

On the female genitalia of some lycaenids of the tribe Arhopalini and the genus *Amblopala*, with a modification on their higher classification

(Lepidoptera, Lycaenidae)

by

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Abstract: ♀-genitalia of some species of the tribe Arhopalini BINGHAM, 1907 are described. Based upon the examination of specimens and the gathered information of external features and genital structures in literature, the higher classification of Arhopalini is revised. The genera *Mota* and *Zinaspa* are transferred from the *Semanga* and *Surendra* sections (sensu ELIOT, 1973) to the *Arhopala* section (sensu ELIOT, 1973). The higher classification of the genus *Amblopala* is also discussed, and we suggest that *Amblopala* should be transferred from Theclini to an independent tribe.

Material and method

The aim of this work is to discuss the higher classification of Arhopalini and *Amblopala*. The basic information has been gathered from the literature and the examination of specimens as follows:

Amblopala avidiæna: ♂-genitalia (material examined: 2 ♂♂, Qingdao, in coll. H. HUANG) (SHIROZU, 1960: 316; ELIOT, 1973: 477; ELIOT, 1987: 27; these figures do not show the detailed membrane between vinculum and tegumen), ♀-genitalia (material examined: 2 ♀♀, Qingdao, in coll. H. HUANG) (WANG & FAN, 2002: 149; this figure does not show the detailed structures).

Semanga superba: ♂-genitalia (INOUE & KAWAZOE, 1962: 389), ♀-genitalia (material examined: 1 ♀, Cameron highland, Malay Peninsula, in coll. TAKANAMI).

Mota massyla: ♂-genitalia (ELIOT, 1973: 479), ♀-genitalia (material examined: 1 ♀, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG).

Surendra quercetorum: ♂-genitalia (material examined: 2 ♂♂, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG) (INOUE & KAWAZOE, 1962: 385; this figure does not show the articulation of juxta to transtilla of valva) (WANG & FAN, 2002: 145; this figure does not show the detailed characters correctly), ♀-genitalia (material examined: 3 ♀♀, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG) (WANG & FAN, 2002: 145; this figure shows the entrance of the ostium incorrectly).

Surendra vivarna: ♂-genitalia (INOUE & KAWAZOE, 1962: 386).

Zinaspa zana: ♂-genitalia (KOIWAYA, 1989: 214), ♀-genitalia (material examined: 2 ♀♀, Lu-ding, Sichuan, in coll. H. HUANG).

Zinaspa todara: ♂-genitalia (ELIOT, 1973: 479; WANG & FAN, 2002: 146), ♀-genitalia (material examined: 3 ♀♀, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG) (WANG & FAN, 2002: 147; this figure does not show the detailed characters).

Zinaspa youngi: ♂-genitalia (Hsu & JOHNSON, 1998: 41), ♀-genitalia (Hsu & JOHNSON, 1998: 41; this figure does not show the detailed sclerite on ductus bursae).

Mahathala ameria: ♂-genitalia (material examined: 2 ♂♂, Gu-niu-jiang, Anhui, in coll. H. HUANG) (INOUE & KAWAZOE, 1962: 383), ♀-genitalia (material examined: ♀, Gu-niu-jiang, Anhui, ♀, Hainan, in coll. H. HUANG).

Thaduka multicaudata: ♂-genitalia (WANG & FAN, 2002: 132), ♀-genitalia (WANG & FAN, 2002: 133).

Flos aereata: ♂-genitalia (material examined: 1 ♂, Nan-ling, Guangdong, in coll. C.-H. ZHAN), ♀-genitalia (material examined: 1 ♀, Nan-ling, Guangdong, in coll. C.-H. ZHAN).

- Flos apidanus*: ♂-genitalia (INOUE & KAWAZOE, 1962: 381), ♀-genitalia (INOUE & KAWAZOE, 1962: 382).
- Arhopala (Panchala) birmana*: ♂-genitalia (material examined: 1 ♂, Hainan, in coll. H. HUANG) (INOUE & KAWAZOE, 1962: 377), ♀-genitalia (material examined: 1 ♀, Hainan, in coll. H. HUANG).
- Arhopala (Panchala) aberrans*: ♂-genitalia (INOUE & KAWAZOE, 1962: 379).
- Arhopala oenea*: ♂-genitalia (material examined: 1 ♂, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG), ♀-genitalia (material examined: 1 ♀, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG).
- Arhopala rama*: ♂-genitalia (material examined: 1 ♂, Chayu, Tibet, 2 ♂♂, Anhui, in coll. H. HUANG), ♀-genitalia (material examined: 2 ♀♀, Anhui, 2 ♀♀, Nuijiang, Yunnan, in coll. H. HUANG).
- Arhopala bazalus*: ♂-genitalia (material examined: 1 ♂, Nuijiang, Yunnan, in coll. H. HUANG), ♀-genitalia (material examined: 2 ♀♀, Anhui, in coll. H. HUANG) (INOUE & KAWAZOE, 1962: 361).
- Arhopala bazaloides*: ♂-genitalia (material examined: 1 ♂, Hainan, in coll. H. HUANG).
- Arhopala pseudocentaurus*: ♀-genitalia (material examined: 1 ♀, Xi-shuang-ban-na, S. Yunnan, in coll. H. HUANG).
- Arhopala allata*: ♀-genitalia (INOUE & KAWAZOE, 1962: 355).
- Arhopala anthelus*: ♀-genitalia (INOUE & KAWAZOE, 1962: 356).
- Arhopala abseus*: ♂-genitalia (INOUE & KAWAZOE, 1962: 373), ♀-genitalia (INOUE & KAWAZOE, 1962: 374).
- Arhopala centaurus*: ♀-genitalia (INOUE & KAWAZOE, 1962: 374).
- Arhopala eumolphus*: ♂-genitalia (INOUE & KAWAZOE, 1962: 360), ♀-genitalia (INOUE & KAWAZOE, 1962: 361).
- Arhopala silhetensis*: ♂-genitalia (INOUE & KAWAZOE, 1962: 362), ♀-genitalia (INOUE & KAWAZOE, 1962: 363).
- Arhopala nicevillei*: ♂-genitalia (INOUE & KAWAZOE, 1962: 364), ♀-genitalia (INOUE & KAWAZOE, 1962: 365).
- Arhopala ariana*: ♂-genitalia (INOUE & KAWAZOE, 1962: 367), ♀-genitalia (INOUE & KAWAZOE, 1962: 368).
- Arhopala aurelia*: ♂-genitalia (INOUE & KAWAZOE, 1962: 371), ♀-genitalia (INOUE & KAWAZOE, 1962: 372).
- Arhopala agaba*: ♂-genitalia (INOUE & KAWAZOE, 1962: 370), ♀-genitalia (INOUE & KAWAZOE, 1962: 370).
- Most species of *Arhopala*: ♂-genitalia (CORBET, 1941: figs. 1–114; INOUE & KAWAZOE, 1962; ELIOT, 1963: plates 33–36; ELIOT, 1973).
- Most species of *Flos*: ♂-genitalia (CORBET, 1941).

In this study, besides the species of Arhopalini, some species of other tribes, such as Theclini, Amblypodini, Deudorigini, and Eumaeini, have their male and female genitalia examined but not illustrated in this paper. The information in literature on genitalia of these tribes and some other tribes is used but may not be cited.

To make an analysis of the higher classification of the Arhopalini, the following processes have been made. At first, the terminology and characters of female genitalia are introduced, all the useful structures are signed by symbols, and for each structure all the characters are described, differentiated and signed by symbols (for some important species that we have examined the specimens, the detailed descriptions of female genitalia will be provided.) Similarly all the important characters in male genitalia and external features are differentiated and signed by symbols. All the information of these characters for most genera of Arhopalini is accumulated into a table. For convenience in publishing, some species belonging to the same genus or the same subgenus and sharing all the important char-

acters have been united into a single genus name in the table. Then after, the previous systematic works on higher classification using female genital characters are consulted and valued, the importance of each character for higher classification is discussed. Because the character that is useful in generic or higher classification for certain group may be only confined to this group and changes its value for other groups, all the characters, which are steady and invariable within a single genus but different and variable between genera, are considered as proposed important characters for higher classification. According to the theory of phylogenetic analysis, all these characters should have the same value before the analysis. On account of similarities and dissimilarities between the studied Arhopalini genera in these proposed important characters, the sections and genera in Arhopalini are defined; according to these definitions, some characters are concluded as primary section-characters (important characters in dividing the tribe into sections) for Arhopalini, and some others are considered as generic characters for Arhopalini.

For the higher classification of the genus *Amblopala*, only a suggestion will be made and some interesting information is presented. According to ELIOT's (1973) fundamental work, we found that most tribes are distinguishable from their allied tribes only by one of the tribe characters, and these tribe characters are often confined to certain subfamilies, sometimes not useful throughout the whole Lycaenidae. Because ELIOT did not use female genitalia characters for his analysis, we tried to find out whether there are important tribe characters in female genitalia for the classification of Theclinae. Because of lack of material we can only examine a few species restricted to several tribes, and the information on female genitalia of Theclinae genera is very scanty in literature except for the Theclini genera. Therefore our investigation has no stable importance but only has some meaning in suggestion. A comparison between some allied tribes of Theclinae in female genitalia provides very few possible tribe characters in female genitalia for Theclinae. Because *Amblopala* differs from all the other Theclini genera in these possible tribe characters of female genitalia and also in some characters in male genitalia, wing shape and wing pattern, we suggest *Amblopala* to be transferred from Theclini to an independent tribe. A complete revision of the higher classification of Theclinae with usage of female genitalia is required in future and the stable arrangement of *Amblopala* is still wanting.

Terminology and characters

Terminology is mainly referred to SHIROZU & YAMAMOTO (1956), SHIROZU (1960), ELIOT (1973) and ELIOT & KAWAZOE (1983) for the male genitalia and KUZNETSOV (1915), SHIROZU & YAMAMOTO (1956) and ELIOT & KAWAZOE (1983) for the female genitalia.

The main structures and characters in female genitalia are introduced and signed as follows.

- Papilla analis (signed as A). The papilla analis is subject to considerable geographic or individual variation. It varies little and irregularly among most genera and species of Arhopalini except *Panchala* (currently treated as a subgenus of *Arhopala*) wherein it is strongly sclerotized, with upper half protruded distad and beak-shaped, and with lower half excavated basad.
 - Character A1: papilla analis commonplace.
 - Character A1: papilla analis specialized, such as in *Panchala*.
- Apophysis anterioris (B). The Apophysis anterioris is present but weakly developed in most genera and species of Arhopalini except *Surendra*. It can be extruded anteriorly or ventrally even in a single genus, such as *Arhopala*. It is absent in *Amblopala* as well as in *Surendra*.
 - B1: apophysis anterioris present.
 - B2: apophysis anterioris absent. (Found in *Surendra*, *Amblopala*).
- Apophysis posterioris. The Apophysis posterioris is always well developed in *Amblopala* and all genera of Arhopalini examined, a little longer than the 8th tergum. No remarkable difference can be found among these genera thus this structure is not signed.

- 8th sternum (C, D). In *Amblopala*, the 8th sternum is not at all sclerotized, and ostium is opened just posterior to the 7th sternum and surrounded by a membranous area as well as in Deudorigini. In most cases, the 8th sternum can be specialized into a single sclerotized plate (lamella) near the ostium or a combination of several sclerites around the ostium connected by a membrane, sometimes it can be a complicated skeleton circumfusing the ostium. The terms, lamella antevaginalis and lamella postvaginalis, introduced by earlier students, are applicable in many cases such as in Theclini; lamella antevaginalis refers to the single lamella or the sclerites situated ventrad of the ostium, and lamella postvaginalis is of the hardened sclerotization situated dorsad of the ostium. However in Arhopalini, the sclerotization of the 8th sternum is very complicated and cannot be simply described by lamella antevaginalis and lamella postvaginalis. In most genera of Arhopalini except *Surendra* and *Semanga*, the sclerotization is developed mainly in the lateral sides of the sternum, sometimes connected narrowly at the anterior side of the ostium, but seldom developed in the ventral line of the sternum posterior to the ostium; it is fully developed as a single lamella anterior to the ostium in *Surendra*, but in *Semanga* it is fully developed as a single lamella posterior to the ostium, occupying the ventral line. Thus the following characters are recognized.
 - C1: sclerotization chiefly developed in lateral areas of sternum. (Found in *Arhopala*, *Flos*, *Mota*, *Zinaspa*, *Mahathala* and *Thaduka*).
 - C2: sclerotization chiefly developed in ventral area posterior to ostium. (Found in *Semanga*).
 - C3: sclerotization chiefly developed in ventral area anterior to ostium. (Found in *Surendra*).
 - C4: sclerotization is absent. (Found in *Amblopala*).

In the case of C1, the following detailed characters can be recognized.

- C11: only a pair of lateral sclerites present, which can be separated or narrowly connected at anterior side of ostium. (Found in *Arhopala*).
- C12: two pairs of lateral sclerites present, which surround ostium and separated from one another by membrane, with free edges. (Found in *Mahathala* and *Thaduka*).
- C13: besides a pair of lateral sclerites, a small sclerite situated dorsad of ostium, and a narrow semi-circular band situated ventrad of ostium and connecting (not fused with) the lateral sclerites. (Found in *Flos*).

The main parts of sclerotization are conjoined with the 8th tergum in *Flos*, but clearly separated from the 8th tergum by a membranous area in all the other genera of Arhopalini. Thus the following characters are recognized.

- D1: part of sclerotization of the 8th sternum conjoined with the 8th tergum. (Found in *Flos*).
- D2: sclerotization of the 8th sternum separated from the 8th tergum.
- 7th sternum and intersegmental membrane connecting 7th and 8th sternums. 7th sternum can be strongly sclerotized (so called lodix) or only weakly sclerotized; such characters have no taxonomic value in generic or higher classification. In Arhopalini and *Amblopala*, the membranous connection between 7th and 8th sternum is smoothly folded for a short distance and usually along the edges of the sclerotization of the 8th sternum, without any intersternal pouch, which is found in the tribe Polyommagini.
- Entrance of ostium bursae (E). In all these genera and species studied, there is no ostium pouch found. The entrance of the ostium bursae can be strongly sclerotized along the outer wall and connected to the genital lamella, or is basically membranous, at most with bacillus (introduced below, a sclerotization along inner wall of ductus bursae and associated with attachment point of ductus seminalis), or partly sclerotized along inner wall (not bacillus).
 - E1: entrance of ostium bursae strongly sclerotized along outer wall and connected to the genital lamella. (Found in *Semanga* and some Theclini genera).
 - E2: entrance of ostium bursae basically membranous, at most only bacillus present. (Found in most Arhopalini genera).
 - E3: entrance of ostium bursae sclerotized along inner wall besides bacillus. (Found in *Amblopala*).

- Delimitation between ductus bursae and corpus bursae in width. In the present study, the term “ductus bursae” is used to refer to the more or less slender portion of the bursa copulatrix. Such delimitation can be clear or indistinct even in a single genus, such as *Arhopala*, thus has no use in taxonomic study.
- Relative length of ductus bursae (F). To be compared with the 8th tergum, the length of ductus bursae varies in some degree among the Arhopalini genera and provides the following characters.
 - F1: ductus bursae shorter than twice the length of the 8th tergum. (Found in *Zinaspa* and *Semanga*).
 - F2: ductus bursae 2 or 3 times as long as the 8th tergum. (Found in *Surendra*, *Mahathala*, *Mota*, *Amblopala*, *Arhopala*, *Panchala*).
 - F3: ductus bursae more than 4 times as long as the 8th tergum. (Found in *Flos*).
- Attachment point of ductus seminalis (S). In *Amblopala* and all genera of Arhopalini examined, the attachment point of ductus seminalis is very close to the ostium, much closer to the ostium than to corpus bursae. Such a point is usually associated with a posterior sclerite on the ductus bursae (bacillus), sometimes also associated with an anterior sclerotization on the ductus bursae. The distance between such a point and the ostium is important in higher classification of certain groups (such as in Polyommattini). The length of the anterior portion of the ductus bursae (the portion anterior to the attachment point of the ductus seminalis) relative to the posterior portion of the ductus bursae (the portion posterior to the attachment point of the ductus seminalis) may be important as well in higher classification of certain groups.
- Bacillus (G). The portion of ductus bursae immediately posterior to the attachment point of the ductus seminalis is more or less sclerotized. Such a sclerite is considered by us to be homologous with the “bacillus” used by ELIOT & KAWAZOE (1983) in the female genitalia of the *Lycaenopsis* section of Polyommattini. ELIOT & KAWAZOE (1983) adopted this term, which was firstly introduced by HIGGINS in his work on female genitalia of Melitaeinae (Nymphalidae), for the elongate sclerite along the inner wall of the caudal portion of the ductus bursae. Such a sclerite is always situated just behind the attachment point of the ductus seminalis in the *Lycaenopsis* section of the Polyommattini, and here I use this term only for the sclerite, which is associated with the attachment point of the ductus seminalis and somewhat posterior to it. The shape of bacillus and the degree of sclerotization are variable even in a single genus (such as in *Arhopala*), thus are not considered as useful characters in generic and higher classification. Only the following useful characters in higher classification have been recognized for this structure.
 - G1: bacillus situated at entrance of ostium. (Found in *Zinaspa*, *Mota* and *Flos*).
 - G2: bacillus situated close to ostium but not reaching the entrance of ostium. (Found in *Semanga*, *Surendra*, *Arhopala*, *Panchala* and *Amblopala*).
 - G3: bacillus absent. (Found in *Mahathala* and *Thaduka*).
- Sclerotization anterior to attachment point of ductus seminalis (H). The portion of ductus bursae immediately anterior to the attachment point of the ductus seminalis is usually membranous, but sometimes can be enlarged and sclerotized, such a sclerotization is fully developed and semi-cylindrical in *Mahathala* and *Thaduka*, but is weakly developed and irregular in *Flos* and some species of *Arhopala*.
 - H1: such sclerotization is fully developed.
 - H2: such sclerotization is weak and irregular, or totally absent.
- Corpus bursae (T). The shape of corpus bursae varies remarkably even in a single genus, such as *Arhopala*, thus has no use in generic or higher classification of Arhopalini.
- Signa (I). The following characters are recognized for signa.
 - I1: signum is absent. (Found in *Flos*, *Semanga*, *Mota*, *Mahathala* and some species of *Arhopala*).

- I2: only a single and minute signum present. (Found in some species of *Arhopala*).
- I3: signa paired, disc like or subovate or oblong, with inner process present (triangular or rounded). (Found in some *Arhopala* species).
- I4: signa paired, elongated in various degrees, shaped as stripes or bands. (Found in some *Arhopala* species, *Amblopala*, *Zinaspa* and *Surendra*).

The main useful structures and characters in male genitalia for generic or higher classification are introduced and signed as follows.

- Subscaphium (J)
 - J1: subscaphium commonplace and weakly developed, not connected tightly with brachia.
 - J2: subscaphium strongly developed and connected tightly with brachia.
- Brachia (K)
 - K1: brachia free.
 - K2: brachia connected tightly with subscaphium.
 - K3: brachia ankylosed and fused with lateral process of tegumen.
- Juxta (L)
 - L1: base of juxta having tight connection with the upper portions of both sacculi, tips of juxta free.
 - L2: base of juxta having tight connection with the upper portions of both sacculi, tips of juxta fused with transtilla of valva.
 - L3: juxta articulated with valva at base by membrane, not connected tightly with sacculi at base.
- Valvae (M)
 - M1: valvae fused or connected tightly at ventral margin for a distance.
 - M2: valvae free.
- Internal lateral ridge of ring (N).
 - N1: lateral ridge absent.
 - N2: lateral ridge present at upper portion near lateral process of tegumen.
 - N3: lateral ridge present at lower portion near saccus.
 - N4: lateral ridges present at both upper and lower portions.

The following structures and characters, which are variable in a single genus of Arhopalini or not varying between genera, are not considered as important characters for generic or higher classification of Arhopalini and not signed with symbols for analysis: coecum, bulbus ejaculatorius, position of zone of phallus, manica, cornuti, direction of vesical opening on phallus, perivesical area, socii, lateral fenestrula, vinculum, saccus and detailed structures of valvae.

The main characters in external features for generic or higher classification of Arhopalini are introduced and signed as follows.

- Forewing veins 4, 5 and 6 (O).
 - O1: vein 5 arising much closer to vein 6 than to vein 4.
 - O2: veins 4, 5 and 6 more or less equidistant at their origins.
- Hindwing tails (P).
 - P1: vein 4 tailed in female.
 - P2: vein 4 never tailed.
- Hindwing costa (Q).
 - Q1: hindwing with costa concaved.
 - Q2: hindwing with costa convex as usual.

The forewing shape and the hindwing shape at tornal area are not considered as generic characters because the concaved forewing termen just below apex and the excavated tornal area of hindwing can be found not only in *Surendra* but also in some *Arhopala* species (*comica* and *curiosa*). The ground colour and wing pattern are also variable in a single genus and not adopted here.

The ecological characters and the characters of immature morphology and biology are not used because of lack of information.

Characters of Arhopalini genera

All information on these important characters of Arhopalini genera has been accumulated in the following table.

Table 1: Important characters of the Arhopalini genera (boldfaced characters refer to section-characters)

Character	<i>Surendra</i>	<i>Semanga</i>	<i>Mota</i>	<i>Zinaspala</i>	<i>Mahat-hala</i>	<i>Thaduka</i>	<i>Flos</i>	<i>Arhopala</i>	<i>Panchala</i>
A	A1	A1	A1	A1	A1	A1	A1	A1	A2
B	B2	B1	B1	B1	B1	B1	B1	B1	B1
C	C3	C2	C11	C11	C12	C12	C13	C11	C11
D	D2	D2	D2	D2	D2	D2	D1	D2	D2
E	E2	E1	E2	E2	E2	E2	E2	E2	E2
F	F2	F1	F2	F1	F2	F2	F3	F2	F2
G	G2	G2	G1	G1	G3	G3	G1	G2	G2
H	H2	H2	H2	H2	H1	H1	H2	H2	H2
I	I4	I1	I1	I4	I1	I1	I1	I1,I2,I3,I4	I3
J	J2	J1	J1	J1	J1	J1	J1	J1	J1
K	K2	K3	K1	K1	K1	K1	K1	K1	K1
L	L2	L3	L1	L1	L1	L1	L1	L1	L1
M	M1	M2	M2	M1	M2	M2	M1	M2	M2
N	N3	N4	N2	N1	N2	N2	N2	N2	N2
O	O2	O2	O2	O2	O1	O1	O1	O1	O1
P	P2	P1	P1	P2	P2	P2	P2	P2	P2
Q	Q2	Q2	Q2	Q2	Q1	Q2	Q2	Q2	Q2

In addition to the information in Table 1, some more detailed descriptions of female genitalia are presented as below for some species.

1) *Surendra quercetorum*

The apophysis anterioris is absent. The sclerotization of 8th sternum is specialized into a single lamella antevaginalis, which is excavated a little at posterior margin; the ostium is membranous and integrated with the mid portion of this lamella and opened between the distal half of inner wall of this lamella and the posterior or dorsal membranous area. Bacillus is strongly sclerotized and semi-cylindrical, leaving the dorsal portion membranous, and is close to the entrance of the ostium. Ductus seminalis is attached to ductus bursae on left lateral side just before bacillus. Delimitation between corpus bursae and ductus bursae is obscure.

2) *Semanga superba*

The apophysis anterioris is sharply protruded ventrally for a longer distance. The sclerotization of 8th sternum is specialized into a single lamella postvaginalis fused with the sclerotized entrance of the ostium; the sclerotization at the entrance of the ostium encircles the ostium completely for a short distance. The lamella postvaginalis is distant from 8th tergum. Bacillus is semi-cylindric, leaving the left lateral portion membranous, and is close to the sclerotized entrance of the ostium. Ductus seminalis is attached to ductus bursae on left lateral side at anterior portion of bacillus. Delimitation between corpus bursae and ductus bursae is very clear and constricted.

3) *Mota massyla*

The apophysis anterioris is bluntly protruded ventrally for a short distance. The sclerotization of the 8th sternum is specialized into a pair of lateral lamellae, which are connected tightly with each other by a very narrow membrane along the ventral line, with their dorsolateral margins reaching the ventral margins of the 8th tergum. The ostium is opened just at the central portion of this pair of lamellae on the ventral line. Bacillus is represented by a pair of elongate sclerites along the inner wall of ductus bursae and they reach the entrance of the ostium. Ductus seminalis is attached to ductus bursae on dorsal side just before bacillus. Corpus bursae is thin and tube-like and delimitation between corpus bursae and ductus bursae is very unclear.

4) *Amblopala avidiena*

The apophysis anterioris is absent. The 8th sternum is not at all sclerotized; the membrane surrounding the ostium is not extruded. The ostium is opened just behind 7th sternum, with an inner sclerite circular or semi-circular along the inner walls of the ostium bursae. Bacillus is semi-cylindric and reaches the end of the ostium sclerite, leaving the dorsal portion membranous. Ductus seminalis is attached to ductus bursae on ventral side just before bacillus. Corpus bursae is egg-shaped at terminal end but very gradually constricted towards ostium thus the delimitation between corpus bursae and ductus bursae is not clear.

5) *Zinaspas todara*

The apophysis anterioris is rather clear and protruded anteriorly. The sclerotization of the 8th sternum is specialized into a pair of lateral lamellae, which are connected narrowly at the anterior side of the ostium, with their dorsolateral margins distant from 8th tergum. The ostium is opened just behind the connection of lateral lamellae, with the bacillus just at entrance of ostium. Bacillus is weakly developed along inner ventral wall of ostium bursae and semi-circular, becoming narrower along the inner lateral walls of the ostium bursae. Ductus seminalis is attached to ductus bursae on dorsal side just before bacillus. Corpus bursae is oblong, with the delimitation to ductus bursae rather clear. The anterior portion of ductus bursae is swollen for a short distance.

6) *Zinaspas zana*

Very similar to those of *Zinaspas todara*, but the apophysis anterioris is blunt, not so apparently protruded as in *todara*, the lateral lamellae are shorter than in *todara*, with their dorsolateral margins reaching the ventral margins of the 8th tergum.

7) *Mahathala ameria*

The apophysis anterioris is protruded ventrally for a longer distance. The sclerotization of the 8th sternum is specialized into two pairs of lateral lamellae, which surround the ostium and are separated from one another by a membrane, with their anterior edges connected with that membrane but with their posterior edges free. These two pairs of lateral lamellae are distant from the 8th tergum. The ostium is opened just between the cephalic portions of posterior lateral lamellae and well behind the anterior lateral lamellae. The entrance of the ostium is membranous and the bacillus is absent. The portion of ductus bursae just before the attachment point of ductus seminalis is abruptly swollen for a short distance and sclerotized along the dorsal and lateral walls, leaving the ventral portion membranous, such a sclerotization is probably homologous with the irregular sclerotization in *Flos*. The ductus

seminalis is attached to ductus bursae on the ventral side. Corpus bursae is egg-shaped, with delimitation to ductus bursae rather clear.

8) *Flos aereata*

The apophysis anterioris is sharply protruded ventrally for a longer distance. The 8th tergum is fused with the lateral lamellae. Besides a pair of lateral lamella, a small ventral sclerite is situated dorsad of the ostium, and a narrow semi-circular band is situated ventrad of the ostium and connecting with (not fused with) the lateral lamella by a membrane. The ostium is opened between the small ventral sclerite and the semi-circular band, just anterior to the lateral lamellae, with the bacillus just at the entrance of the ostium. The bacillus is short and semi-cylinder along the ventral wall of the ostium bursae, leaving the dorsal portion of the ostium bursae membranous. Ductus seminalis is attached to ductus bursae on the left lateral side well before bacillus, with the portion near the attachment point being coiled. The portion of ductus bursae just before the attachment point of the ductus seminalis is swollen and irregularly sclerotized for a distance. The delimitation between corpus bursae and ductus bursae is clear.

9) *Arhopala oenea*

The apophysis anterioris is bluntly protruded ventrally for a short distance. The sclerotization of the 8th sternum is specialized into a pair of narrow lateral lamellae, which are connected narrowly at the anterior side of the ostium. This pair of lateral lamellae does not extend to the posterior side of the ostium, but extends dorsally and reaches the ventral margins of the 8th tergum at a point, with their lateral edges free and not connected with the membrane. The ostium is opened just behind the connection of lateral lamellae. Bacillus is hardly developed, represented by some irregular sclerotization near the attachment point of ductus seminalis; that sclerotization does not reach the entrance of the ostium. Ductus seminalis is attached to ductus bursae on the left lateral side. Corpus bursae is egg-shaped, with the delimitation to ductus bursae rather clear. The signa are oblong, with their inner processes rounded, not pointed.

10) *Arhopala rama*

The apophysis anterioris is bluntly protruded anteriorly for a short distance. The sclerotization of the 8th sternum is specialized into a pair of disc-like lateral lamellae, which are situated dorsad of the ostium, extending narrowly to the dorsal wall of the ostium bursae and distant from the ventral margins of the 8th tergum. The ostium is opened between this pair of lamellae and the membrane of the 7th sternum. Bacillus is weakly developed at the ventral wall of ductus bursae and expanded dorsally, leaving the dorsal surface of ductus bursae membranous. Ductus seminalis is attached to ductus bursae on the left lateral side just before bacillus. Corpus bursae is elongated, with the delimitation to ductus bursae somewhat clear. The signa are disc-like, with their inner triangular processes pointed.

11) *Arhopala pseudocentaurus*

The apophysis anterioris is bluntly protruded anteriorly for a short distance. The sclerotization of the 8th sternum is specialized into a pair of oblong lateral lamellae, which are widely separated from each other, excavated a little at their inner margin in accordance with the position of the entrance of the ostium. This pair of lateral lamellae is distant from the ventral margins of the 8th tergum. The ostium is opened just between the excavations of the lateral lamellae and membranous. Bacillus is represented by a pair of minute elongate sclerites along the inner wall of ductus bursae just behind the attachment point of ductus seminalis. Ductus seminalis is attached to ductus bursae on left lateral side. Corpus bursae is elongated and constricted gradually to ductus bursae, with the delimitation to ductus bursae very unclear. Signa are absent.

12) *Arhopala (Panchala) birmana*

Papilla analis is strongly sclerotized, with distal half protruded distad and beak-shaped, and with basal half excavated basad forming an excavation. The apophysis anterioris is protruded anteriorly for a longer distance. The sclerotization of the 8th sternum is specialized into a pair of elongate lateral

lamellae, which are separated from each other and excavated a little at the ventral ends where the ostium is opened. This pair of lateral lamellae does not extend to the posterior side of the ostium, but extends dorsally and reaches the ventral margins of the 8th tergum at a point. 7th sternum is strongly sclerotized as a lodix. The ostium is opened just behind the lodix and between the excavations of lateral lamellae. The area just dorsad of the ostium is membranous and excavated in continuation with the excavation formed by the papillae anales. Bacillus is weakly developed at the ventral wall of ductus bursae well behind the attachment point of ductus seminalis, and does not reach the entrance of the ostium. Ductus seminalis is attached to ductus bursae on the dorsal side. Corpus bursae is egg-shaped, with the delimitation to ductus bursae rather clear. The signa are disc-like, with their inner processes bluntly pointed.

Character weighting

1. Discussion on previous systematic works using female genitalia.

In the revision of the *Lycaenopsis* section of Polyommagini by ELIOT & KAWAZOE (1983), the following characters of female genitalia were considered to have generic importance:

- i) appearance of signa;
- g) appearance of bacilli;
- f) relative length of bursae and ductus.

In the generic revision of Theclini by SHIROZU & YAMAMOTO (1956), the following characters of female genitalia were considered to have generic value:

- i) appearance of signa;
- b) appearance of apophysis anterioris;
- c) appearance of genital plate;
- f) relative length and shape of ductus bursae;
- g) sclerotization of ductus bursae;
- r) presence or absence of ventral pouch at opening of corpus bursae;
- t) shape of corpus bursae.

In HIROWATARI's (1992) work on the higher classification of the Polyommagini, the following characters of female genitalia were considered to be section-characters:

- s) distance between attachment point of ductus seminalis and ostium;
- a) appearance of papilla analis, commonplace or specialized.

The following characters of female genitalia were considered to have generic value in certain sections of Polyommagini:

- s) distance between attachment point of ductus seminalis and ostium;
- u) shape of ductus seminalis near the attachment point;
- v) shape of ductus bursae near the attachment point of ductus seminalis, swollen or slender;
- w) shape of ductus bursae near ostium, swollen or slender;
- x) natural shape of ductus bursae, flattened or not flattened.

We can find out that some characters that are useful in generic classification for certain groups may be only confined to this group and change their value for other groups. This is in accordance with the theory of phylogenetic analysis, wherein all characters should have the same value before the analysis and there is no changeless important character for higher classification of all groups.

For instance, the papilla analis, which is considered as section-character in Polyommagini by HIROWATARI, however is only of subgeneric importance in Theclini genus *Japonica*; the recently discovered *Japonica bella* Hsu, 1997 has very much specialized papilla analis, but can not be separated from the other members of *Japonica* at generic level in all other characters including early stages and biologi-

cal behavior. Another section-character in Polyommataini is the distance between the attachment point of the ductus seminalis and the ostium, which however has no remarkable difference between the genera of Arhopalini and has no use in Arhopalini.

2. Proposed important characters for generic and higher classification.

All the characters, which are steady and invariable within a single genus but different and variable between genera, should be considered as proposed important characters for generic and higher classification.

All these important structures and features for generic and higher classification have been included in table 1, signed with A–R, but signa (I) are not considered to be important and omitted in the forthcoming analysis, because they are variable in the single genus *Arhopala*. The signa may have great value in the definition of species groups within the genus *Arhopala*.

Account and conclusion

Based upon the information in Table 1, the following account on dissimilarities between genera has been made.

Table 2: Account of dissimilarities between Arhopalini genera.

Number of dissimilarities	<i>Surendra</i>	<i>Semanga</i>	<i>Mota</i>	<i>Zinaspa</i>	<i>Mahathala</i>	<i>Thaduka</i>	<i>Flos</i>	<i>Arhopala</i>	<i>Panchala</i>
<i>Surendra</i>	0	10	9	8	11	10	10	8	9
<i>Semanga</i>	10	0	7	8	11	10	11	8	9
<i>Mota</i>	9	7	0	4	5	4	5	3	4
<i>Zinaspa</i>	8	8	4	0	7	6	4	5	6
<i>Mahathala</i>	11	11	5	7	0	1	6	3	4
<i>Thaduka</i>	10	10	4	6	1	0	5	2	3
<i>Flos</i>	10	11	5	4	6	5	0	4	5
<i>Arhopala</i>	8	8	3	5	3	2	4	0	1
<i>Panchala</i>	9	9	4	6	4	3	5	1	0

1) Dividing Arhopalini into sections and genera

Table 2 shows that *Panchala* and *Arhopala* only differ from each other in one character and so do *Mahathala* and *Thaduka*.

Considering the remarkable difference in both wing-shape and wing-pattern, *Mahathala* and *Thaduka* may be regarded as independent genera.

In the case of *Panchala* and *Arhopala*, it is reasonable to merge *Panchala* into *Arhopala*, because the species of *Arhopala* vary considerably in several traditionally important characters of female genitalia, such as signa and shape of corpus bursae, and because *Panchala* shows no difference in external features and all other male and female genital characters from *Arhopala*. The great variation of some female genital characters in the genus *Arhopala* (including *Panchala*) should be important in dividing the genus into species groups, and *Panchala* may be regarded as a good subgenus.

Surendra shows more than 7 different characters from all other genera and so does *Semanga*, both of them should be separated respectively as independent sections.

All genera excluding *Surendra* and *Semanga* have dissimilarities from one another less than 7 in number, and there is no clear dividing line found between any of them, thus all of them could be placed into a single section.

The change of generic classification of Arhopalini is shown in the following table. The genus *Apporasa* is very close to *Mahathala* in external features though the male and female genitalia have not been investigated, thus it is placed together within *Mahathala* here. Genus *Keraunogramma* which is very close to *Semanga* and probably only deserves a subgenus of the latter is placed together with *Semanga* here.

Table 3: Tentative correction of generic classification of the Arhopalini (The genera with asterisk were not investigated in specimens or literatures)

ELIOT (1973)	HUANG & XUE (2004)
<i>Arhopala</i> section	<i>Arhopala</i> section
<i>Arhopala</i>	<i>Arhopala</i>
<i>Narathura</i>	= <i>Narathura</i>
<i>Nilasera</i>	= <i>Nilasera</i>
<i>Panchala</i>	= <i>Panchala</i>
<i>Satadra</i>	= <i>Satadra</i>
<i>Darasana</i>	= <i>Darasana</i>
<i>Acesina</i>	= <i>Acesina</i>
<i>Aurea</i>	= <i>Aurea</i>
<i>Thaduka</i>	<i>Thaduka</i>
<i>Apporasa</i>	* <i>Apporasa</i>
<i>Mahathala</i>	<i>Mahathala</i>
<i>Flos</i>	<i>Flos</i>
<i>Semanga</i> section	<i>Zinaspa</i>
<i>Semanga</i>	<i>Mota</i>
<i>Keraunogramma</i>	<i>Semanga</i> section
<i>Mota</i>	<i>Semanga</i>
<i>Surendra</i> section	* <i>Keraunogramma</i>
<i>Surendra</i>	<i>Surendra</i> section
<i>Zinaspa</i>	<i>Surendra</i>

2) Section-characters and generic characters for Arhopalini

In ELIOT's work, the characters M, N, O and P were considered as section-characters. As discussed above, all these characters cannot be considered as section-characters of Arhopalini, but deserve generic value in classification. (The character M should not be used as section-character even before this analysis, because *Flos* also shares the conjoined valvae with *Surendra* and *Zinaspa*). The result that the lateral ridge in male genitalia is not important for section definition in Arhopalini recalls the case in Theclini wherein the sibling genera *Cordelia* and *Gonellia* differ from each other in the presence or absence of a lateral ridge.

In accordance with the definition of sections, the characters B, C, E, J, K and L should be regarded as section-characters, whilst all the others except A and I are generic characters. The definition of each genus can be made on the basis of these generic characters.

Remarks on biology

Larvae of *Surendra vivarna* have been observed attended by the ant *Anoplolepis longipes* (MASCHEWITZ et al., 1985) and considered "steadily myrmecophilous" by FIEDLER (1991). Three *Arhopala* and one *Thaduka* species are known to be associated with *Crematogaster* ant within Arhopalini (FIEDLER, 1991). According to YOUNG's observation (Hsu & JOHNSON, 1998), the association between *Zinaspa youngi* and a *Crematogaster* ant was found to be fairly strong and the collected larvae grew poorly without the presence of the ants. These biological facts may suggest that *Zinaspa* is closer to *Arhopala* and *Thaduka* than to *Surendra*.

Suggestion on higher classification of *Amblopala*

Due to the lack of material, one of the closest tribes of Theclini (sensu ELIOT, 1973), Ogyrini has not been examined in female genitalia. Information on female genitalia is only accumulated for some genera of Amblypodini, Eumaeini, Deudorigini, Arhopalini and Theclini. And we found that the possible tribe-characters in Theclinae may include 1) the presence or absence of genital plate and 2) the appearance of sclerotization at caudal portion of ductus bursae.

According to ELIOT's (1973) fundamental work, we found that most tribes are distinguishable from their allied tribes only by one of the tribe-characters, and these tribe-characters are often confined to certain subfamilies, sometimes not useful throughout the whole Lycaenidae. We summarized the constant tribe-characters for Theclinae into the following table to show the dissimilarities between the studied tribes. Those characters, such as male brand, smooth or hairy of eyes, male fore tarsus, nudum, relative positions of forewing veins 4, 5 and 6, relative positions of forewing veins 6 and 7, valvae, branches of forewing vein 7, which are not constant in a single tribe, are not considered as tribe-characters.

Table 4: Dissimilarities between some tribes and *Amblopala* in tribe-characters and possible tribe-characters of female genitalia.

Characters	Amblypodini	Arhopalini	Theclini less <i>Amblopala</i>	<i>Amblopala</i>	Deudorigini	Eumaeini
Juxta	Present	Present	Present	Present	Absent	Absent
Chief tail	At vein 1b	Not at vein 1b	Not at vein 1b	Not at vein 1b	Not at vein 1b	Not at vein 1b
Origin of forewing vein 7	Well before end-cell	Well before end-cell	At apex of cell or beyond it	At apex of cell	Before end-cell or at apex of cell	At apex of cell
Genital plate	Present	Present	Present	Absent	Absent	Present
Sclerotization of bursae near entrance of ostium	Bacillus just at entrance of ostium, no other inner sclerite at ostium beside bacillus	Bacillus close to or just at entrance of ostium or obsolete, entrance of ostium membranous or sclerotized along genital plate, no inner sclerite present at ostium besides bacillus	Bacillus extending to entrance of ostium or near ostium or obsolete, entrance of ostium connected to bacillus or membranous or sclerotized along genital plate, no inner sclerite present at ostium	Bacillus close to ostium, in addition an inner sclerite present at entrance of ostium	Bacillus or its rudiment near ostium, no other sclerite at entrance of ostium	Bacillus fully developed as a tube to entrance of ostium

Besides the difference in female genitalia, *Amblopala* shows the following considerable differences from all other Theclini genera in male genitalia and wing-features.

1) There is a remarkable membranous area between vinculum and tegumen at dorsal portion, whereas in other Theclini genera the vinculum and tegumen are fused.

2) Forewing apex is slightly truncate; hindwing is produced into a long tornal lobe.

Moreover, according to FIEDLER (1991), the placement of *Amblopala* in Theclini is also questionable based on data from immature morphology and biology. The morphology of early stages of *Amblopala* has been also reported by Hsu (2002: 172).

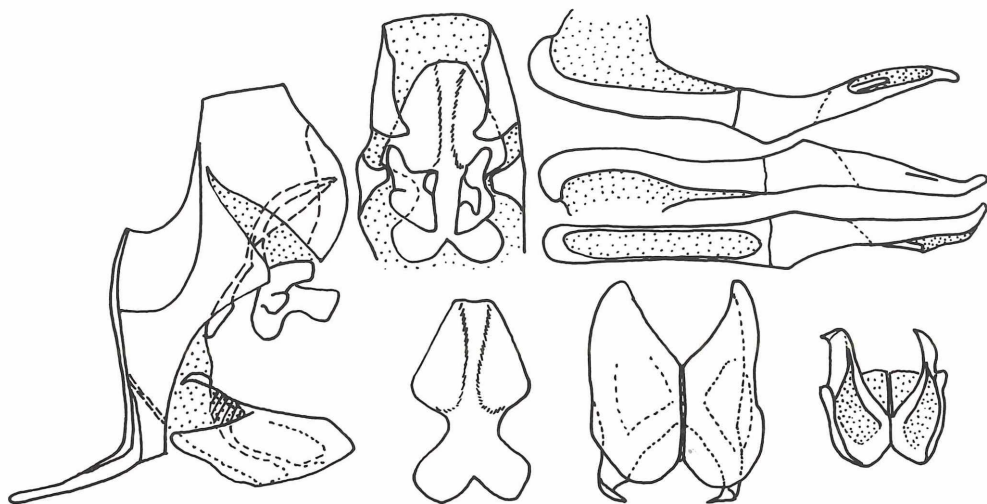
The above-mentioned characters of male and female genitalia need to be weighted on their importance in higher classification when the information of male and female genitalia of all other tribes in Theclinae is complete.

Because *Amblopala* differs from all the other Theclini genera in these possible tribe-characters of female genitalia and some characters in male genitalia, wing shape, wing pattern and probably also early stages, we suggest *Amblopala* to be transferred from Theclini to an independent tribe. A complete revision of the higher classification of Theclinae with usage of female genitalia is required in future and the stable arrangement of *Amblopala* is still wanting.

In their book on the Chinese Lycaenidae fauna, WANG & FAN (2002) placed *Amblopala* into Arhopalini, however *Amblopala* differs from Arhopalini not only in female genitalia characters but also in the origin of forewing vein 7, which has been proved to be a good tribe-character in ELIOT's work.

Acknowledgement

We should express our hearty thanks to Dr. Y. TAKANAMI for his help in literature and female specimens of *Semanga superba* from Malay Peninsula, and to Mr. C.-H. ZHAN for his help in specimens of *Flos aerea* from Guangdong. We are also grateful to Dr. Y. UEMURA for his constant help in literature.



2



Fig. 1 (right): Male genitalia of *Amblopala avidiena* (Qingdao, N. China) consisting of lateral view of genital capsule with left valve and phallus removed (top) and of lateral view of phallus (bottom).

Fig. 2 (above): Male genitalia of *Surendra quercetorum* (S. Yunnan) consisting of lateral view of genital capsule with phallus removed (left), of posterior view of socii, lateral processes of tegumen, brachia and subscaphium (central top), of left lateral, right lateral and dorsal views of phallus (right top), of posterior view of subscaphium (central bottom), of ventral view of valvae (central bottom), and of dorsoposterior view of valvae to show the conjoining juxta and transtilla (right bottom).

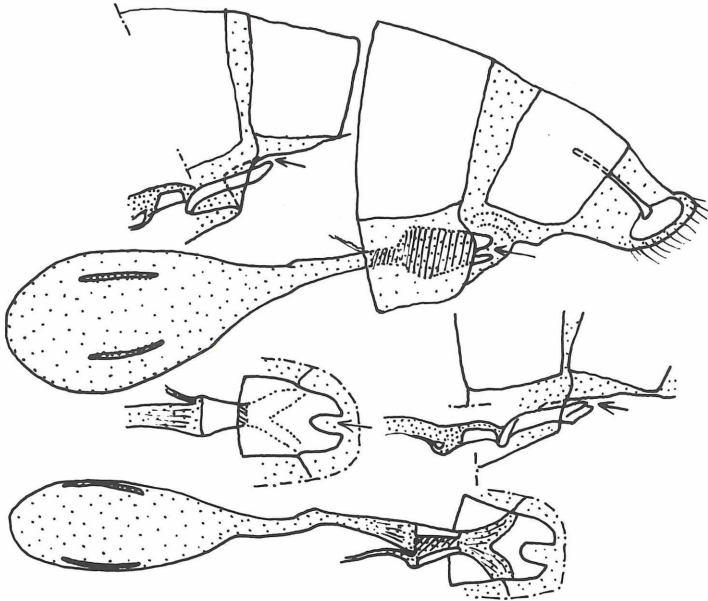


Fig. 3: Female genitalia of *Surendra quercetorum* (S. Yunnan) consisting of the lateral view of complete genitalia (right top), of the lateral view of circum-ostium region to show the intersegmental membrane (left top), of the ventral view of circum-ostium region (central left), of the lateral view of circum-ostium region (central right), and of the inner dorsal view of lamella, ductus bursae and corpus bursae (bottom). (The arrow is directed to the entrance of ostium, this sign is applied to all figures of female genitalia).

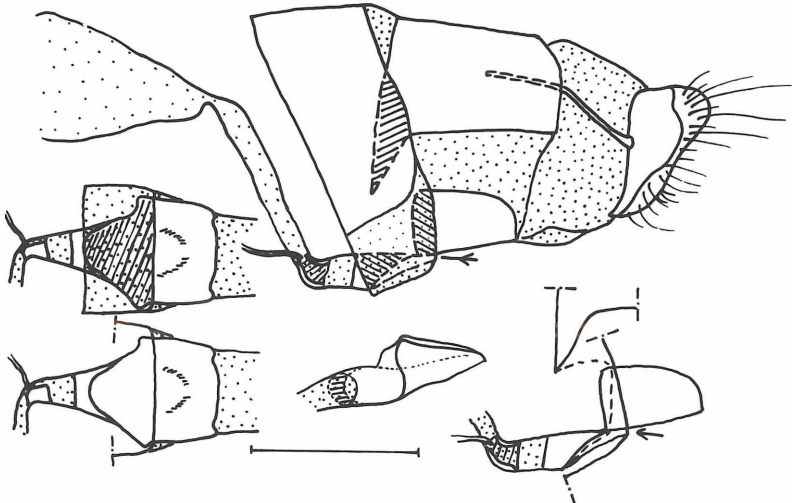


Fig. 4: Female genitalia of *Semanga superba* (Malay Peninsula) consisting of the lateral view of complete genitalia (top), of ventral view of circum-ostium region (left center), of ventral view of circum-ostium region with 7th sternum not shown (left bottom), of lateral view of lamella and sclerotized entrance of ostium (central bottom), and of lateral view of circum-ostium region with only outlines of membranes shown (right bottom).

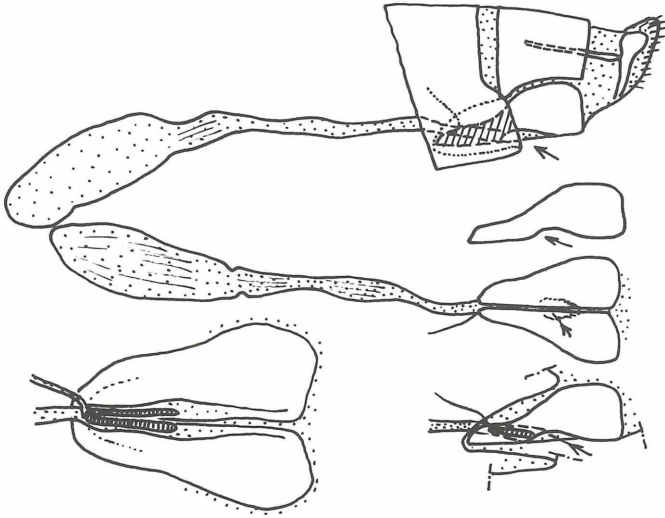


Fig. 5: Female genitalia of *Mota massyla* (S. Yunnan) consisting of the lateral view of complete genitalia (top), of lateral view of lamellae (right top), of ventral view of lamellae, ductus bursae and corpus bursae (center), of inner dorsal view of enlarged circum-ostium region (left bottom), and of lateral view of circum-ostium region with only outlines of membranes shown (right bottom).

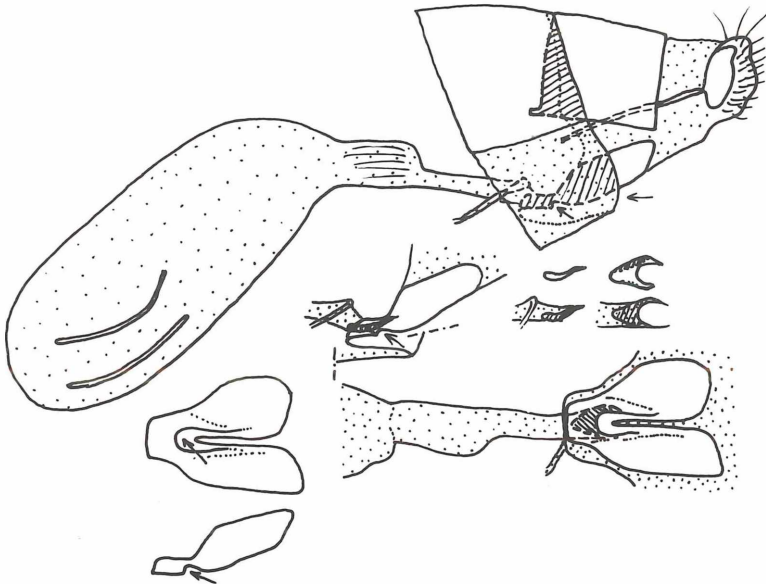


Fig. 6: Female genitalia of *Zinaspa todara* (S. Yunnan) consisting of the lateral view of complete genitalia (top), of ventral view of lamellae (left center), of lateral view of lamellae (left bottom), of lateral view of circum-ostium region with only outlines of membranes shown (center), of lateral and ventral views of bacillus (central right), and of ventral view of circum-ostium region (right bottom).

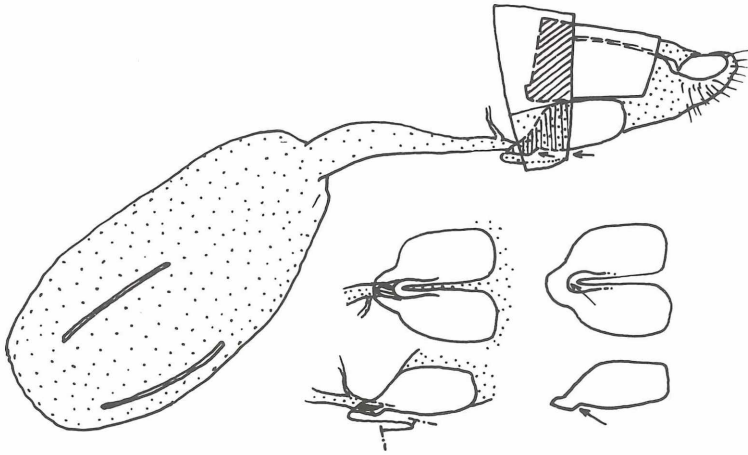


Fig. 7: Female genitalia of *Zinaspa zana* (Sichuan) consisting of the lateral view of complete genitalia (top), of ventral view of circum-ostium region (center), of lateral view of circum-ostium region with only outlines of membranes shown (central bottom), of ventral view of lamellae (central right), and of lateral view of lamellae (right bottom).

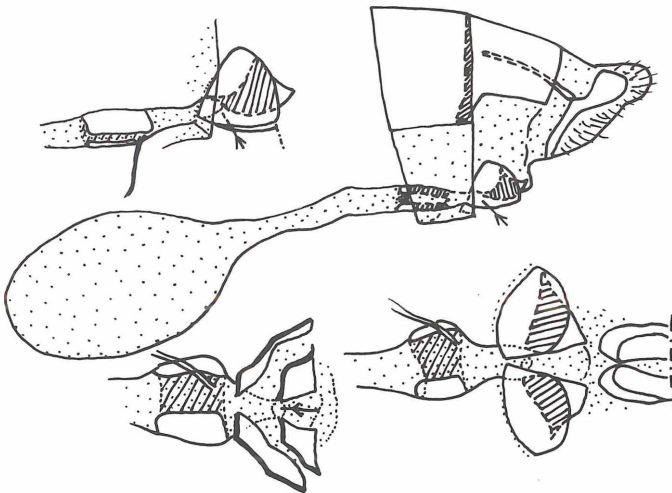


Fig. 8: Female genitalia of *Mahathala ameria* (Anhui) consisting of the lateral view of complete genitalia (right top), of lateral view of enlarged circum-ostium region (left top), of ventral view of enlarged circum-ostium region with free edges of lamellae erected to show the ostium bursae (left bottom), and of ventral view of enlarged circum-ostium region with free edges of lamellae recumbent (right bottom).

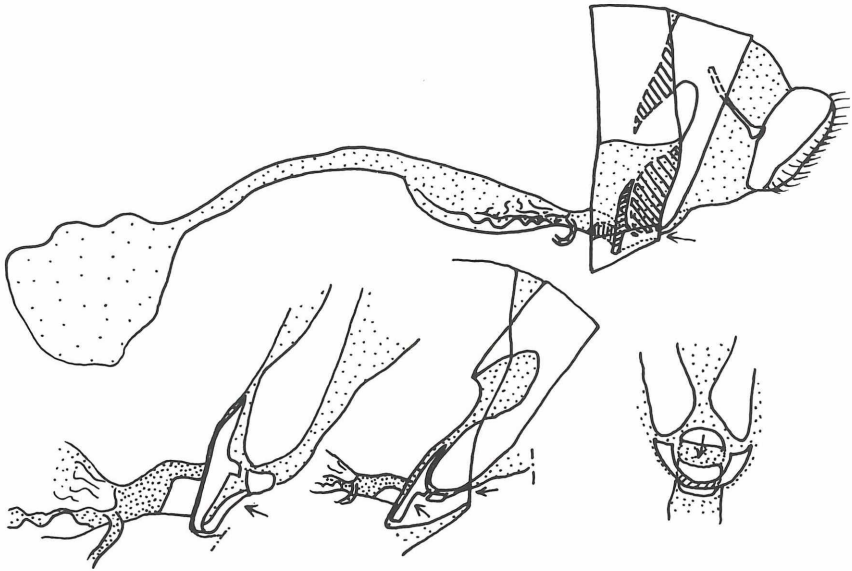


Fig. 9: Female genitalia of *Flos aereata* (Guangdong) consisting of the lateral view of complete genitalia (top), of lateral view of enlarged circum-ostium region (left bottom), of lateral view of circum-ostium region with outlines of membranes shown (central bottom), and of ventral view of circum-ostium region (right bottom).

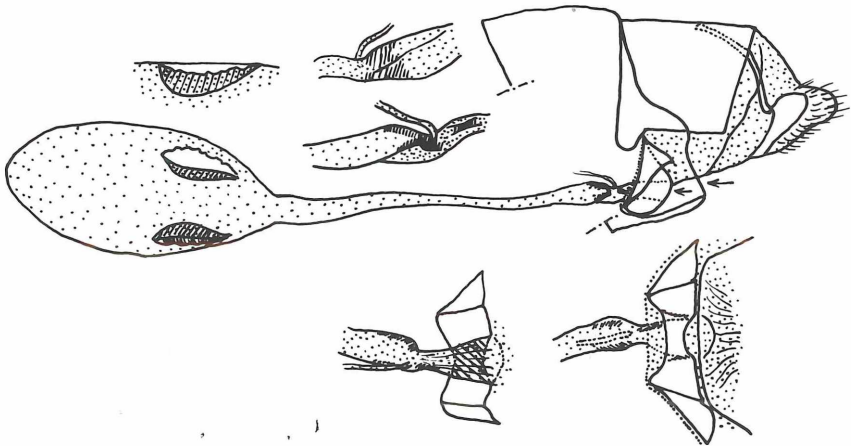


Fig. 10: Female genitalia of *Arhopala oenea* (S. Yunnan) consisting of the lateral view of complete genitalia (right top), of lateral view of signum to show the inner process of signum (left top), of right lateral and left lateral views of enlarged sclerotization on ductus bursae (central top), of inner dorsal view of circum-ostium region (left bottom), and of ventral view of circum-ostium region (right bottom).

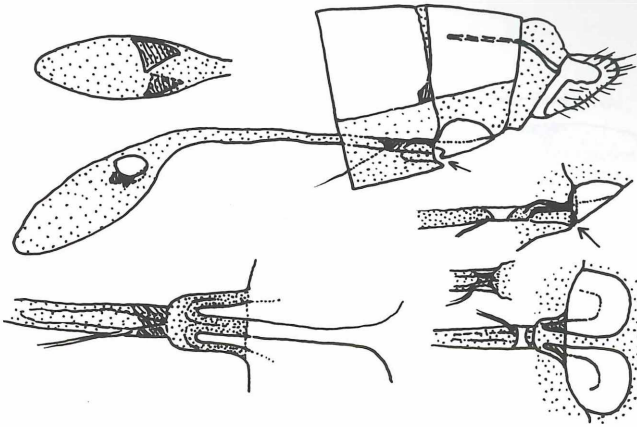


Fig. 11: Female genitalia of *Arhopala rama* (Nujiang, Yunnan) consisting of the lateral view of complete genitalia (right top), of lateral view of signa to show the inner process of signum (left top), of inner dorsal view of enlarged circum-ostium region to show ostium bursae and bacillus (left bottom), of lateral view of circum-ostium region and dorsal view of bacillus (central right), and of ventral view of circum-ostium region (right bottom).

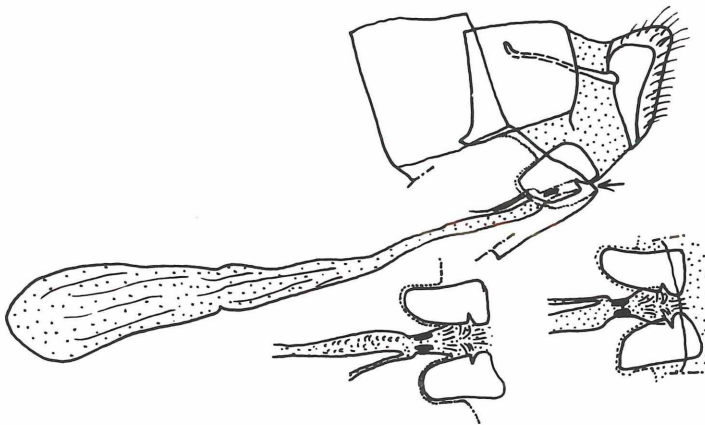


Fig. 12: Female genitalia of *Arhopala pseudocentaurus* (S. Yunnan) consisting of the lateral view of complete genitalia (top), of inner dorsal view of circum-ostium region (left bottom), and of ventral view of circum-ostium region (right bottom).

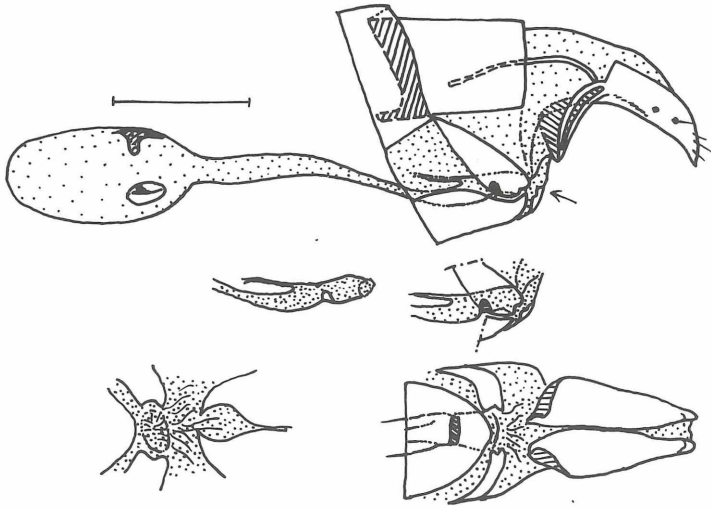


Fig. 13: Female genitalia of *Arhopala (Panchala) birmana* (Hainan) consisting of the lateral view of complete genitalia (top), of lateral view of caudal portion of ductus bursae to show bacillus (central left), of lateral view of circum-ostium region (central right), of posterior view of ostium entrance (left bottom), and of ventral view of circum-ostium region (right bottom).

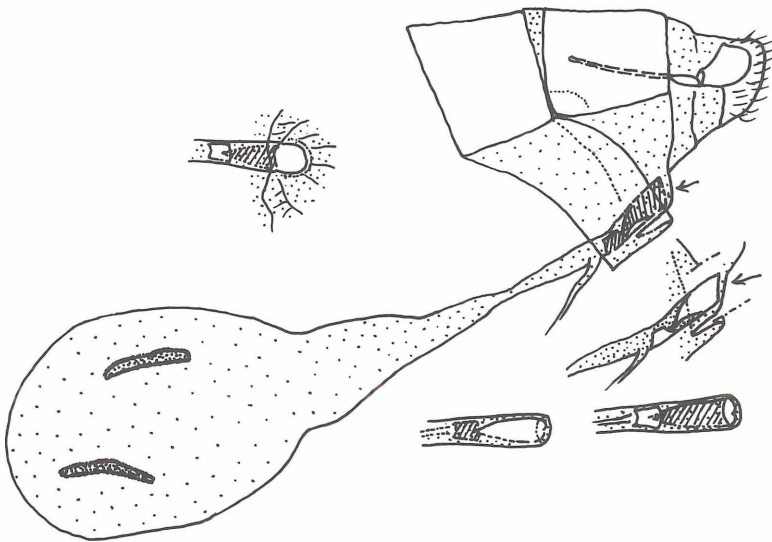


Fig. 14: Female genitalia of *Amblopala avidiena* (Qingdao) consisting of the lateral view of complete genitalia (right top), of ventroposterior view of ostium entrance (left top), of lateral view of circum-ostium region with outlines of membranes shown (central right), of dorsal view of caudal portion of ductus bursae to show the inner ostium sclerite and bacillus (left bottom), and of ventral view of caudal portion of ductus bursae (right bottom).

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