



A Preliminary Study on Relationships among Selected Australian Members of the Tribe Spilomelini (Lepidoptera: Crambidae: Pyraustinae)

Author: Sutrisno, Hari

Source: Zoological Science, 19(8) : 915-929

Published By: Zoological Society of Japan

URL: <https://doi.org/10.2108/zsj.19.915>

A Preliminary Study on Relationships among Selected Australian Members of the Tribe Spilomelini (Lepidoptera: Crambidae: Pyraustinae)

Hari Sutrisno*†

Museum Zoologicum Bogoriense, Cibinong, PO. Box 25, Bogor, Indonesia

ABSTRACT—A preliminary study was conducted on phylogenetic relationships among some selected genera of the Australian Spilomelini, focusing on relationships among the Australian *Glyphodes* group (*Glyphodes* Guenée, 1854, *Dysallacta* Lederer, 1863, *Talanga* Moore, 1885 and *Agrioglypta* Meyrick, 1932) and the 17 genera which are morphologically similar to it. Representatives of three genera of the Pyraustini were used as outgroups. Cladistic analysis of morphological data from the adult moths produced 10 equally MP trees (length = 221, CI=0.294, and RI=0.608). The clade formed by the 21 selected genera of the Australian Spilomelini had low bootstrap support even though a good apomorphy supported the monophyly of this group, namely, a strong, bilobed praecinctorium of abdominal tympanal organs. The analysis showed that the *Glyphodes* group is not monophyletic because the genus *Chrysothyridia* Snellen appears within it in the 10 MP trees. The concept of the *Glyphodes* group should be expanded to include *Chrysothyridia* and also the *Synclera* Zeller and *Didymostoma* (Walker) since the *Synclera* + *Didymostoma* clade, as the hypothesised sister group of the *Glyphodes* group, is not sufficiently supported as a separate monophyletic group. The analysis also showed that genus *Glyphodes* is not a monophyletic group, while *Metallarcha* Meyrick is a monophyletic group.

Key words: apomorphies, *Glyphodes* group, monophyly, parsimonious trees, phylogeny

INTRODUCTION

The Spilomelini was erected by Guenée (1854) as the family Spilomelidae, based on the type genus *Spilomela* Guenée. Munroe (1976) treated the group at tribal level and put it under the subfamily Pyraustinae. This concept was followed by Common (1990), Scoble (1992), Shaffer *et al.* (1996) and Munroe & Solis (1999).

As for most other crambid genera, the genera of the Australian Spilomelini are poorly defined and the relationships among them have never been examined. The current classification of the Australian Spilomelini is based on external similarity only, which has proved to be taxonomically unreliable for crambids in comparison to genitalic structures, and the monophyly of each genus of the Spilomelini needs to be examined phylogenetically.

The Spilomelini is a large tribe, with more than half of the species of pyraustines belonging to it. In Australia, there are about 360 species represented in about 125 genera

(Shaffer *et al.* 1996). Therefore, only some genera of the Spilomelini were chosen and included in this study.

The aim of this preliminary study was to reconstruct the phylogenetic relationships among some selected genera of the Australian Spilomelini with focus on the relationships among 17 genera which are similar morphologically to the Australian *Glyphodes* group. The four genera, *Glyphodes*, *Talanga*, *Dysallacta* and *Agrioglypta* were defined as the *Glyphodes* group by Hampson (1896) based on external features such as palpi upturned, the 2nd segment broadly scaled in front, the 3rd segment porrect, maxillary palpi triangularly dilated with scales, antennae of male near simple, tibia with the outer spurs less than half the length of inner, and male with the anal tuft large. A cladistic study was undertaken using morphological characters of the adult moths, including many features from the male and female genitalia.

MATERIALS AND METHODS

Materials

Most specimens used in this study belong to the Australian National Insect Collection (ANIC), CSIRO Entomology, Canberra, or were borrowed from the National History Museum, London

* Corresponding author: Tel. +81-11-706-2251;
FAX. +81-11-706-4864.
E-mail: hari@ees.hokudai.ac.jp

† Present address: Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan.

(BMNH). Both the outgroup and ingroup taxa included in the analysis are listed in Appendix 1.

Preparation of slide-mounts

Head structure preparation was made of each species used in the analysis. The labial palpi, the maxillary palpi and the antennae were dissected and mounted into euparal. The wing preparation was made following Common (1990) whereas the genitalic preparation following Robinson and (1976) and Maes (1985).

Morphological terms

The morphological terms used for adult features are as given in Zimmerman (1958), Munroe (1976), and Maes (1995). Definitions of certain terms which have been modified are given below:

The terms "strongly sclerotized" and "weakly sclerotized" refer to degree of sclerotization of various structures. A strongly sclerotized structure is darkened and totally opaque, and weakly sclerotized one is yellow brown, readily visible but translucent.

Choice of Outgroup

The most appropriate outgroup taxa for this analysis were gen-

era from the sister group of the Spilomelini, which is the Pyraustini (Common, 1990; Munroe, 1976). *Pyrausta testalis* (Fabricius) was chosen as the prime outgroup (= *Pyrausta* 1), and *P. panopealis* (Walker) (= *Pyrausta* 2), *Isocentris filalis* Guenée and *Hyalobathra archeleuca* Meyrick were used as the comparison outgroups.

Choice of Ingroup

In this study, the ingroup taxa was chosen for those genera which share certain morphological characters with the *Glyphodes* group (Hampson 1896), such as shape of head, structures of maxillary and labial palpi, wing venation and abdomen features. I assumed that they were closely-related genera even though this criteria was assessed only based on an external examination which does not guarantee a close relationship. All the selected taxa are the type species of the genus concerned, unless otherwise stated.

In this analysis, I used three species of *Glyphodes* to represent the range of variation of the genus. The selected species were *G. stolalis* Guenée (the type species of the genus, referred to as *Glyphodes* 1), *G. bicolor* (Swainson) (referred to as *Glyphodes* 2) and *G. bivitalis* Guenée (referred to as *Glyphodes* 3). I used two species to represent *Metallarcha* because it is a large genus for

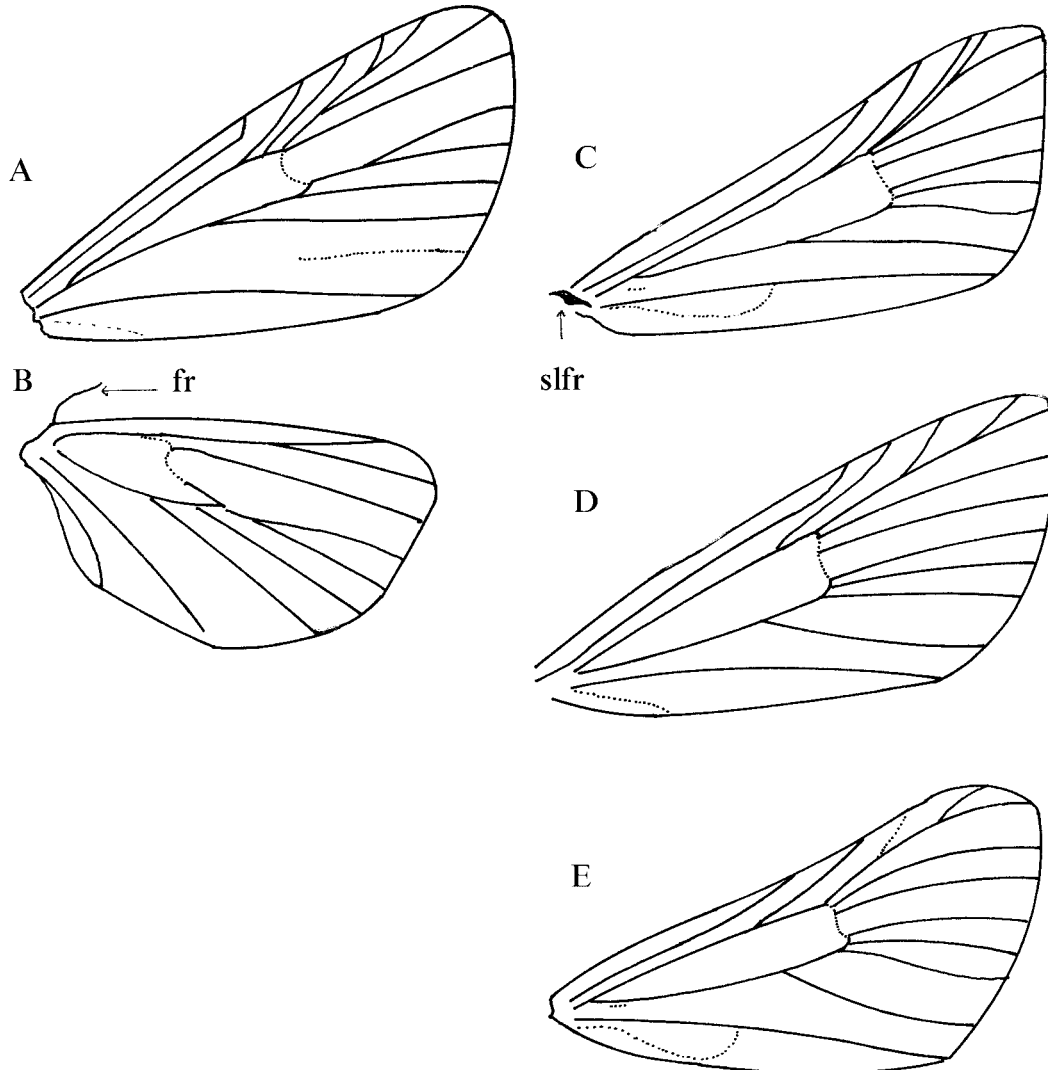


Fig. 2. Wing venation of male: A. Forewing of *Aboetheta pteridonoma*; B. Hindwing of *A. pteridonoma*; C. Forewing of *Pyrausta panopealis*; D. Forewing of *Tatobotys janapalis*; E. Forewing of *Niphograptia alboguttalis*. slfr.-strap-like frenulum hook; fr.-frenulum.

which the current classification is based on external characters only (Shaffer *et al.*, 1996). *Metallarcha* was represented by *M. eurychrysa* Meyrick (the type species of the genus, referred to as *Metallarcha* 1) and *M. diplochrysa* Meyrick (referred to as *Metallarcha* 2) in the subsequent analysis. All other genera were represented by just their type species.

Characters used

A total of 42 characters from the head, thorax, abdomen and genitalia structure were chosen. All characters were treated as

ordered (Wagner Parsimony) with the exception of character 16 which was treated as unordered. The data matrix for morphological characters used in the analysis is presented in Appendix 2.

Head structure:

1. Shape of frons of head: (0) rounded; (1) flat. The character state of rounded is plesiomorphic condition.
2. Antennal ciliation on male: (0) normal; (1) reduced. The character state of normal (0) is plesiomorphic condition.
3. Antennal ciliation of male and female: (0) of equal length; (1) of different length. The character state of equal length is ple-

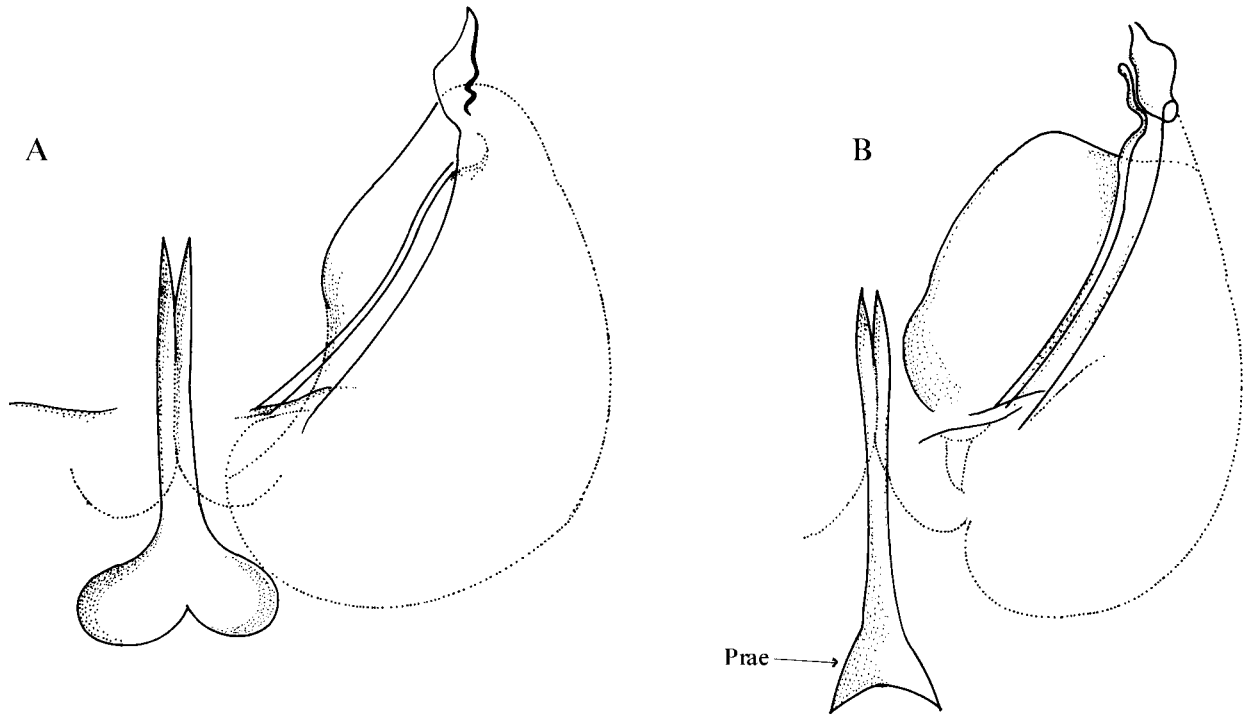


Fig. 3. Praecinctorium of tympanum: A. *Glyphodes bivitalis*; B. *Pyrausta panopealis*. prae.-praecinctorium.

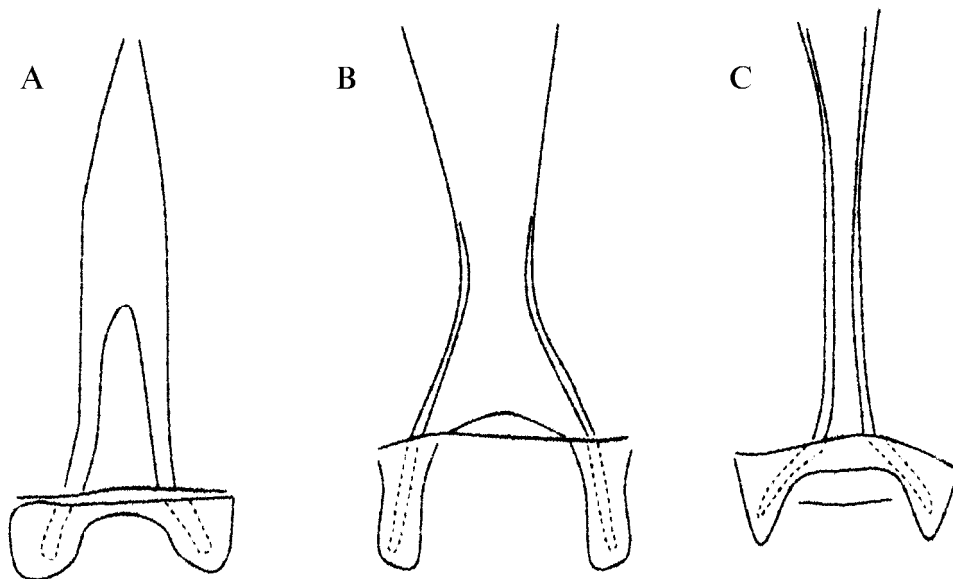


Fig. 4. T8 of male: A. *Pyrausta testalis*; B. *Talanga sexpunctalis*, C. *Glyphodes stolalis*.

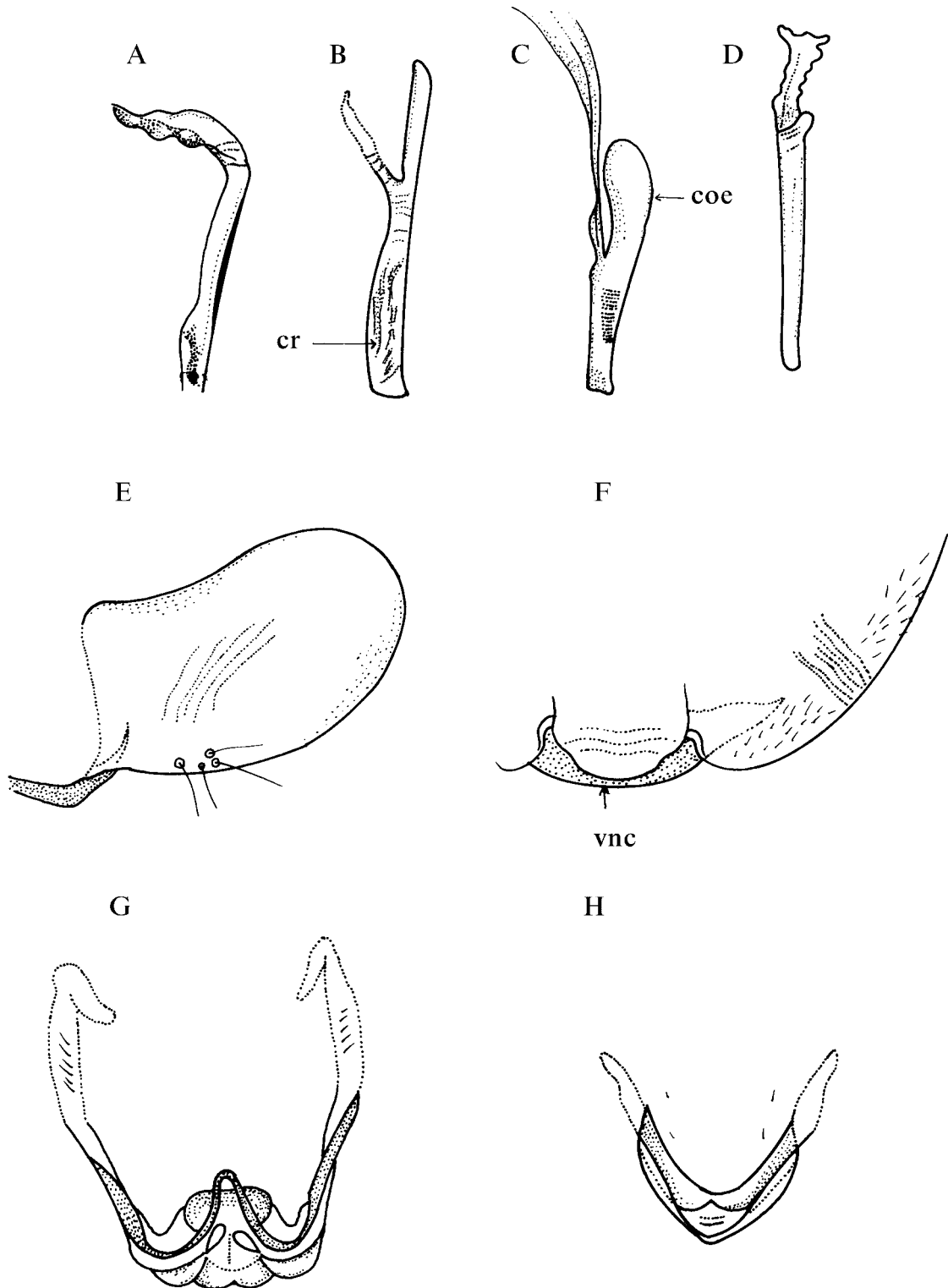


Fig. 5. A–D, Aedeagi and E–H Vinculum of male genitalia: A. *Glyphodes stolalis*; B. *Diasemiopsis ramburialis*; C. *Diplopseustis perieresalis*; D. *Tatabotys janapalis*; E. *Aboetheta pteridonoma*; F. *Hyalobathra archeleuca*; G. *Glyphodes stolalis*; H. *Hymenia perspectalis*. cr.-cornuti; coe.-coecum; vnc.-vinculum.

siomorphic condition.

4. Labial palpus: (0) ascending or upturned; (1) forward directed. I assumed that the character state of ascending or upturned is plesiomorphy.
5. Third segment of labial palpus: (0) ovate or rounded; (1) cylindrical or elongate. I assumed that the character state of ovate or rounded (0) is plesiomorphy.
6. Length of second segment of labial palpus: (0) very long, more than 2x length of first segment; (1) short, longer than length of first segment but less than 2x length of first segment; (2) very short, less than length of first segment. I assumed that the character state of very long more than length of first segment (0) is plesiomorphy.
7. Length of last segment of maxillary palpus: (0) longer than length of 3rd segment; (1) as long as or shorter than length of 3rd segment. The character state of longer than length of 3rd segment is plesiomorphic condition.

Thorax:

8. Base of costa of forewing of male: (0) a strap-like frenulum hook present (Fig. 2.C); (1) a strap-like frenulum hook absent. This structure is very difficult to observe on the specimens and very often is lost during slide preparation. The best way to observe it is by removing the scales at the base of the costa with a fine brush. I assumed that the character state of a strap-like frenulum hook absent (1) is apomorphy for Spilomelini.
9. Frenulum of female: (0) >2 bristles; (1) only 1 bristle. I assumed that the character state of >2 bristles (0) is plesiomorphy.
10. Veins 1A+2A of forewing of male: (0) forming a loop (Figs. 2.C, 2.E); (1) not forming a loop (Figs. 2.A, 2.D); If vein 1A+2A are very slightly stained but form a loop, even if is not complete, they were scored as state 1. I assumed that the character state of not forming a loop (1) is apomorphy for Spilomelini.
11. Wing venation of forewing of male: (0) R 2 distinctly separate

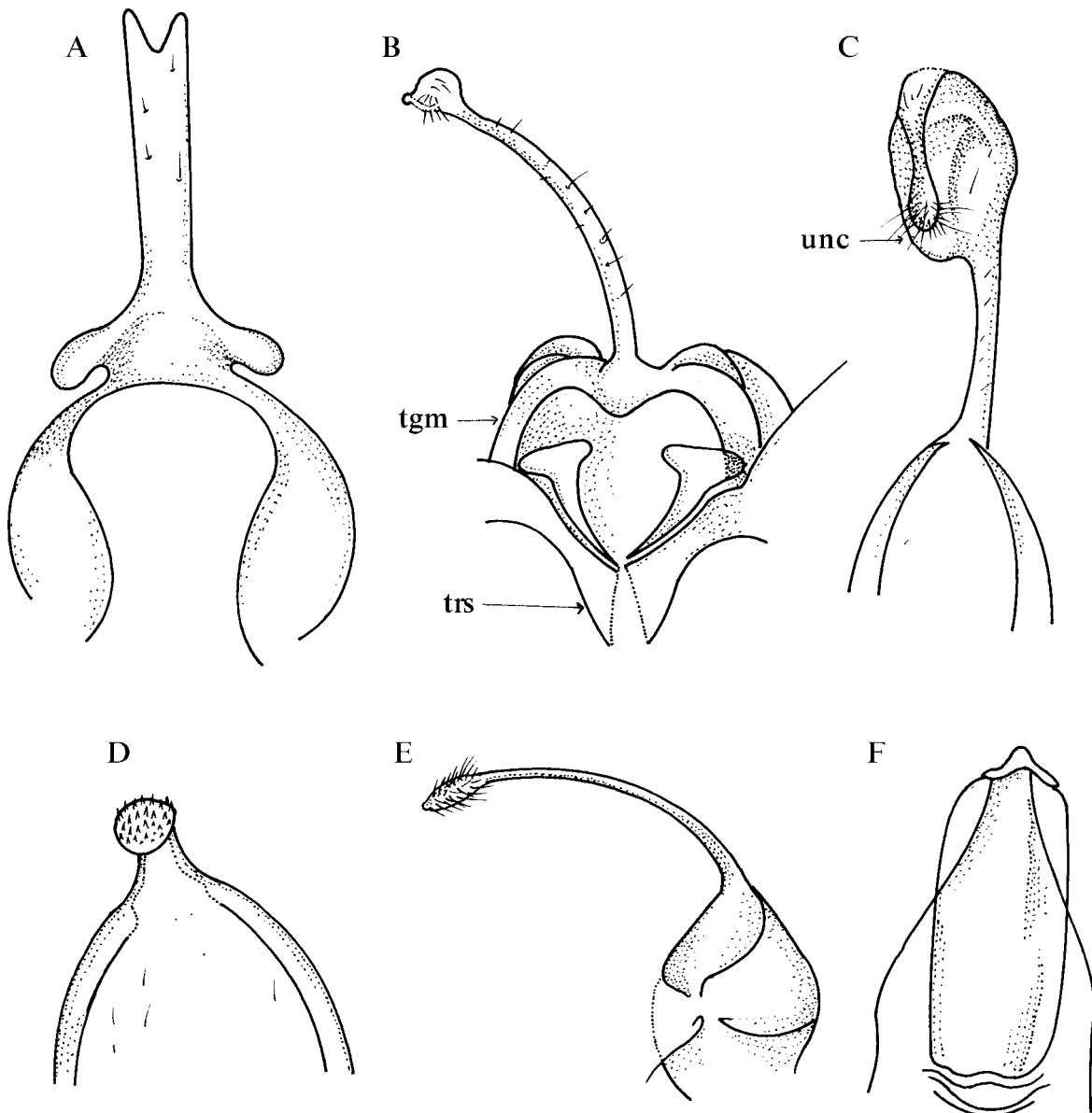


Fig. 6. Uncus and tegument of male genitalia: A. *Hyalobathra archeleuca*; B. *Glyphodes stolalis*; C. *G. bivitalis*; D. *Hymenoptychis sordida*; E. *Synclera traducalis*; F. *Sameodes cancelalis*. trs.-transtilla; tgm.-tegumen; unc.-uncus.

from R 3+R 4 (Fig. 2.D); (1) R 2 close at basal of with R 3+R 4 (Fig. 2.C); (2) R 2 fused to middle of R 3+R 4 (Fig. 2.D). The characters state of R 2 distinctly separate from R 3+R 4 is plesiomorphy.

12. Base of R 5 of male's forewing: (0) from discal cell (Figs. 2.C, 2.D); (1) stalked with R 3+R 4 (Fig. 2.A). The character state from discal cell (0) is plesiomorphic condition.
13. Wing pattern of forewing on both sex: (0) median band normal, narrow; (1) median band wide; (2) median band absent, transparent dots present; (3) no median band, no transparent dots but other patterns. I assumed that the character state of median band normal, narrow (0) is plesiomorphic condition.

Abdomen:

14. Praecinctorium of tympanum: (0) weakly bilobed (Fig. 3.B); (1) strongly bilobed (Fig. 3.A). The character state of strongly

bilobed (1) is apomorphic condition for Spilomelini.

15. Hair pencil of S8: (0) absent; (1) present. The character state of present (1) is apomorphic condition.
16. T8 sclerite (inverted): (0) not forming inverted Y-shaped sclerite (Fig. 4.A); (1) roughly inverted Y-shaped sclerite, lateral margin parallel only in posterior 1/3 (Fig. 4.B); (2) clearly inverted Y-shaped sclerite and parallel in posterior 2/3 (Fig. 4.C). This character was treated as unordered.
17. Shape of 8th abdominal segment in male: (0) abdomen normal; (1) very long. The character state of abdomen normal (0) is plesiomorphic condition.
18. Scaling of 8th abdominal segment in male: (0) dense bundle of scales present; (1) without dense bundle of scales. The character state of dense bundle of scales present is plesiomorphy.

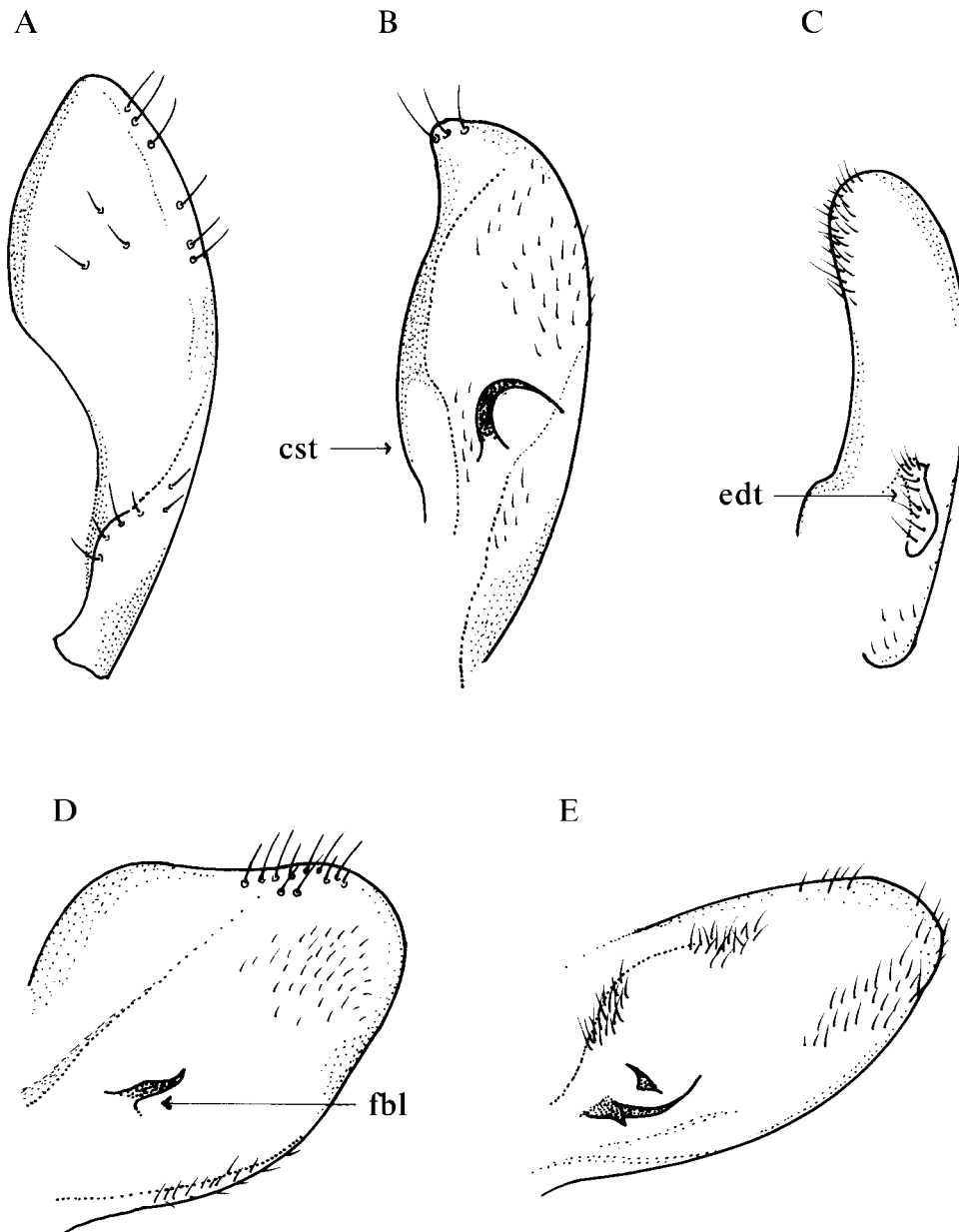


Fig. 7. Valvae of male genitalia (ventral view): A. *Myrmidonistis hoplora*; B. *Sameodes cancellalis*; C. *Pyrausta panopealis*; D. *Glyphodes bivitalis*; E. *Hymenoptychis sordida*. cst.-costa; edt.-editum; fbl.-fibula.

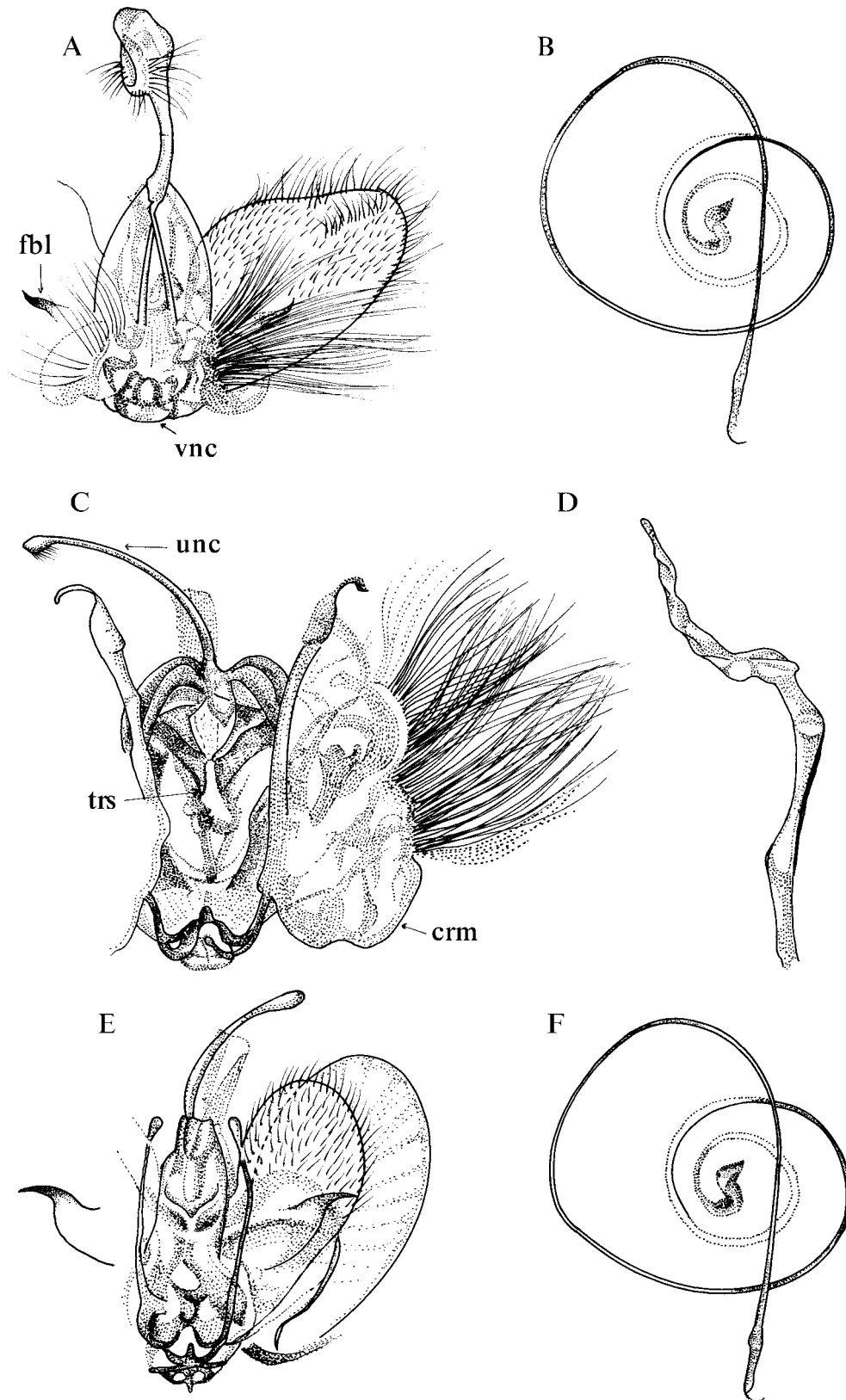


Fig. 8. Male genitalia: valvae and aedeagi: A, B. *Glyphodes bivitalis*; C, D. *G. stolalis*; E, F. *Talanga sexpunctalis*. crm.-coremata; fbl.-fibula; trs.-transtila; unc.-uncus; vnc.-vinculum.

Male genitalia:

19. Length of aedeagus: (0) short, less than length of abdomen (Figs. 5.A-5.D); (1) very long, narrow, more than length of abdomen (Figs. 8.B, 8.F). The character state of very long, narrow, more than length of abdomen is apomorphic condition.
20. Cornuti: (0) present (Fig. 5.B); (1) absent. The character state of cornuti present (0) is plesiomorphic condition.
21. Coecum of aedeagus: (0) absent; (1) short (Fig. 5.A); (2) long (Fig. 5.B); (3) modified (Fig. 5.C). The character state of absent (0) is plesiomorphic condition.
22. Sclerotization ventrally along aedeagus: (0) absent; (1) present (Fig. 5.A). The character state of absent (0) is plesiomorphic condition.
23. Uncus: (0) present with a long "neck" (Figs. 6.A, 6.B); (1) present with a short "neck" (Fig. 6. D); (2) reduced (Fig. 6.F). The character state of present with long "neck" (0) is plesiomorphic condition.
24. Apex of uncus: (0) with strong, short spines (Fig. 6.D); (1) with

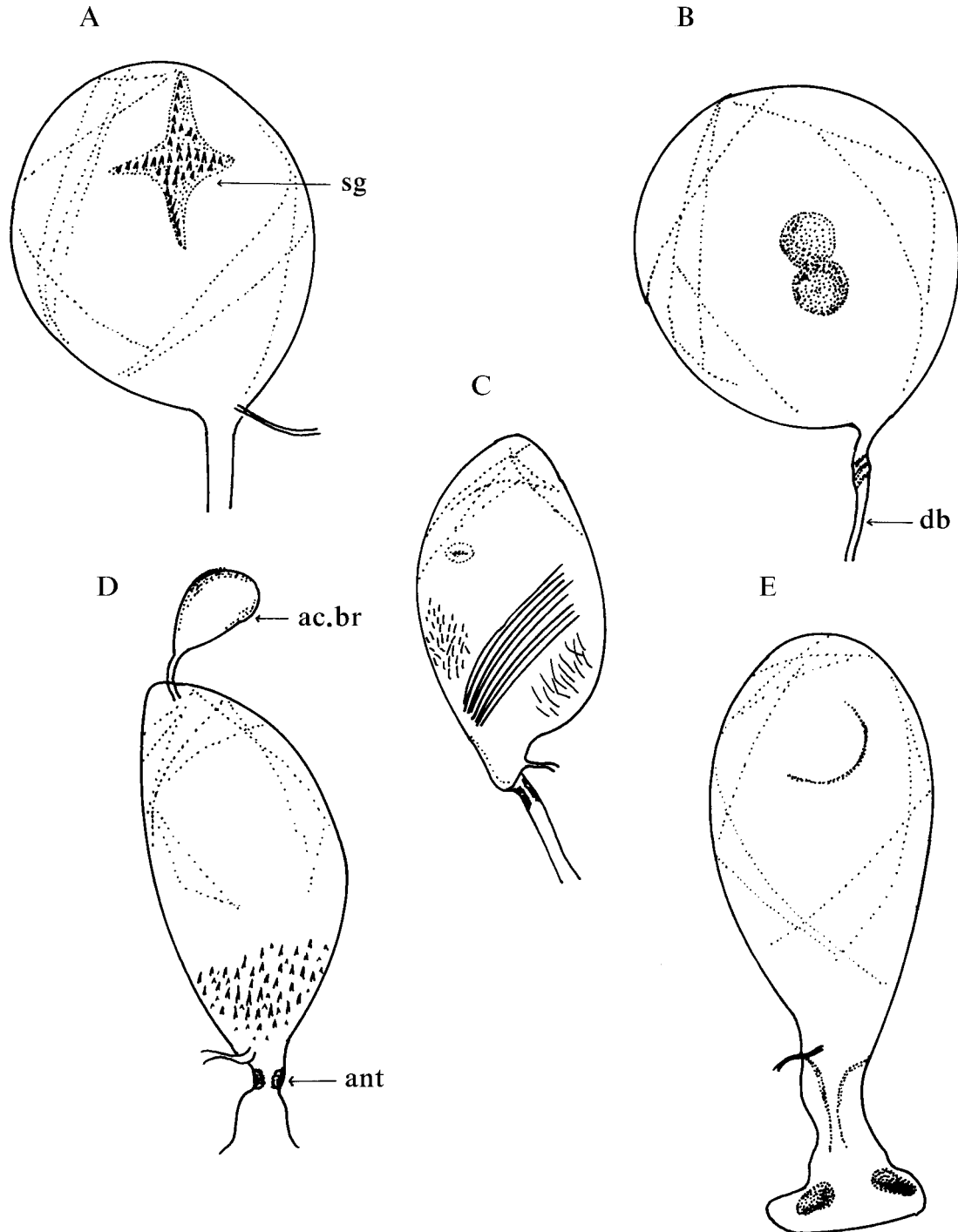


Fig. 9. Corpus bursae: A. *Hyalobathra archeleuca*; B. *Talanga sexpunctalis*; C. *Spoladea recurvalis*; D. *Otiophora leucura*; E. *Metallarcha eurychrysa*. ac.br.-accessory bursae; ant.-antrum; db.-ductus bursae; sg.-signum.

- hair (Fig. 6.B); (2) without spines or hair (Fig. 6.A). The character state of with strong, short spines (0) is plesiomorphic condition.
25. Base of uncus: (0) united to tegumen (Figs. 6.D, 6.E); (1) split from tegumen (Fig. 6.A–6.C); For taxa without uncus this character was scored as ? (inapplicable). The character state of split from tegumen (0) is plesiomorphic condition.
26. Sclerotization of base of tuba analis: (0) present, normal sclerotized (Fig. 6.B); (1) absent; (0) present, weakly sclerotized. The character state of present, normal sclerotized (0) is plesiomorphic condition.
27. Sclerotization of transtilla: (0) normal, sclerotized; (1) strongly sclerotized (Fig. 6.B); (2) not sclerotized. The character state of normal sclerotized (0) is plesiomorphic condition.
28. Costa: (0) inflated (Fig. 7.B); (1) not inflated. The character state inflated (0) is plesiomorphic condition.
29. Valva: (0) no fibula but editum or sella present (Fig. 7.C); (1) fibula present, normal (Figs. 7.D); (2) fibula with tip recurved (Fig. 7.B); (3) more than 1 fibula present (Fig. 7.E); (4) without any processes (Fig. 7.A). The character state of no fibula but editum or sella present is plesiomorphy.
30. Valva: (0) without any sclerotization along middle (Figs. 7.A–7.C); (1) with sclerotization along middle (Fig. 7.D). The character state of without any sclerotization along middle (0) is plesiomorphic condition.
31. Ventral angle of vinculum: (0) simple, strongly curved, ovate, triangular, ventrally not expanded (Fig. 5.A); (1) ventral portion of vinculum not expanded, hardly curved (Fig. 5.F); (2) ventral angle with keel-shaped sclerotized extension (Fig. 5.H); (3) ventral angle with sclerotized extension not keel-shaped but invaginated (Fig. 5.G). The character state of simple, strongly curved, ovate, triangular, ventrally not expanded (0) is plesiomorphic condition.
32. Base of coremata: (0) absent; (1) present but simple; (2) complex structures without extension (Fig. 8.C); (3) complex structure with a lamellate extension (Fig. 8.E). The character state of absent (0) is plesiomorphic condition.
33. Shape of coremata scales: (0) long, hair-like smooth (Fig. 8.A); (1) long, large, paddle-shaped scales; (2) long, hair-like with sculptured surface (Fig. 8.C); (3) strong widened, lamellate scales (Fig. 8.E). For taxa without base of coremata this character was scored as ? (inapplicable). The character state of long, hair-like smooth (0) is plesiomorphic condition.
- Female genitalia:*
34. Corpus bursae: (0) with a smooth membranous wall (Figs. 9.A, 9.B); (1) with spines or sclerotization on wall (Figs. 9.C, 9.D). The character state of with a smooth membranous wall (0) is plesiomorphic condition.
35. Signum: (0) present, only one, rhomboidal-shaped (Fig. 9.A); (1) present, only one, not rhomboidal-shaped (Fig. 9.E); (2) present, a pair (Fig. 9.B); (3) absent. The bipartite signum of *G. bicolor* was treated as state 2. The character state of present one, rhomboidal-shaped (0) is plesiomorphic condition.
36. Length of ductus bursae: (0) very short, antrum attached directly to corpus bursae (Fig. 9.D); (1) long, antrum separated from corpus bursae by distinct ductus bursae (10.A–10.C). The character state very short, antrum attached directly to corpus bursae (0) is plesiomorphic condition.
37. Accessory bursae: (0) absent; (1) present (Fig. 9.D). The character state of accessory bursae absent (0) is plesiomorphic condition.
38. Ductus seminalis: (0) originating from corpus bursae (Figs. A, 9.C, 9.D); (1) originating from ductus bursae (Figs. 10.A–10.D). The character state of originating from corpus bursae (0) is plesiomorphic condition.
39. Antrum: (0) absent; (1) reduce to weakly sclerotized; (2) well-

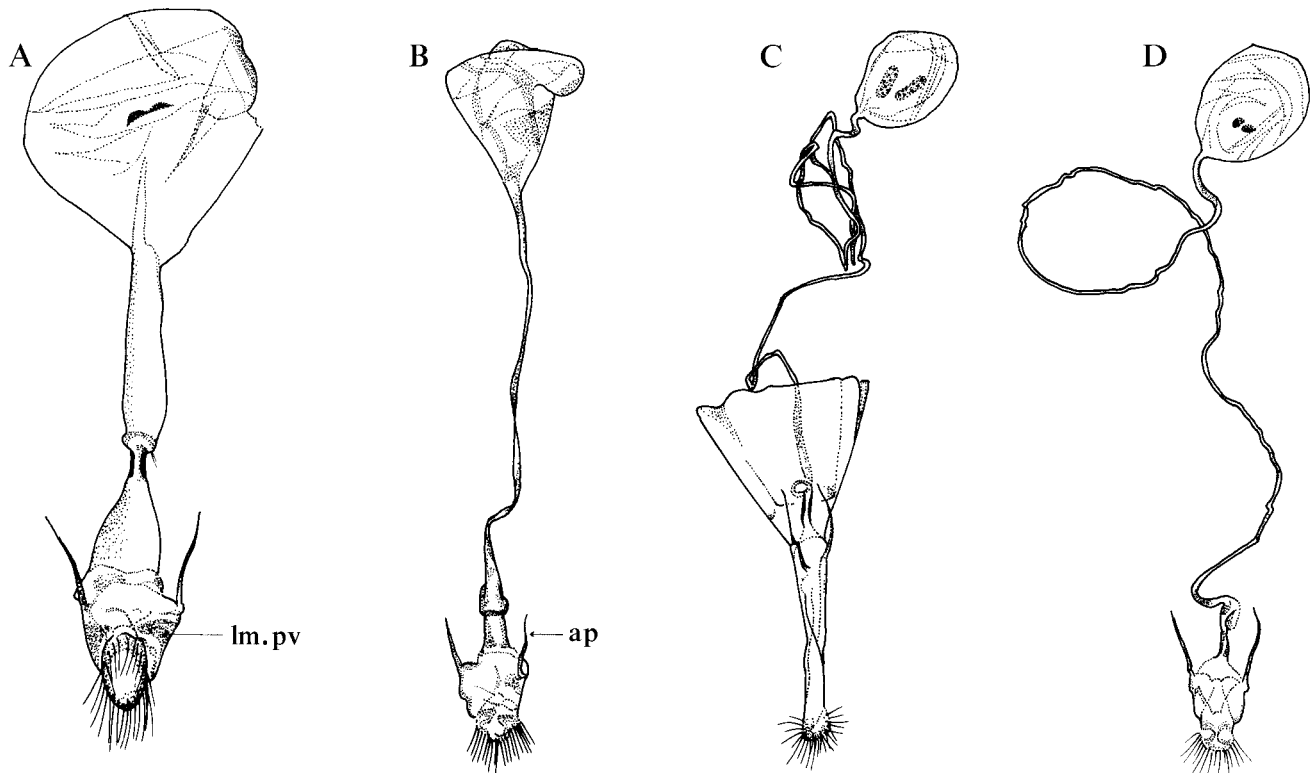


Fig. 10. Female genitalia: A. *Glyphodes bicolor*; B. *Glyphodes stolalis*; C. *Agrioglypta excelsalis*; D. *Talanga sexpunctalis*. lm.pv.-lamella post vaginalis; ap.-apophysis.

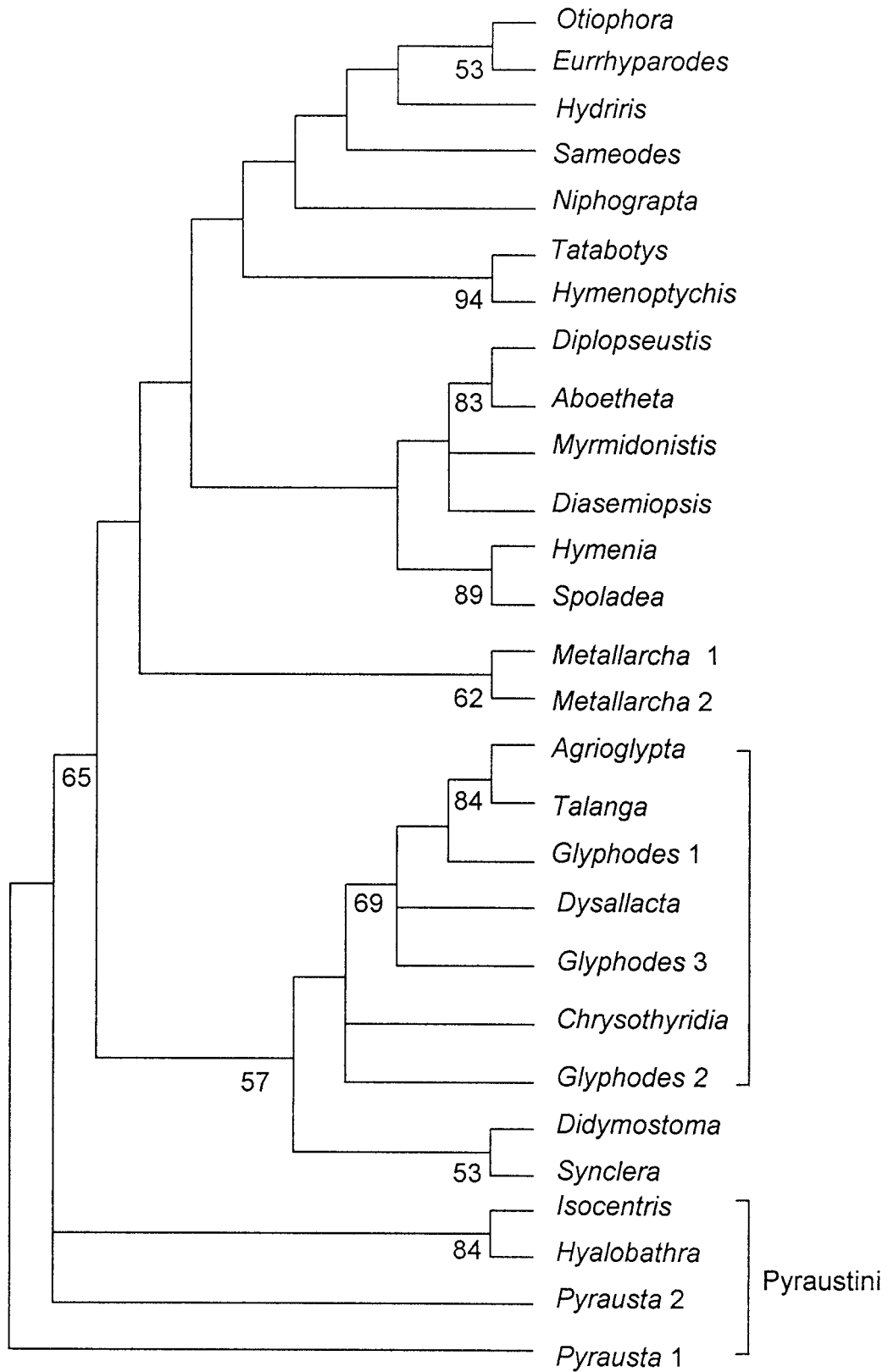


Fig. 1. A strict consensus of the 10 MP trees, numbers on the node are bootstrap values (from 100 bootstrap replicates × 10 *random addition sequences*).

sclerotized (Fig. 9.D). The character state of absent is plesiomorphy.

40. Sclerotization of anterior most part of ductus bursae, posterior to antrum: (0) present (Fig. 10.A); (1) absent. The character state of present (0) is plesiomorphic condition.
41. Sclerotization of lamella postvaginalis: (0) present (Fig. 10.A); (1) absent. I assumed that the character state of present (0) is plesiomorphic condition.
42. Length of anterior apophyses: (0) longer than posterior apophyses; (1) shorter than posterior apophyses. The character state of longer than posterior apophyses (0) is plesiomorphic condition.

Phylogenetic Inference

The cladistic analysis was undertaken using PAUP*4.0 beta version (Swofford 1998) on a Macintosh computer, and involved 42 characters and 28 taxa. All searches of the data matrix were performed with the Heuristic option. Random addition with 10 replicates was used to generate initial trees for TBR branch-swapping routine.

The MP trees that resulted from this analysis were summarized in a strict consensus tree. Bootstrap tests (Felsenstein 1985) and T-PTP (Topology-dependent cladistic permutation Tail Probability) tests (Faith 1991) were applied to estimate support for clades in the tree. The MacClade version 3 (Maddison & Maddison 1992) was used to evaluate the changes of character states.

RESULTS

A heuristic search in PAUP with all taxa included produced 10 equally MP trees (length=221, CI=0.294, and RI=0.608). The genus *Chrysothyridia* consistently appears within the *Glyphodes* group.

A strict consensus tree, with bootstrap support indicated, is presented in **Fig. 1**. Only a few nodes have bootstrap support. Support for the monophyly of the 24 taxa of the Spilomelini is very low. The monophyly of the group ((*Didymostoma* + *Synclera*) + (*Glyphodes* 2 + (*Chrysothyridia* + (*Glyphodes* 1 + (*Glyphodes* 3 + (*Dysallacta* + (*Agrioglypta* + *Talanga*)))))) and the group (*Glyphodes* 1 + (*Glyphodes* 3 + (*Dysallacta* + (*Agrioglypta* + (*Talanga*))))) also are weakly supported.

A T-PTP test was conducted only for the monophyly of the group formed by *Didymostoma* + *Synclera* + *Glyphodes* 2 + *Chrysothyridia* + *Glyphodes* 1 + *Glyphodes* 3 + *Dysallacta* + *Agrioglypta* + *Talanga*. There were significant support for the monophyly for the group, with P (normal) 0.01 and P (reverse) 1.0.

The list of apomorphies demonstrating the monophyly of the groups is presented here only for those groups that comprise more than two taxa and which have bootstrap support. Only the apomorphies that are regarded as unambiguous or least controversial are listed for each monophyletic group considered.

The monophyly of the 24 taxa of the Spilomelini is supported by the following possible apomorphies:

1. A strong, bilobed praecinctorium (a median extension of the intersegmental thoracho-abdominal membrane) of abdominal tympanal organs. This state is assumed to be the ancestral condition for the Spilomelini following

Munroe (1976) and Minet (1981, 1991).

2. Base of costa of male's forewing without a strap-like frenulum hook. It is possible that the loss of a strap-like frenulum hook has occurred several times in other sub-families of the Crambidae.

The possible apomorphies of the group ((*Didymostoma* + *Synclera*) + (*Glyphodes* 1 + (*Glyphodes* 2 + (*Glyphodes* 3 + (*Chrysothyridia* + (*Dysallacta* + *Agrioglypta* + (*Talanga*)))))) are:

1. Signum paired. This state is assumed to be apomorphic condition of this group. All the members of this group have paired signa except *Glyphodes* 1 where the signum is reduced to a thickening of the bursa wall. I assumed that the signum of this species is reduced into a thickening of the bursa wall.
2. T8 (inverted) forming a roughly Y-shaped sclerite, with its lateral margin parallel only in posterior 1/3. This state is known to have evolved several times within the Spilomelini. T8 (inverted) of *Pyrausta* also forms a roughly Y-shaped sclerite, with the lateral margin parallel only in posterior 1/3.

The monophyly of the group ((*Glyphodes* 1 + (*Glyphodes* 3 + (*Dysallacta* + (*Agrioglypta* + (*Talanga*)))))) is supported by the following possible apomorphies:

1. Apex of uncus with hairs. This state is known to have evolved twice during its evolution within the Spilomelini. In *Otiopora*, apex of the uncus also has hairs.
2. Cornuti absent. The loss of cornuti occurs several times within the pyraustines and frequently in all crambids group where cornuti are present in the ground plan.

DISCUSSION

In the 10 equally MP trees, the genus *Chrysothyridia* appears consistently within the *Glyphodes* group. The four genera, *Glyphodes*, *Talanga*, *Dysallacta* and *Agrioglypta*, that were believed to form a monophyletic group (Hampson, 1896; Shaffer in pers. comm), but do not do so unless the generic concept is expanded. Species of *Chrysothyridia* share at least one good apomorphy with the *Glyphodes* group, namely paired signa. The analysis also shows that the genus *Glyphodes* is not a monophyletic group, whereas the two species of *Metallarcha* do form a monophyletic group.

Well-supported relationships occur only for the following taxon pairs: *Talanga* and *Agrioglypta*, *Hymenia* and *Spoladea*, *Diplopseustis* and *Aboetheta*, *Tatabotys* and *Hymenoptychis*, and *Otiopora* and *Euryparodes*.

The bootstrap analysis showed that the group formed by the 24 taxa of the Spilomelini is poorly supported. It is important to note that the low bootstrap support for monophyly does not amount to evidence of non-monophyly. A node supported by relatively few characters will be recovered infrequently in bootstrap replicates, even if there is evidence for their existence through apomorphies (Trueman

1993). According to Trueman (1993) and Bremer (1994) it is possible that in the bootstrap test some of the original characters may not be sampled and are thus omitted, whereas other characters are sampled more than once. At least one good apomorphy, namely, a strong, bilobed praecinctorium of abdominal tympanal organs supports the Spilomelini.

The group formed by *Didymostoma* + *Synclera* + *Glyphodes 2* + *Chrysothyridia* + *Glyphodes 1* + *Glyphodes 3* + *Dysallacta* + *Agrioglypta* + *Talanga* also receives low bootstrap support (57%) but the T-PTP test gives significant support. The group formed by *Didymostoma* + *Synclera* and the group formed by *Glyphodes 2* + *Chrysothyridia* + *Glyphodes 1* + *Glyphodes 3* + *Dysallacta* + *Agrioglypta* + *Talanga* did not receive bootstrap support. The *Didymostoma* + *Synclera* clade as the hypothesised sister group of the *Glyphodes* group, is not sufficiently supported as a separate monophyletic group. Therefore the definition of the *Glyphodes* group should be expanded to include also these two genera. There could be more genera of the *Glyphodes* group since only 17 genera apart of the *Glyphodes* have been sampled in this study.

This current analysis should be regarded as preliminary because it was based only on the adults of selected genera of Spilomelini. More species of the Spilomelini need to be examined, and further analysis should be based not only on adult characters but also on other characters sources such as the immature stages, molecular data and biological information in order to test the validity of the relationships proposed here.

ACKNOWLEDGMENTS

I am grateful Dr. M. Horak from CSIRO Entomology, Canberra and Dr. P. J. Gullan from Division of Entomology, University of California, Davis, USA (formerly of the Australian National University) for discussing and advising during my research and also for critical comments that improved the manuscript. My thanks go to the Director of Australian National Insect Collection, CSIRO Entomology and to the School of Botany and Zoology, the Australian National University, Canberra, for providing of all the facilities for my research studies. I thank Mr Kevin R. Tuck who kindly arranged the loan specimens from the Natural History Museum, London and Mr M. Shaffer (Natural History Museum, London) and Mr E. D. Edwards (CSIRO Entomology), who generously answered numerous que-

ries. This study was supported by a grant from GEF-Indonesia Biodiversity Project.

REFERENCES

- Bremer K (1994) Branch support and tree stability. *Cladistics* 10: 295–304
- Common I F B (1990) *Moths of Australia*. Melbourne University Press, Carlton
- Faith D (1991) Cladistic permutation tests for monophyly and non-monophyly. *Syst Zool* 40: 366–375
- Felsenstein J (1985) Confidence limits on phylogenies: an approach using the bootstrap. *Evolution* 39: 783–791
- Guenée A (1854) *Species général des Lépidoptères*. Tome huitième. Deltoïdes et Pyralites. Librairie Encyclopédique Roret, Paris
- Hampson G H (1896) *The fauna of British India, including Ceylon and Burma. Moths*. Vol 4. Taylor and Francis, London
- Maddison W P, Maddison D R (1992) *MacClade: Analysis of Phylogeny and Character Evolution*. Sinauer Associates, Inc. Sunderland, Massachusetts, USA
- Minet J (1981) Les Pyraloidea et leurs principales divisions systématiques (Lep: Ditryisia). *Bull Soc Entomol France* 1981: 262–280
- Minet J (1983) Étude morphologique et phylogénétique des organes tympaniques des Pyraloidea. 1. Généralités et homologues (Lepidoptera: Glossata). *Ann Soc Entomol France* 19 (2): 175–207
- Minet J (1991) Tentative reconstruction of the ditryisian phylogeny. *Entomol Scand* 22: 69–95
- Munroe E (1976) Pyraloidea Pyralidae comprising the subfamily Pyraustinae tribe Pyraustini (part). pp 1–78 In: Dominick, R. B. *et al.*, (ed). *The Moths of America North of Mexico* 13.2b. E.W. Classey and The Wedge Entomological Research Foundation, London
- Munroe E, Solis M A (1999) The Pyraloidea. pp 233–256. In: Kristensen, N. P. (ed). *Lepidoptera, Moths and Butterflies; Volume 1: Evolution, Systematics, and Biogeography*. Walter de Gruyter, Berlin
- Scoble M J (1992) *The Lepidoptera: Form, Function and Diversity*. Oxford University Press, Oxford
- Shaffer M, Nielsen E S, Horak M (1996) Pyraloidea. In: Nielsen E S, Edwards E S, Rangsi T V (eds). *Checklist of the Lepidoptera of Australia*. CSIRO Australia
- Swofford D L (1998) PAUP*. *Phylogenetic Analysis Using Parsimony (* and Other Methods)*. Version 4. Sinauer Associates, Sunderland, Massachusetts
- Trueman J W H (1993) Randomization confounded: a response to Carpenter. *Cladistics* 9: 101–109

(Received December 15, 2001 / Accepted May 16, 2002)

Appendix 1. The list of the specimens examined**Outgroup:*****Hyalobathra archeleuca* Meyrick**

Queensland: 1#, 15°08'S 145°15'E, 37 km W of Cooktown, 22.i.1976, V. J. Robinson & Pratt. **New South Wales:** 1\$, 28°25'S 152°46'E, Richmond River, x.1923, V. J. Robinson.

***Isocentris filalis* Guenée**

Western Australia: 1#, 15°42'S 128°41'E, Ivanhoe, 7.iv.1962, IFBC. **Northern Territory:** 1\$, 14°27'S 132°16'E, Katherine, 17.iv.1962, IFBC.

***Pyrausta panopealis* (Walker)**

Northern Territory: 1#, 12°36'S 132°52'E, Mudginberri, 25.v.1973, EDE & MSU. **Queensland:** 1\$, 19°00'S 146°12'E, Paluma, 7.iv.1979, D. W. Frith.

***Pyrausta testalis* (Fabricius)**

Queensland: 1 #, 28°05'S 153°27'E, Burleigh, 17.vi.1963, MSU; 13, 7°34'S 151°57'E, Toowoomba, 9.iv.1973, IFBC.

Ingroup:***Aboetheta pteridonoma* Turner**

New South Wales: 2#, 30°20'S 152°43'E, Dorrigo NP, xi.1926, V. J. Robinson; 3\$, 5#, 30°24'S 152°21'E, Ebor, 5.i.1916.

***Agrioglypta enneactis* Meyrick**

Fiji: 3\$, 1#, Fiji, 1966/1967, H. S. Robinson (British Museum, 1967.236).

***Chrysothyridia invertalis* (Snellen)**

Queensland: 2\$, 2#, 13°45'S 143°22'E, Upper Leo Ck, Mcllwraith Ra, 11.vii.1989, E. S. Nielsen & EDE & M. Horak.

***Diasemiopsis ramburialis* (Duponchel)**

Queensland: 1\$, 28°10'S 153°32'E, Coolangatta, 8.ix.1913. **New South Wales:** 1#, 35°00'S 150°45'E, Jervis Bay, 17.v.1956, IFBC.

***Didymostoma euphranoralis* (Walker)**

Celebes [Sulawesi]: Type. 1#. Pyralidae. Brit. Mus. Slide No. 20111.

***Diplopseustis perieresalis* (Walker)**

New South Wales: 1#, 28°25'S 152°46'E, Richmond River, 23.ix.1934, V. J. Robinson; 1 \$, 29°01'S 151°04'E, Como West, 20.xi.1970, L. Willan & V. J. Robinson.

***Dysallacta negatalis* (Walker)**

New South Wales: 3\$, 28°25'S 152°46'E, Richmond River, i.1936, V. J. Robinson; 1#, 28°52'S 153°24'E, 2 km NE by E of Rous Mill, 18.x.1976, IFBC & EDE.

***Eurrhyarodes bracteolalis* (Zeller)**

Northern Territory: 1\$, 12°35'S 132°52'E, Magela Ck, 2 km N of Mudginberri, HS, 25.v.1973, EDE & MSU. **Queensland:** 1#, 12°40'S 142°41'E, Batavia Downs, 25.v.1993, P. Zborowski & A. Roach.

***Glyphodes actorionalis* Walker**

Queensland: 1#, 10°41'S 142°32'E, Cape York, 10.vi.1928, W. B. Barnard; 1\$, 10°48'S 142°28'E, Lockerbie Area, Cape York, 13-27.iv.1973, S. R. Monteith.

***Glyphodes bicolor* (Swainson)**

Northern Territory: 1\$, 11°01'S 136°45'E, Rimbija Isl., 14.i.1977, EDE; **Queensland:** 1#, 15°29'S 145°16'E, 1 km SE of Mt. Cook, Cooktown, 13.x.1980, EDE.

***Glyphodes stolalis* Guenée**

Western Australia: 2#, 14°33'S 126°57'E, Drysdale River, 18-21.viii.1975, IFBC & MSU. **Queensland:** 1\$, 10°48'S 142°28'E, Lockerbie, Cape York, 3.iii.1964, IFBC & MSU.

***Hydriris chalybitis* Meyrick**

Northern Territory: 1\$, 11°09'S 132°09'E, Black Point, Cobourg Pen., 19.v.1977, EDE; 1#, 12°35'S 132°52'E, Magela Ck, 2 km N of Mudginberri, HS, 25.v.1973, EDE & MSU.

***Hymenia perspectalis* (Hübner)**

Queensland: 5\$, 1#, 27°28'S 153°02'E, Brisbane, 3.vi.1906, F. P. Dodd.

***Hymenoptychis sordida* (Zeller)**

Queensland: 10\$, 2#, 12°46'S 143°17'E, Claudie River, 5-16.v.1961, J. Macqueen.

***Metallarcha diplochrysa* Meyrick**

New South Wales: 3\$, 3#, 31°18'S 149°02'E, Warrumbungles, 24.x.1967, V. J. Robinson.

***Metallarcha eurychrysa* Meyrick**

Queensland: 2\$, 1#, 28°21'S 145°45'E, 32 km S by E of Cunnamulla, 20.iii.1990, EDE & J. H. Fisk.

***Myrmidonistis hoplora* Meyrick**

Northern Territory: 2\$, 12°28'S 132°52'E, Jabiluka Lagoon, 14 km N of Mudginberri, 13.xi.1972, EDE & MSU. **Queensland:** 13, 1#, 11°45'S 142°35'E, Heathlands, 16-22.iii.1994, P. Zborowski.

***Niphograptia albiguttalis* (Warren)**

Queensland: 3\$, 3#, 27°28'S 153°02'E, Brisbane, 10.x.1978.

***Otiophora leucura* (Lower)**

Queensland: 1\$, 13°59'S 143°33'E, Silver Plains HS, Cape York, 7.v.1965, J. L. Wassel; 2#, 27°28'S 153°02'E, Brisbane, 21.ii.1906 ñ 15.x.1915.

***Sameodes cancellalis* (Zeller)**

Queensland: 1\$, 13°40'S 142°40'E, Rokeby, 26.v.1993, P. Zborowski & Shattuck; 1#, 14°54'S 142°50'E, Long Lagoon, Coleman River, 16.viii.1993, P. Zborowski & J. Balderson.

***Spoladea recurvalis* (Fabricius)**

Western Australia: 1\$, 21°35'S 117°04'E, 1 km NNE of Millstream, HS, 3.iv.1971, MSU & Mitchell. **Northern Territory:** 1#, 23°42'S 133°52'E, Alice Springs, 15.ii.1966, Britton & MSU & Mc Innes.

***Synclera traducalis* Zeller**

Africa: Type. 1#. Pyralidae. Brit. Mus. Slide No. 60.92.

***Talanga sexpunctalis* Moore**

Northern Territory: 1\$, 11°01'S 136°45'E, Rimbija Isl., 16.i.1977, EDE. **Queensland:** 2#, 17°16'S 145°54'E, Base Cableway, Mt. Belenden-Ker, 23.x.1981, EDE.

***Tatobotys janapalis* (Walker)**

Northern Territory: 1\$, 15°54'S 136°32'E, Batten Point, 30 km NE by E Borroloola, 30.x.1975, EDE. **Queensland:** 1#, 19°16'S 146°49'E, Townsville, 19.iii.1900, F. P. Dodd.

Abbreviation and Symbols used in **Appendix 1:**

#: male

\$: female

EDE: ED. Edwards.

IFBC: IFB. Common.

MSU: MS. Upton.

Appendix 2. Data matrix

	1	10	11	20	21	30	31	40	42
<i>Pyrausta 1</i>	1000001000		1000000100		1000120100		00?0001010		00
<i>Pyrausta 2</i>	1000001000		1000010101		0000120000		0100000010		00
<i>Isocentris</i>	1011101000		1000000101		0022?1100?		1000000010		10
<i>Hyalobathra</i>	0010001000		1000000101		1002101?0?		10?0011110		00
<i>Diploseustis</i>	0000000111		0131000101		2000?12040		00?0310111		11
<i>Aboetheta</i>	0000010111		0101000101		2002010040		00?0110111		11
<i>Otiophora</i>	00?0010110		0001100100		0121?12110		00?1301010		10
<i>Myrmidonistis</i>	0010000100		0101000100		1010120140		0100111011		00
<i>Hydriris</i>	0001011100		0101100100		1022?10110		00?1301021		00
<i>Eurrhyarodes</i>	0001011111		1001000100		0020?12110		00?1300020		10
<i>Sameodes</i>	1011011100		1001000000		0122?20120		0000100021		10
<i>Niphograptia</i>	00?0???100		1001000101		1022?10120		00?0300011		11
<i>Hymenia</i>	0001?11100		1001000?00		0100010141		2220100021		10
<i>Spoladea</i>	0001010100		1001000000		0100020140		2201100021		10
<i>Diasemiopsis</i>	0010010110		2001000100		2000010140		0101100011		10
<i>Metallarcha 1</i>	1010121111		2001000001		1100011110		0100100020		10
<i>Metallarcha 2</i>	1000110100		1001000001		1000011110		0100100020		10
<i>Chrysothyridia</i>	1011100100		1001010000		0100101041		0110210100		10
<i>Didymostoma</i>	1011111100		1001010101		0000020011		0100210100		10
<i>Tatabotys</i>	0101011101		2001001101		3020?00030		0110300010		10
<i>Hymenoptychis</i>	0101111101		2031001101		30100??030		0110310010		10
<i>Synclera</i>	1011121100		1021010100		0000010111		0100210100		10
<i>Dysallacta</i>	1001111100		1011020000		0002111011		3100210111		10
<i>Glyphodes 1</i>	1011111100		1011020001		0101101011		3220210120		10
<i>Glyphodes 2</i>	1001111100		1021010000		0100110011		0100210120		00
<i>Glyphodes 3</i>	1011101100		1021010011		?101121111		3100210111		10
<i>Agrioglypta</i>	1001101100		1011010011		?101110111		3330210111		01
<i>Talanga</i>	1001111100		1011010011		?101121111		3330210120		01