremely polyphagous species. Additional African cereal stem borer hosts not mentioned by Nixon (1974) are the following: Noctuidae: *Sesamia nonagrioides* Lefebvre, Pyralidae: *Chilo zacconius*

Distribution. Cosmopolitan in the Palaeotropics and Palaearctic.

Biology. A gregarious endoparasitoid.

Remarks Reared from *M separatella* at Kotiessou, Côte d'Ivoire, by Dr A Pollet (1♂, 2♀, CIRAD, examined)

CERAPHRONIDAE

Aphanogmus fijiensis (Ferrière)
(figs 1, 12, 77)

Calliceras fijiensis Ferrière, 1933: 106. Holotype ♀, FIJI: Taveuni, xi 1931 (R.W. Paine) *ex Apanteles tirathabae* (BMNH) [examined]
Aphanogmus fijiensis (Ferrière). Dessart, 1971: 98.

Diagnosis. Length 0.9–2.2 mm Wing venation as in figure 12 Mesopleuron almost entirely smooth (fig 1), genitalia as in figure 77.

Hosts Aphanogmus fijiensis attacks a wide range of hymenopterous primary parasitoids, mostly Braconidae It is especially commonly recorded from cocoons of *Apanteles* spp., *Cotesia* spp. and *Dolichogenidea* spp (*Apanteles sensu lato*) and is often reared from braconid primary parasitoids of cereal stem borers in Africa

Distribution Pantropical, accidentally introduced into many parts of its range (Dessart, 1971).

Biology A gregarious secondary endoparasitoid.

Remarks. *Aphanogmus fijiensis* has never, to our knowledge, been recorded in association with *M separatella*, but it seems likely that it eventually will be, and is therefore included here

CHALCIDIDAE

Psilochalcis soudanensis (Steffan)

(figs 4, 14, 82)

Hyperchalcidia soudanensis Steffan, 1951· 67
Invreia soudanensis (Steffan) Bouček, 1988 53.
Psilochalcis soudanensis (Steffan)· Narendran, 1989· 184

Diagnosis. Length 3 0–7 0 mm Head, hind femur and wing venation as in figures 4, 14 and 82.

Alternative hosts Noctuidae. *Busseola fusca* (Fuller), Pyralidae. *Chilo auricilius* Dudgeon, *C. infuscatellus*, *C partellus*, *C zacconius*, *Coniesta ignefusalis*, *Eldana saccharina*
Distribution Africa· Cameroon, Ghana, Kenya, Nigeria, Mali, Niger, Senegal, Sudan, Uganda. Asia. India, Pakistan

Biology. Solitary larval-pupal endoparasitoid

Remarks Despite the widespread occurrence of *P. soudanensis*, we have not seen any specimens from Madagascar A single male of a very closely related (and probably undescribed) species, almost certainly reared from *M. separatella* at Tanandava, Madagascar, has been examined by Y Jongema (pers. comm) It seems wise to wait until further, reliably reared, material becomes available before treating this species. Appert (1973) referred to the proposed introduction of *P soudanensis* into Madagascar and the Comoros against *Chilo* sp. and *Maliarpha separatella*. Presumably this introduction never took place

ELASMIDAE

Elasmus sp. A

Diagnosis. Length 1 90 mm Hind coxa enlarged and flattened as in figure 3. Wings uniformly infuscate (brown) head and body with a contrasting pattern of orange and black areas, the following black: most of head, pronotum centrally, central mesoscutum proximally, axillae, postscutellum and propodeum centrally, hind coxae and most of metasoma dorsally.

Alternative hosts. None known.

Distribution Senegal.

Biology. Not known.

Material examined. 3♀ SENEGAL: Casamance iv–v.90 (G Bianchi) *ex M. separatella* (specimen labelled as follows: *Elasmus* sp A Bull. Ent Res 1994, Polaszek *et al.*) (BMNH)

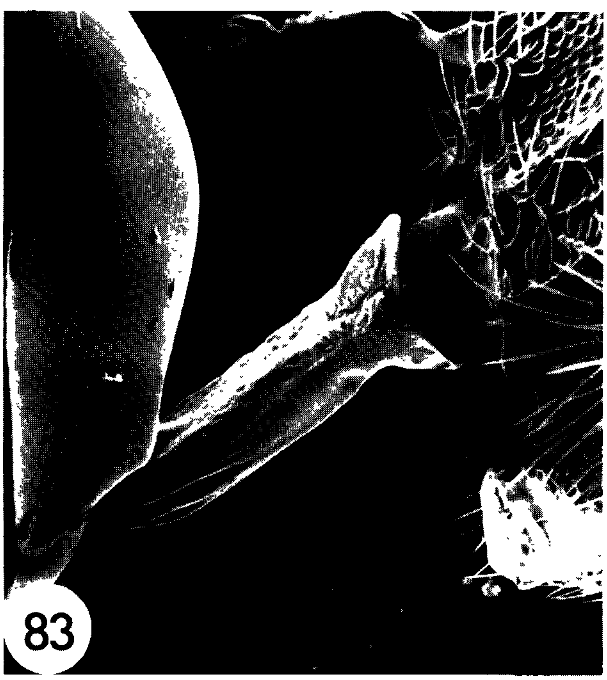
Remarks *Elasmus* spp. are known both as primary parasitoids, mostly of Lepidoptera, but also as hyperparasitoids *Elasmus zehntneri* is a primary parasitoid of stem borers in Asia. The species treated here is known from only three specimens reared from *M. separatella*, and it is not known whether they were primary or secondary parasitoids

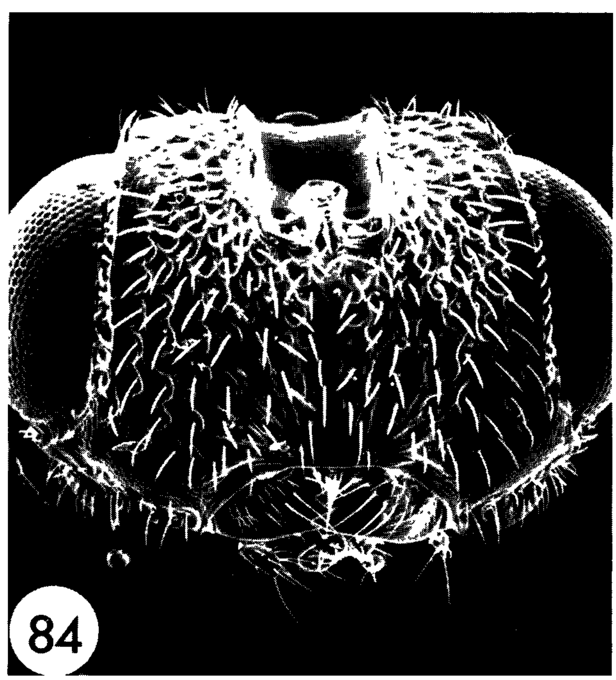
EULOPHIDAE

Tetrastichomyia sp. *A*

(fig. 76)

Diagnosis. Length 1 70 mm Wing venation reduced with the stigmal vein straight (as in figs 11 & 13) Tarsi 4-segmented, the hind coxa not expanded and flattened. Dorsum of mesosoma as in figure 76, dorsellum of mesosoma divided by a median longitudinal ridge.





Figs 83–84. *Eurytoma oryzivora*. 83, petiole lateral; 84, head, anterior.

Alternative hosts. None known.

Distribution. Uganda.

Biology. Presumably a primary parasitoid

Material examined. 1♀ UGANDA: Toro (*Tetrastichomyia* sp. A Bull Ent Res 1994, Polaszek *et al.*) (BMNH).

Remarks. This species differs from *Tetrastichomyia clisiocampae*, a widespread species (Italy and USA), which is also known to attack cereal stem borers (Graham, 1991; J. LaSalle, pers. comm.).

EUPELMIDAE

Macroneura sp. A

Diagnosis (♀). Length 3.50 mm. Mesopleuron convex as in figure 5, wings reduced. Pronotal dorsum with two prominent tufts of thick dark setae. Brown/black with blue/purple irridescence.

Alternative hosts. None known.

Distribution. Senegal.

Biology. Not known.

Material examined. 2♀ SENEGAL· Casamance iv–v.90 (G. Bianchi) *ex Maliarpha separatella* (*Macroneura* sp. A Bull. Ent Res 1994, Polaszek *et al.*) (BMNH).

Remarks. This species is included here on the basis of two females reared from *Maliarpha separatella* in Senegal.

EURYTOMIDAE

Eurytoma oryzivora Delvare
(figs 6, 7, 83, 84)

Eurytoma sp.. Jordan, 1966; Agyen-Sampong, 1980; Agyen-Sampong & Fannah, 1987; Etienne, 1987.
Eurytoma oryzivora Delvare, 1988: 130. Holotype ♀, CAMEROON· Yagoua, i.1955 (Descamps) 'ex borer du Riz' (MNHN) [examined].

Diagnosis. Length 3.2–3.6 mm almost entirely black, with some areas reddish-brown. Metasoma petiolate (fig 83), petiole longer than wide. Mesopleuron with a distinct subpleural area, defined anteriorly by an epicnemial carina (fig. 7). Clypeus without a deep medial depression; face with foveolate/striate sculpture (fig. 84).

Alternative hosts *Chilo* sp.

Distribution. Cameroon, Senegal, Sierra Leone, Tanzania.

Biology. Assumed to be a primary parasitoid.

Remarks. The only other *Eurytoma* species commonly reared from cereal stem borers in Africa is the polyphagous hyperparasitoid *E. braconidis* Ferrière, which can be distinguished from *E. oryzivora* by the diagnosis given above, particularly by the lack of an elongate petiole and presence of a clypeal depression. *Eurytoma braconidis* has never, to our knowledge, been reared in association with *M. separatella*.

ICHNEUMONIDAE: Campopleginae

Venturia jordanae Fitton *sp. n.*
(figs 40–44, 66, 69)

Scenocharops sp.: Jordan, 1966 [misidentification].
Cassarina [*sic*] sp.: Njokah & Okhoba, 1985 [misspelling of *Casinaria*; misidentification]
Venturia crassicaput (Morley)· Agyen-Sampong & Fannah, 1987 [misidentification].

Diagnosis. Length 7.0–10.0 mm Slender, with the metasoma laterally compressed. Colour as described below. Characteristic campoplegine combination of confluent face and clypeus, black in colour, with coarse granulate sculpture and clothed with conspicuous silver hairs.

A closely related species of *Venturia* attacks *Sesamia* spp. boring in rice (Jordan, 1966). It can be distinguished from *V. jordanae* by its slightly less slender proportions and, in the female, by its much longer ovipositor, which is more than 2.7 times as long as the hind tibia. The visible part of the ovipositor, the length of which equals the ovipositor sheaths, is more than twice as long as the hind tibia.

Description. Fore wing length 4.3–5.7 mm. Head comparatively buccate, in dorsal view (fig. 43) gena about 0.9 times as long as eye. Mesosoma elongate, profile as in figure 42. Propodeal carinae as in fig 69. Mesosoma, including entire upper lateral area of pronotum and metapleuron, coarsely and closely punctate, with coarse granulate sculpture between the punctures. Fore wing with cu-a meeting Cu at the point of divergence of M and Cu (fig. 44). Metasoma elongate; segment 1 in profile as in figure 42; tergite 2, 2.3–2.5 times as long as wide posteriorly Ovipositor about 1.6 (the visible portion, which equals the ovipositor sheaths, about 1.0) times as long as hind tibia, with the tip slightly upcurved.

Colour: mainly black and dark brown, with underside of antenna, mouthparts, tegula, fore and mid legs, hind trochantelli, and part or all of metasomal tergites 3–7 reddish or yellowish.

Alternative hosts. Jordan's data (1966) suggest that the species is restricted to *M separatella.*

Distribution. Côte d'Ivoire, Kenya, Sierra Leone.

Biology. A solitary koinobiont endoparasitoid of the larva, killing the host in its pupal chamber or sometimes before the pupal chamber has been made. In the first case the adult *V. jordani* emerges through the 'window' prepared by the larval lepidopteran for the escape of the adult moth. In the latter case *V jordani* has to make its own emergence hole (Jordan, 1966). In Sierra Leone the first adults emerge in November, rising to peak numbers in February and then declining until August (Jordan, 1966).

Material examined Holotype ♀, Sierra Leone: Rokupr, 1964–65, reared from *M. separatella* in rice (Jordan) (BMNH, London). Paratypes, 11♂, 12♀. Sierra Leone. 5♂, 11♀, same data as holotype (BMNH, London). Sierra Leone: 2♂, 1♀, Rokupr, 1979–80 *ex Maliarpha* sp. on rice (WARDA) (BMNH, London). Ivory Coast 1♂, Man, iv–v.90, *ex M. separatella* (Bianchi) (BMNH). Kenya: 2♂, Ahero, 22+23.ix.71, *ex M. separatella* in rice (Greathead) (KPCRS); 1♂, Ahero Irrigation Scheme, near Kisumu, 350 km W of Nairobi, i.1991 (Bianchi) (BMNH).

Remarks. Of the described African species of *Venturia* this species and the related parasitoid of *Sesamia* come closest to *V crassicaput* (Morley), of which the lectotype has been examined

ICHNEUMONIDAE: Cremastinae

Pristomerus africator Aubert & Shaumar
(figs 48, 52, 54, 57, 64, 72, 75)

Pristomerus sp.: Jordan, 1966.
Pristomerus pallidus africator Aubert & Shaumar, 1978. 18. Holotype ♂, IVORY COAST: Bouaké, 28.i.1977 [P Cochereau] (Aubert collection) [not examined].
Pristomerus africator· Horstmann, 1990. 16

Diagnosis. Length 6.5–8.5 mm. Colour as in *P. bullis* sp. n. brownish-yellow overall, with face paler and antenna, wing veins and stigma, hind tarsi and a patch on metasoma tergite 2 darker. The two species can be separated as shown in the key.

Alternative hosts. ?*Chilo* on rice. Two specimens reared in Senegal may be *P. africator*, but this requires further consideration in conjunction with a revision of *Pristomerus* in Africa.

Distribution. Côte d'Ivoire, ?Egypt, Senegal, Sierra Leone. The record from Egypt is doubtfully correct (Horstmann, 1990)

Biology. A solitary, koinobiont, larval endoparasitoid. Jordan (1966) reports the host being killed as a larva and two adult males emerging in May and June. Dates (months) associated with other adult specimens examined are February, March, April and December, but some of these may refer to rearing under laboratory conditions.

Remarks. The species of *Pristomerus* are in need of revision. There are six described Afrotropical species, but there are many more in collections. Of the three species attacking *M. separatella*, *P. africator* and *P bullis* are superficially similar and may be related to *P cunctator* Tosquinet (of which the lectotype has been examined), while *P. caris* sp. n clearly belongs to another species-group. As noted above, the identity of some material reared from rice and other stem borers is currently in doubt.

Pristomerus bullis Fitton *sp. n.*
(figs 47, 51, 53, 56, 59, 62, 63, 70, 74)

Description. Length 6.3–8.1 mm Fore wing length 4.5–5.6 mm Clypeus wider and less convex than in *P. africator* and with face less strongly widened ventrally (figs 47, 51, compare figs 48, 52). Malar space narrow, about 0.5 (slightly less in male) of basal width of mandible Female with mesoscutum strongly punctured, male with centre of mesoscutum with only a few strong punctures. Propodeum with area superomedia shaped as in figure 70. Tergite 2 of metasoma 1.6–2.0 times as long as broad posteriorly and thyridia shaped as in figure 74. Hind femur stout in male, with a well developed tooth ventrally (fig. 63), relatively slender in female and with a small tooth (fig 62). Ovipositor about 1.8 (the visible portion, which equals the ovipositor sheaths, about 1.2) times as long as hind tibia, with the apex sinuous

Colour: brownish-yellow overall, with face paler and antenna, wing veins and stigma, hind tarsi and a patch on metasoma tergite 2 darker.

Alternative hosts. None known

Distribution Tanzania.

Biology. Probably a solitary, koinobiont, larval endoparasitoid like other cremastines.

Material examined. Holotype ♀, Tanzania, Morogoro region, Mkindo, i.1991, reared from *M. separatella* in rice (Bianchi) (BMNH). Paratypes 2♂, 2♀, Tanzania: 1♂, 1♀, same data as holotype (BMNH). Tanzania: 1♀, Zanzibar, 14.i.1986, reared from *M separatella* (Feijen) (RMNH). Tanzania· 1♂, Zanzibar, Ungoja, Bumbw[e]: irr[igated] rice, 3.vi.1985 (Feijen) (RMNH).

Remarks. See remarks under *P. africator*.

Pristomerus caris Fitton *sp. n.*
(figs 49, 50, 55, 58, 60, 61, 65, 71, 73)

Description. Length 4.4–5.8 mm. Fore wing length 3.4–4.6 mm Head with eyes relatively large, gena narrow (figs 55, 58, compare figs 53, 54, 56, 57), face relatively narrow and strongly widened ventrally in male (fig. 49), male with enlarged ocelli, very close to eyes laterally (fig. 60). Mesoscutum strongly punctured. Propodeum with area superomedia shaped as in figure 71. Tergite 2 of metasoma 1 7–2.1 times as long as broad posteriorly and thyridia shaped as in figure 73. Hind femur relatively slender in female and without a distinct tooth ventrally (fig. 61) (tooth present in male) Ovipositor 2.2–2 5 (the visible portion, which equals the ovipositor sheaths, 1.5–1 8) times as long as hind tibia; with the apex sinuous

Colour· brownish orange overall, with antennae and tergites 1 and 2 of metasoma blackish, and the head pale cream, except the face centrally brown, extending across the frons and back of the head as a broad black area. Male with the remainder of the metasoma infuscate and the female with the hind tarsi and ovipositor sheaths blackish.

Alternative hosts. None known.

Distribution. Madagascar.

Biology. Probably a solitary, koinobiont, larval endoparasitoid like other cremastines.

Material examined. Holotype ♀, Madagascar· Lac Alaotra, Stn Cala, 12.ii 1988, almost certainly reared from *M. separatella* (P. Bousses) (BMNH). Paratypes, 2♂, 2♀, same data as holotype (BMNH)

Remarks. See remarks under *P. africator*

Temelucha sp. A

Diagnosis. Length 4.3 mm. A small species with a contrasting black-and-yellow colour pattern, the yellow areas varying to a lighter creamy colour and the black areas to a dark brown. The head, mesosoma and ventral surface of the metasoma are all extensively yellow.

Alternative hosts. None known.

Distribution. Madagascar.

Biology. Probably a solitary, koinobiont, larval endoparasitoid like other cremastines.

Material examined. 1♀ MADAGASCAR: Lac Alaotra, Station Cala 15 02.88 *ex M. separatella* (*Temelucha* sp. A Bull. Ent. Res. 1994, Polaszek *et al.*) (BMNH).

Remarks. The single known specimen, a female, very probably represents an undescribed species. However, it seems prudent to wait until more material is available before giving it a name.

ICHNEUMONIDAE: Phygadeuontinae

Amauromorpha sp. A
(figs 45, 68)

Diagnosis Length 8.5 mm. The females, especially, of this and *Vadonina ?nimbipennis* Seyrig have a heavier build than most of the other ichneumonid species. *Amauromorpha* sp. A is mainly brownish orange in colour with the end of the metasoma black with a white band and with the head and antennae black, the latter with a white band in females.

Alternative hosts. None known.

Distribution. Togo (but see below)

Biology. Unknown, but possibly a solitary, idiobiont ectoparasitoid.

Material examined. 1♀ TOGO. 22.ii.80 (M. Tore) *ex M. separatella* CIE A12209 (*Amauromorpha* sp. A Bull. Ent. Res. 1994, Polaszek *et al*) (BMNH).

Remarks. The single reared specimen, almost certainly represents an undescribed species. Two much larger female *Amauromorpha* in the BMNH collection—one from Malawi (not reared) and one from Nigeria (from a rice stem)—may be the same species. It seems prudent to wait until more material is available before deciding.

Vadonina ?nimbipennis Seyrig
(figs 46, 67)

Vadonina nimbipennis Seyrig, 1952: 181. Holotype ♀, MADAGASCAR. Marsansitra (MNHN) [examined]
Gen. near *Isotima* sp.: Jordan, 1966.
Isotima nimbipennis: Townes & Townes, 1973· 105.
Menaforia spp.: Agyen-Sampong & Fannah, 1987 [misidentification].

Diagnosis. Length 6.5–11 mm. See note under *Amauromorpha*. Colour brownish with the mesosoma and anterior metasoma more reddish and the posterior metasoma, head and antennae darker, often almost black. The posterior tip of the metasoma and, in females, a band on the antennae, white.

Alternative hosts. Not known, see remarks below.

Distribution. Ghana, Kenya, Madagascar, Sierra Leone, Swaziland, Tanzania, Togo, Uganda.

Biology. Reported by Jordan (1966) to be a larval-pupal parasitoid, but with no data supporting the contention that oviposition is into or onto the larva. Data attached to other specimens indicate they were reared from pupae Further investigation is obviously desirable in view of the wide geographic range and relative abundance of the species. Quartey (1975) recorded what is almost certainly this species from pupae of *M. separatella* in Ghana. At Lac Alaotra this species is found only rarely, but most frequently between September and December. Dates (months) associated with adults are January to May, August, November and December (but some of these may refer to laboratory rearings)

Remarks. Townes (1970) included *V. nimbipennis* within *Isotima* *Isotima* as recognized by Townes is a moderately large genus with an Afrotropical and Oriental distribution. However, *V nimbipennis* and most (but not all) of the African species of this group lack the key character used by Townes to distinguish it (frons with a semi-circular carina above each antennal socket) As well as lacking frontal carinae *V. nimbipennis* and related African forms have a distinctive habitus They are rather more 'robust' than *Isotima* spp from the Oriental region Considering the state of the systematics of the group it seems best at present to regard them as separate genera.

Vadonina includes only one described species Study of the material available, much of it reared from lepidopterous cereal stem borers, reveals a range of variation in a number of characters. Species limits are not obvious and since material reared from *M. separatella* does not differ very significantly from the holotype of *V. nimbipennis* it is tentatively identified as that species until a revision of the genus is undertaken. Other material of *Vadonina* examined includes specimens from the following additional host and crops· *Chilo partellus*, sorghum and maize.

ICHNEUMONIDAE: Pimplinae

Itoplectis naranyae (Ashmead)
(figs 38, 39)

Nesopimpla naranyae Ashmead, 1906· 180 Holotype ♀, JAPAN: Sapporo ex *Naranga diffusa* (USNM) [not examined].
Itoplectis narangae Appert, 1973· 85.

Diagnosis. Length 7 0–10.5 mm. The metasoma is rather broad (somewhat depressed) and mainly orange in colour. The head, the mesosoma usually, and the tip of the metasoma are black The legs are orange-yellow with conspicuous dark bands

Itoplectis naranyae is very close to, and may even be the same as, the Palaearctic species *I. melanocephala* (Gravenhorst) The latter differs mainly in having the legs (apart from the claws) entirely orange-yellow.

Hosts. Not yet recorded from *M separatella*, but known from a very wide range of hosts, mainly Lepidoptera, but also Ichneumonidae (Hymenoptera) and Chrysomelidae (Coleoptera) (Gupta, 1987). Included here for the reasons given below.

Distribution. An eastern Asian species, introduced into several parts of the world to control various lepidopterous pests Stock of Japanese origin was introduced into Madagascar to control *M. separatella* in 1972 (Appert, 1973), but probably did not establish An attempt to introduce this species into Senegal against *M separatella* (Vercambre, 1977b) also appears to have failed.

Biology. A solitary idiobiont endoparasitoid usually of cocooned or weakly concealed pupae, but sometimes of pharate pupae or even pharate adults. Acting as a facultative pseudohyperparasitoid when it attacks ichneumonids in their own cocoon or their host's cocoon or pupa.

Remarks We have seen no material of this species from the Afrotropical region. Even if established in the region it may not attack *M. separatella* and is included in our key only in case it does so.

PTEROMALIDAE

Norbanus sp. A
(figs 8, 9)

Diagnosis Wing venation reduced, with the stigmal vein straight, as in figures 11, 13. Tarsi 5-segmented Mesopleuron divided, not in the form of a convex shield. Antenna of female with an elongate, pointed sensillum at the apex of the club (fig. 9). Mesosoma as in figure 8.

Alternative hosts. None known.

Distribution Madagascar.

Biology Not known.

Material examined 1♀ MADAGASCAR. Lac Alaotra, Station Cala. 1991 (P. Bousses) *ex. M. separatella* 91–34 (*Norbanus* sp A Bull. Ent. Res. 1994, Polaszek *et al.*) (BMNH).

Remarks. This species is known from a single female specimen reared from *M separatella* from Madagascar. The genus *Norbanus* is in need of taxonomic revision Several records of species parasitizing lepidopterous cereal stem borers are known from Africa.

SCELIONIDAE

Telenomus bini Polaszek & Kimani
(figs 13, 80)

Telenomus bini Polaszek & Kimani, 1990: 62. Holotype ♂, MADAGASCAR: Lac Alaotra, Stn 'Cala', 2.iii.1983 (P. Bousses) [ex *M. separatella*] 'LB7' (MNHN) [examined].
Telenomus applanatus (part) Bin & Johnson, 1982. 234.
Telenomus sp.1, groupe *lemoleae* Nixon, Etienne, 1987.

Diagnosis. Minute black species, length less than 1 mm. The genus is extremely large, and several closely related *Telenomus* spp. are associated with rice stem borers in Africa These can only be successfully identified using male genitalia characters (fig. 80). Detailed treatments of these species are available (Polaszek & Kimani, 1990, Polaszek *et al*, 1993).

Alternative hosts. Pyralidae: ?*Chilo* sp.; *Scirpophaga ?subumbrosa* Meyrick.

Distribution. Côte d'Ivoire, Ghana, Kenya, Madagascar, Malawi, Senegal, Tanzania.

Biology. Telenomus bini, like all Scelionidae, is an egg-parasitoid. Records from hosts other than *M separatella* are extremely rare, and all records are associated with rice. This species can be reared easily on *Maliarpha* in the laboratory, but it does not oviposit into eggs of *Ephestia kuehniella* Zeller or *Corcyra cephalonica* Stainton (both Pyralidae) (Brenière *et al.*, 1962) At Lac Alaotra (Madagascar) its life cycle lasts 16 days during the warmest months (December, January), and it has a fecundity of about 26 eggs (Bianchi *et al.*, 1991)

Remarks. We have examined many hundreds of specimens of *T bini* from populations spanning its known distribution. Most previously published records of *Telenomus* spp. from *M separatella* probably refer to *T. bini*

TRICHOGRAMMATIDAE

Lathromeris ovicida (Risbec)
(figs 10, 11)

Garouella ovicida Risbec, 1956c· 818. Lectotype ♀ (here designated): [CAMEROON:] Garoua viii.1955 [(M] Descamps[)] 'ex w Lepid. s/riz' (MNHN) [examined].
Lathromeris ovicida (Risbec). Doutt & Viggiani, 1968: 504; Viggiani, 1969: 205 (redescription).

Diagnosis. Minute species with wing venation as in figure 11. Antennal club five-segmented, terminating in an elongate projection (fig. 10). Funicle absent, two ring segments present.

Alternative hosts. Noctuidae: *Busseola fusca*; *Sesamia calamistis*; Pyralidae: *Chilo zacconius*; *Scirpophaga subumbrosa*.

Distribution. Benin, Cameroon, Côte d'Ivoire, Ghana, Nigeria, Uganda.

Biology. A primary egg parasitoid, attacking several species of stem borers in a variety of habitats Commonly recorded from eggs of maize stem borers.

Discussion

During the present survey over 20 species of Hymenoptera were found to parasitize *Maliarpha separatella*, a few as definite or probable hyperparasitoids. This study was carried out in conjunction with a broader survey of all parasitoids of lepidopterous cereal stem borers in Africa, Madagascar and the associated islands (Polaszek, 1992). From the broad survey it was found that several species attacking *M. separatella* are polyphagous for cereal stem borers, or for a broader host range, and very few appear to show any degree of host specificity at the species level. Only *Telenomus bini*, an egg parasitoid, appears to be strongly host specific. *Telenomus bini* is extremely common on *M. separatella* both in Africa and Madagascar, and has been reared from alternative (also rice inhabiting) stem borer species on only two occasions. Some of the other species have been reared on too few occasions to be certain of any degree of host specificity, e g *Chelonus maudae*, but should be further investigated for biological control capabilities.

A striking feature of the survey for *M. separatella* parasitoids is the complete lack, so far, of any dipterous parasitoids. For other stem borer species, in Africa and elsewhere, Tachinidae in particular are commonly encountered attacking stem borer larvae. However, for Africa and Madagascar there is only a single published record of a native tachinid species attacking a rice inhabiting stem borer larva (*Actia* sp. on *Chilo zacconius*, Sierra Leone, Jordan, 1966) Hence, an available niche may exist for an imported tachinid biological control agent.

Current studies on biological control of cereal stem borers in Africa are focusing on the Asian braconid *Cotesia flavipes* (Cameron) to control *Chilo partellus*, also an Asian species (Overholt, 1993) Another Asian species, *Cotesia chilonis* (Matsumura), is invariably associated with *Chilo* sp. in rice. Its ability to develop successfully on *M. separatella* is worthy of investigation. The related, indigenous (African), *Cotesia sesamiae* (Cameron) is common on most stem borer species, but does not give adequate control. *Cotesia sesamiae* has not, to our knowledge, been recorded from *M. separatella*. A study of the reasons for this may shed light on the suitability of *Cotesia* spp. as potential biological control agents of *M. separatella*.

In summary, it would appear that despite the abundance and diversity of hymenopterous parasitoids of *M. separatella*, neither their individual nor collective impact is sufficient to control it in the areas where it is a recognized pest. This is certainly true of the common, widespread parasitoid species. More detailed studies on the less common species, or those with a restricted distribution, are likely to suggest agents which could be imported from one region into another. In particular, the biological control potential of Tachinidae and exotic *Cotesia* spp. merits investigation for *M. separatella* control.

Whatever initiatives develop in the future of biological control of *M. separatella*, it should now at least be possible to identify the parasitoids associated with this species, or species-complex. Identification of natural enemies should always be the first step in the development of any biological control programme, and should certainly be an early step in the development of integrated pest management programmes.

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