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Revision of the Genus *Ogygioses* (Palaeosetidae)

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Abstract

The systematics and external morphology of the oriental genus *Ogygioses* are reviewed. Monophyly of the genus is demonstrated by the two segmented labial palpi, loss of the jugal lobe in the forewing, stalking of the forewing R4 with the base of R2 + 3 and a specialised scale arrangement on the forewing base. Sculpturing of the egg chorion differs from that of other Exoporia in exhibiting elongate tubercles regularly dispersed over the surface. The genus is retained tentatively in the Paleosetidae on the basis of the loss of all tibial spurs, including the epiphysis, and the extreme reduction of the maxillae. Four species are recognised: *O. caliginosa* Issiki & Stringer, *O. eurata* Issiki & Stringer, *O. issikii* Davis, sp. nov., from Taiwan, and *O luangensis* Kristensen, sp. nov., from Thailand. Adults are diurnal with the males forming hovering groups, or leks, similar to some species of Hepialidae.

Introduction

In 1932, Syuti Issiki and Herbert Stringer published (in two parts) a small but important paper describing two primitive hepialoid genera from the Oriental Region. *Genustes lutata* [immediately synonymised in the second part under *G. minutus* (Hampson)] was described from Assam, India, together with a related genus, *Ogygioses*, consisting of two species from Taiwan. The only New World genus associated with these genera is *Osrhoes* from Colombia (Robinson and Nielsen 1984; Kristensen and Nielsen 1994). The relationship of all three taxa to the Australian *Palaeoses* is tentative at present.

This study is intended as an update on the systematics and integumental morphology of one of these problematic genera, *Ogygioses*, in anticipation of a general review of all members of the questionably monophyletic family Paleosetidae. We here report the occurrence of the genus in continental Asia, based on the finding of a new species in north-eastern Thailand. Bouin-fixed material of the latter taxon has been available, and histological sections have enhanced our understanding of some details of the integumental structure. Further findings on *Ogygioses* soft anatomy will be published elsewhere.

Materials and Methods

It should be noted that the Japanese place names on the labels of the Taiwanese specimens collected by Professor Syuti Issiki have been transliterated in this paper to currently used Chinese names as listed in Chu and Yamanaka (1973, 1975).

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The acronyms of the institutions listed in this study are as follows:

ANIC	Australian National Insect Collection, CSIRO, Canberra, Australia
BMNH	The Natural History Museum, London, UK
FSCA	Florida State Collection of Arthropods, Gainesville, FL, USA
KMNH	Kitakyushu Museum of Natural History, Kitakyushu, Japan
TPM	Taiwan Provincial Museum, Taipei, Taiwan, Republic of China
USNM	National Museum of Natural History (formerly United States National Museum), Smithsonian Institution, Washington, DC, USA
ZMUC	Zoological Museum, University of Copenhagen, Denmark

Biology

Distribution

Taiwan can be roughly partitioned into three major altitudinal zones with the plains below 100 m occupying only 31·3% of total land area, the areas between 100 and 1000 m totalling 37·2%, and the high mountains above 1000 m occupying 31·5% (Li *et al.* 1975). The chief feature of the island is a high mountain system extending nearly the entire length of the country from north to south. In all, 48 peaks exceed 3000 m in height with the highest, Yushan, reaching 3997 m. In addition to the central mountain system, which is divided into approximately four distinct ranges, there exists along the eastern coast the lower, nearly parallel Haian, or Coastal Range. *Ogygioses* is currently known only from the central mountain system of Taiwan.

Li *et al.* (1975) subdivided the Taiwanese flora into seven major zones: 1, coastal-tropical; 2, subtropical forest (below 500 m); 3, warm temperate mixed forest (700–1800 m); 4, cool temperate coniferous forest (1800–2500 m); 5, cold temperate coniferous forest; 6, subalpine coniferous forest (3000–3500 m); and 7, alpine (above 3800 m). *Ogygioses* spp. have been collected from an elevation of 300 m (near Kwantzuling), and possibly as low as 100 m (Wulai), to as high as 2400 m on Mt Alishan. Their habitats thus occur in at least three major botanical zones, including subtropical, warm temperate and cool temperate forests.

Positioned as it is, with the Tropic of Cancer dividing the island, Taiwan possesses a generally tropical–subtropical climate. Consequently, the summers are long and the winters mild, with the mean monthly temperature of the coldest month (February) ranging from 14·8°C in the north (Taipei) to 20·5°C in the south (Hengchun). Adult capture records of *Ogygioses* reflect this favourable climate in ranging from March to October.

Outside Taiwan, *Ogygioses* is known only from the Phu Luang Wildlife Sanctuary, south-west of Loei in north-eastern Thailand. The sanctuary is situated on an elevated plateau, with fairly steep sides above lowlands, which are now largely deforested (Round 1988). The top of the plateau, 1400–1500 m above sea level, is covered by low evergreen forest with numerous glades.

Life History

No species has been reared and, consequently, little has been published on the life history of *Ogygioses*. The eggs are white when laid, but become black within a few hours, as is typical of Hepialidae (Stokoe and Stovin 1948; Madge 1954; d'Aguilar 1966) and Mnesarchaeidae (Gibbs 1979). Chauvin and Barbier (1979) report that the colour change is the result of the melanisation and sclerotisation of the vitelline envelope. The eggs may not be scattered in flight, as generally reported for Hepialidae, but may be deposited on the host or some nearby substrate. The few eggs collected of *Ogygioses caliginosa* were attached randomly to the inside walls of a vial by the enclosed female (Heppner, personal communication). Aspects of the adult behaviour of *O. caliginosa* have been summarised by Kuroko (1990) and Heppner (1987). These reports, for the most part, agree with the unpublished observations received from K. Ueda and the late Professor S. Issiki.

Adults have been encountered over an 8-month period from spring to fall (March–October). Flight activity is strictly diurnal and most often noted from midday to early afternoon. No specimens have been collected at light. Adults have been observed flying in semi-shaded areas on overcast days and in periods of full sun (Heppner 1987). Ueda

Fig. 1. Habitat of *Ogygioses caliginosa*, Mt Alishan, 2400 m. Adults were collected along path in ravine. Photograph courtesy of K. Ueda.

Fig. 2. Lekking site of *Ogygioses caliginosa*, Mt Alishan, 2400 m. Adults were observed swarming in this area as well as resting on broad-leaf, unidentified shrubs. Photograph courtesy of K. Ueda.

(in litt.) has noticed males hovering under bushes during heavy rains. Both Ueda and Issiki (personal communication) have noticed that males tend to swarm in groups, or leks, often in forested ravines (Figs 1–2). Kuroko (1990) observed swarming males of *O. caliginosa* along

steep, moist banks bordering an asphalt road above 2000 m on Mt Alishan. The swarms usually contained 10–20 males which occupied a flying space 10–30 cm in width and 10–15 cm in height. Kuroko noted that each individual while swarming tended to fly in a pendulum-like sideways swinging motion on an arc about 10–20 cm long. The duration of swarming varied according to climatic conditions, from as brief as 1·5 min to as long as 20 min. On Mt Alishan, swarming was observed by Kuroko to occur between 1400 and 1800 hours, most often under low light conditions with optimum illumination between 3000 and 4500 lux. Ueda (in litt.) has compared the swinging, pendulum-like motion of hovering males to the similar flight of hovering male *Hepialus hecta* (L.) in Hokkaido, Japan. Issiki observed (personal communication) *Ogygioses* most commonly along mountain streams between 600 and 2000 m. He usually found them flying in shade *c.* 1 m above the ground in small swarms of 10–20 individuals, but sometimes solitary. The presence of prominent hair pencils, both on the hindwing and hindtibia of the males, suggests that females are attracted to swarming males by olfactory substances as well as by visual stimuli. Both lekking behaviour and pheromone production by males are means of long-distance female attraction developed in some Hepialidae (Mallet 1984). Wagner and Rosovsky (1991) have shown that the reversed calling system is a derived condition in Hepialidae and is present only in the most advanced genera.

The Thai species, *O. luangensis*, has been observed only within a quite small (about 10 × 50 m) rocky area with trees growing to 5–10 m height. This area was more humid than the surrounding forest, with trunks and branches overgrown by bryophytes and epiphytic ferns. While some males were observed flying (singly) on a sunny afternoon, most specimens (including the four females) were found on a morning in moist weather; they were then sitting on the fern- and bryophyte-covered branches. The species may be somehow associated with this periphyton. Specimens were found partly by direct searching, and partly by sweep-netting and beating.

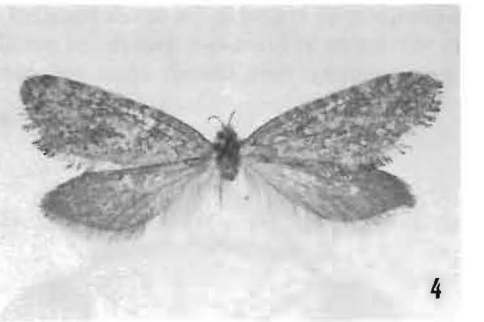
Heppner (1987) described the normal flight of *O. caliginosa* as relatively slow, straight, and very much resembling that of Trichoptera. He also observed that when disturbed in flight, as by a missed net swing, a moth would drop straight to the forest floor, possibly feigning death. This behaviour is similar to that observed by Mallet (1984) in a few 'bumping' incidents involving female *Hepialis humuli* striking a lekking male. After contact in flight, both male and female fell to the ground where they mated. Kuroko (1990) found mating pairs of *O. caliginosa* on grass leaves near the swarming site.

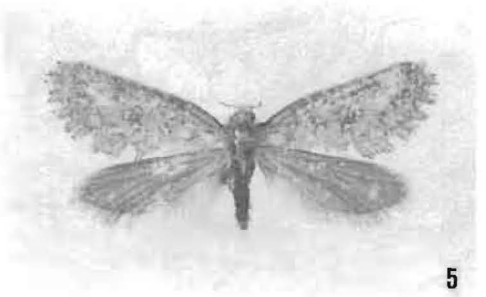
The lekking behaviour of the males may partially explain the overwhelming predominance of male *Ogygioses* to females in collections. Swarming, diurnal males obviously are more likely to attract the attention of collectors, who tend, as a result, to collect mostly males.

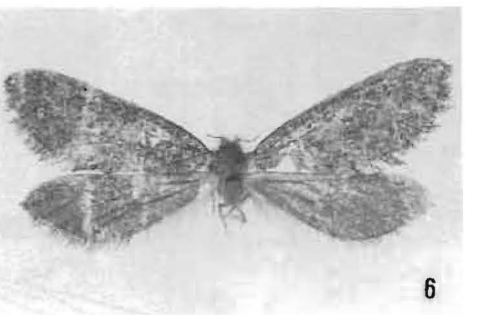
Family Relationship

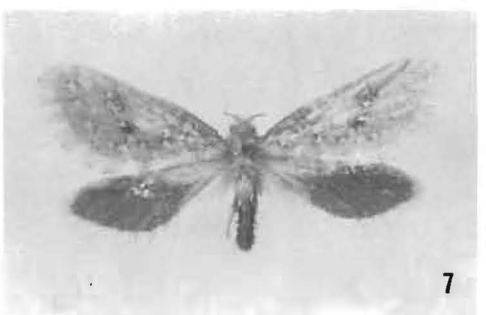
As discussed by Kristensen (1978*a*), the genera currently assigned to Paleosetidae differ from all other Hepialoidea in lacking the inter-M crossvein. Evidence supporting the possibility that this crossvein has been secondarily lost in these genera is equivocal (Kristensen and Nielsen 1994). Issiki and Stringer (1932*b*) originally proposed *Genustes* and *Ogygioses* in the Palaeosetidae largely on the basis of venational similarities and the extreme reduction or loss of tibial spurs and maxillae. Kristensen (1978*a*) suggests maxillary reduction as an autapomorphy for the family, noting that the maxilla can also be extremely reduced in most Hepialidae. Except for the foregoing regressive characters, no other apomorphies have been found to demonstrate the monophyly of the family.

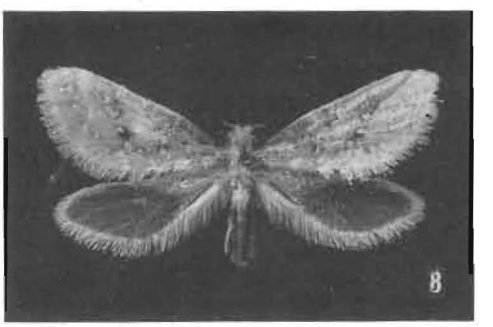
As in other genera assigned to the Palaeosetidae, the maxillary vestiges in *Ogygioses* are smaller than the mandibles (Figs 11, 26). The dense microtrichiation of the latter is known from other hepialoid clades as well; it is illustrated for *Afrotheora* and *Fraus* by Nielsen and Scoble (1986) and Nielsen and Kristensen (1989), respectively. As in *Palaeoses*, the labial palpus has a long terminal segment, evidently formed by fusion of segments 2 and 3; in *Osrhoes* (Kristensen and Nielsen 1994) and *Genustes* (Issiki and Stringer 1932*b*), a three-segmented palpus is retained. Shared by *Ogygioses*, *Genustes* and *Palaeoses* is the presence







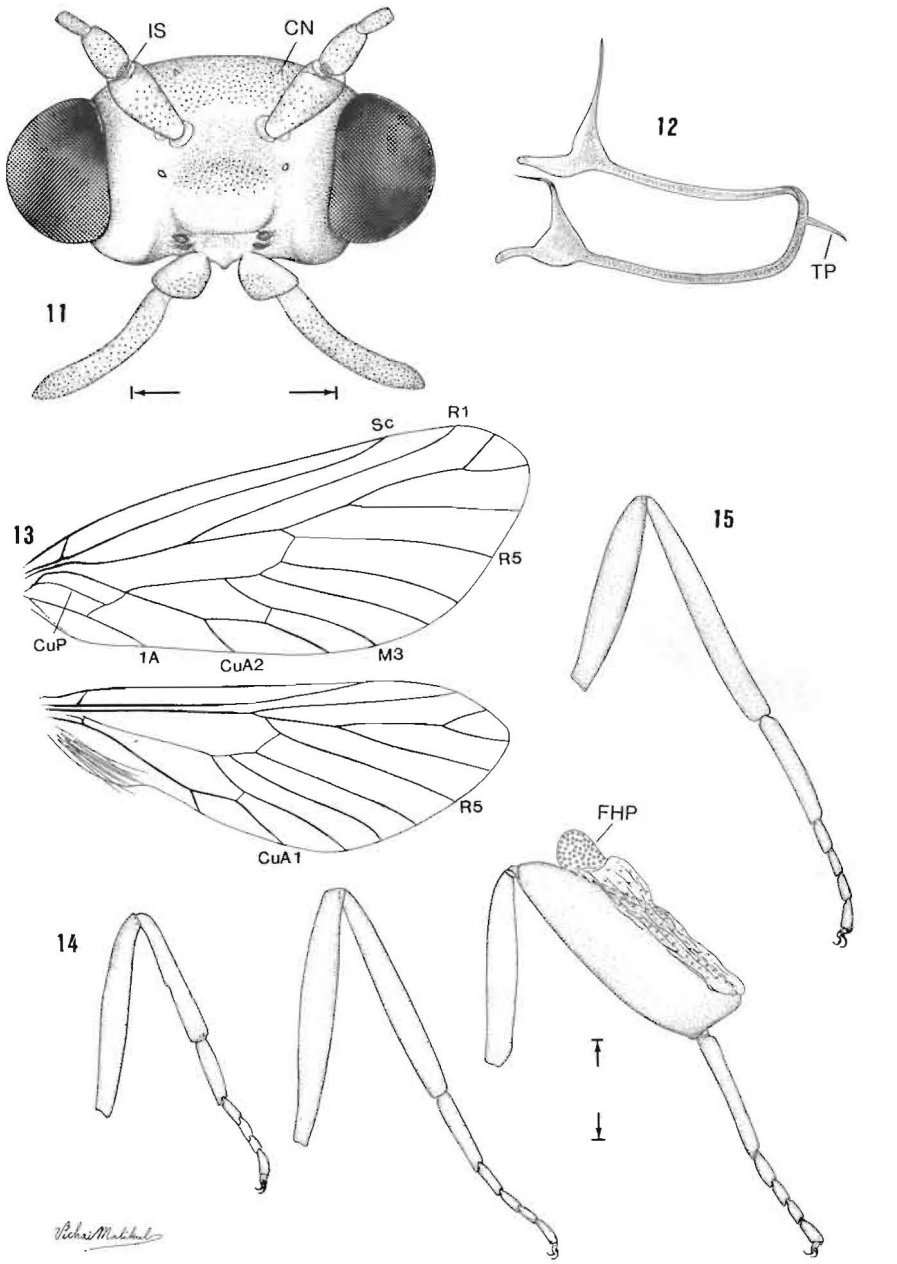




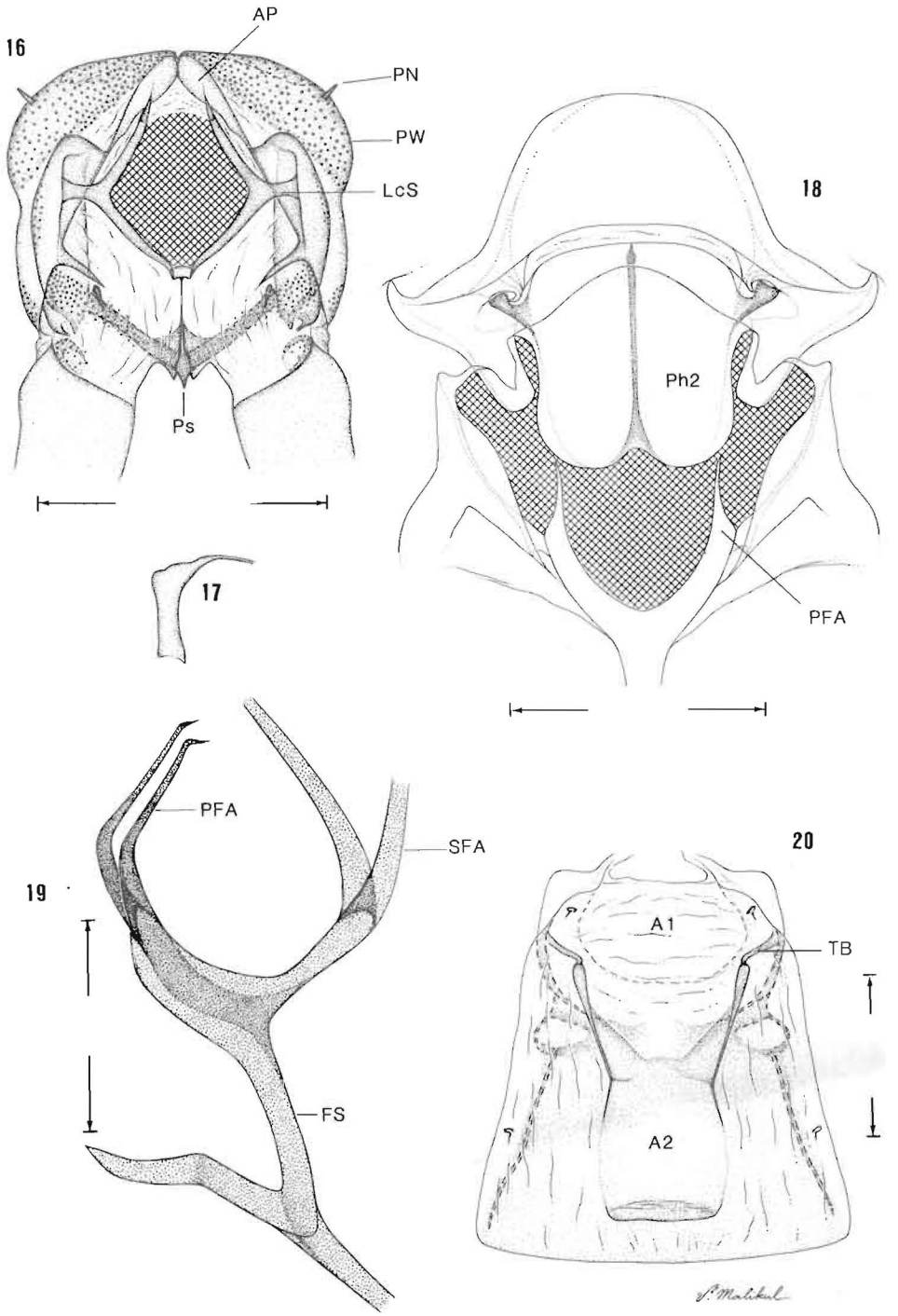
Figs 3–10. *Ogygioses* adults (wingspan in parentheses): *3*, *O. caliginosa* (15·4 mm); *4*, *O. caliginosa* (17·6 mm); *5*, *O. eurata* (16 mm); *6*, *O. eurata* (17·6 mm); *7–8*, *O. issikii*, holotype (16 mm); *9*, *O. luangensis*, holotype (13·8 mm); *10*, *O. luangensis*, paratype (15·7 mm).

of two pairs of cranial nipples (Figs 11, 21) immediately caudad to the antenna. Kristensen (1978*b*) reports these structures in other Hepialoidea, with three pairs present in *Anomoses*. Superficially, they appear to be sensory in function (Kristensen 1978*b*) and resemble paired processes present on the pronotum (Figs 16, 22) of several Hepialoidea.

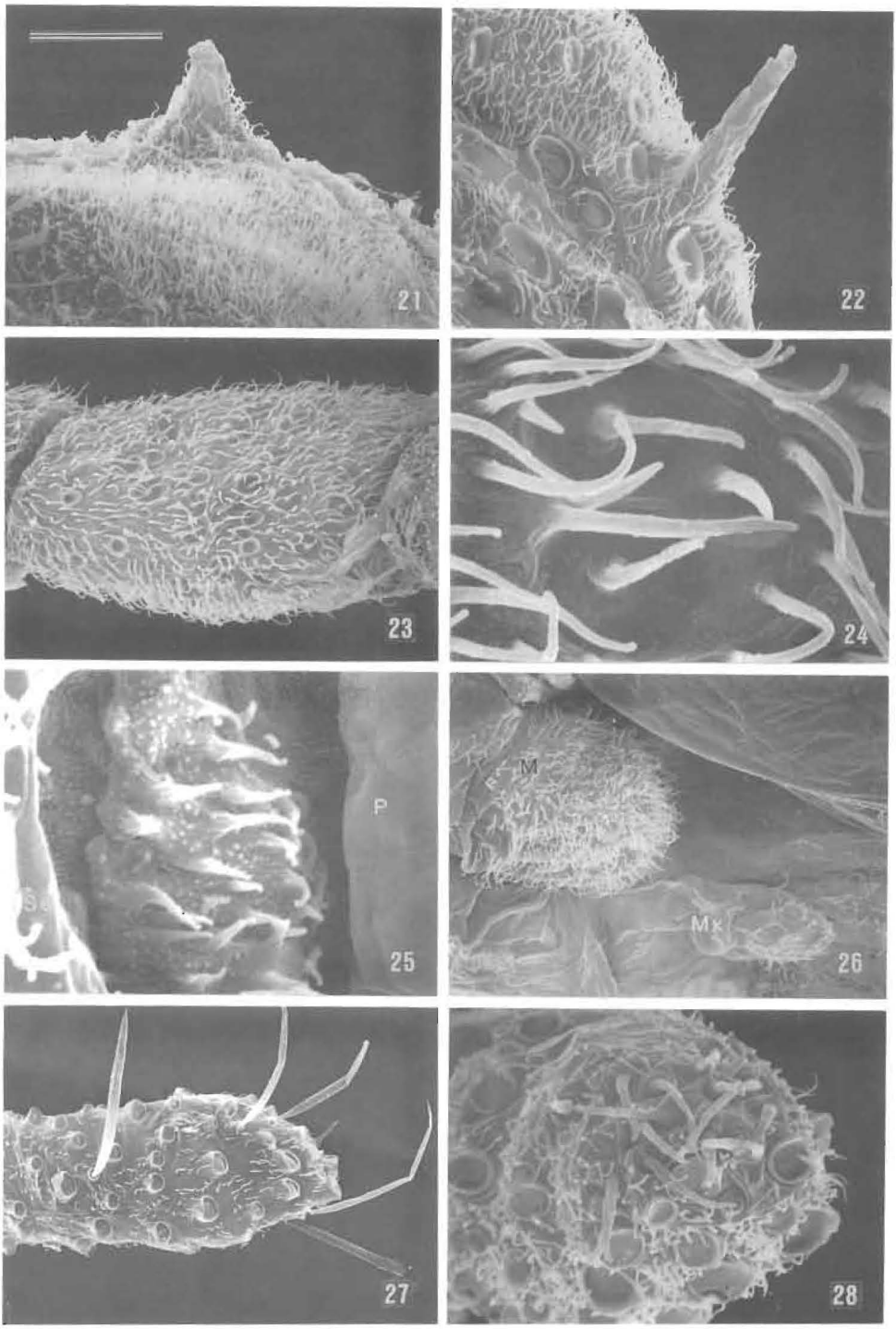
Among the previously described Paleosetidae, *Ogygioses* shows closest affinities to *Genustes* with regard to the development of a tibial hair pencil and similar forewing pattern. In the latter at least the 'bands' of small bluish white spots may count as a genuine synapomorphy; such distinct spots are absent from the mottled forewings of *Osrhoes*, and



Figs 11–15. *Ogygioses eurata*, head and thoracic structure: *11*, head, anterior view; *12*, tentorium; *13*, wing venation, male; *14*, fore, mid and hindlegs, male; *15*, hindleg, female. CN, cranial nipple; FHP, follicles of tibial hair pencil; IS, intercalary sclerite; TP, posteromedian tentorial process. All scales = 0·5 mm.



Figs 16–20. *Ogygioses caliginosa*, thoracic and abdominal structure (scale lengths in parentheses): *16*, prothorax, anterior view (0·5 mm); *17*, prothoracic furca, lateral view; *18*, mesothorax, posterior view (0·5 mm); *19*, metathoracic furasternum, lateral view (0·25 mm); *20*, abdominal segments 1–2, ventral view (0·5 mm). A, abdominal segment; FS, furcal stem; LcS, laterocervical sclerite; PFA, primary furcal arm; PN, pronotal nipple; Ps, prosternum; PW, pronotal wart; SFA, secondary furcal arm; TB, tergal process.



Figs 21–28. *Ogygioses caliginosa*, head structure (scale lengths in parentheses): *21*, cranial nipple (25 μm); *22*, pronotal nipple (20 μm); *23*, antenna, sixth segment (27 μm); *24*, sensilla coeloconica, paired, in *23* (4·3 μm); *25*, intercalary sclerite (6 μm); *26*, mandible (left), maxilla (30 μm); *27*, apical (second) labial palpus (20 μm); *28*, sensilla trichodea at apex of labial palpus; note lack of sensory pit (17·6 μm). S, scape; P, pedicel. Bar scale for all photographs as shown in *21*.

the forewings of *Palaeoses* are without any distinct markings. The hair pencil of the hindwing of the *Ogygioses* male is superficially similar to that of Anomosetidae (Kristensen 1978*b*), but the hair ultrastructure is not; there are no other indications of a close relationship between these two taxa. Another hepialoid taxon from which a superficially similar hair pencil on the male has been reported is the neotropical genus *Puermytrans* Viette, 1951 in the Hepialidae s. str. (Nielsen and Robinson 1983). It is intriguing, that the *Puermytrans* male also has, in the posterior part of the forewing base, a scale pocket strongly reminiscent of that in *Ogygioses laungensis*. However, since this pocket is invaginated behind, not in, vein 1A, strict homology seems ruled out; one cannot, therefore, even speak of 'underlying' synapomorphy here.

The male genitalia of all four genera differ strikingly, revealing little evidence to support their monophyly. Both *Palaeoses* (Davis, in press) and *Osrhoes* possess tergal processes (tergum X), lacking in *Ogygioses* and *Genustes*. The valvae of the latter two genera are relatively simple (unlobed) in contrast to the prominently lobed valvae of *Palaeoses* and *Osrhoes*. The pseudoteguminal arms differ in all four genera, with the condition in *Genustes* and *Ogygioses* most similar. Here the pseudoteguminal plates are not synscleritous in the middle, and the arms arise widely separated; they taper gradually and are joined to the apex (or almost so) by the membranous body wall. The pseudoteguminal arms in *Palaeoses* and *Osrhoes* arise close together with those of *Osrhoes* more elongate with long apical portions, slender, and free, as well as spined. The trulleum of *Ogygioses* is very similar to that of *Palaeoses* in being well sclerotised and finely tapered.

Ogygioses currently consists of four species restricted to Taiwan and Thailand. The monophyly of *Ogygioses* is clearly demonstrated by a suite of notable synapomorphies of its constituent species, including the forewing Rs configuration, the unique scale arrangement on the forewing base, and the loss of the jugal lobe [as noted by Issiki and Stringer (1932*b*), a minute disruption of the forewing anal margin is evident in some specimens that may represent a vestigial jugum]. The close resemblance in genital structure of both sexes is similarly noticeable, but since few inferences can so far be made about details in the groundplans of hepialoid and palaeosetid genitalia, the phylogenetic significance of these genital similarities remains largely uncertain. The presence of spiny hindgut sclerites is, of course, another remarkable similarity shared by the *Ogygioses* species, but a careful search for similar formations in other hepialoids is obviously needed, before their phylogenetic significance can be assessed. One cannot easily attribute any physiological significance to sclerotised hindgut plates in non-feeding moths; however, such plates have been recorded from a few lepidopteran larvae (Dauberschmidt 1933), and their presence in adults can most probably be explained in terms of a takeover of the larval proctodael intima with little modification at metamorphosis. Obviously, only a future examination of *Ogygioses* larvae can test the validity of this conjecture.

By far the greatest surprise that emerged from the present study is the difference in the antennal intercalary sclerite of the Thailand and Taiwanese *Ogygioses*. Kristensen (1978*a*, 1978*b*) tentatively considered the retention in 'the Palaeosetidae' of what we here call the 'primitive lepidopteran type' intercalary sclerite to be a plesiomorphy, that set this family apart from a clade comprising the other hepialoid families. However, Kristensen (1978*a*: footnote 5) stressed that the character in question had then been checked only in *Ogygioses* among palaeosetids. Our subsequent observations have revealed, that a 'typical hepialoid' intercalary sclerite is also present in *Osrhoes* and *Palaeoses*. It is possible, then, that the 'primitive type' intercalary sclerite in Taiwanese *Ogygioses* is an autapomorphic character reversal.

The 'pterostigma' reported by Issiki and Stringer in both fore and hindwings of fixed *Ogygioses* specimens is not a noticeable sclerotisation of the wing membrane. It is a spacious lacuna (Fig. 78) in which epidermal cell bridges here and there extend between the upper and lower wing walls, and after fixation coagulated haemolymph forms a spongy mass in the lacuna; the wing surface here also has dense scale-sockets. Staining emphasises the concentration of these sockets not only in the subcostal regions shown by Issiki and Stringer but also around most of the perimeter of both wings.

Species Inter-relationships

It is straightforward to assume that a sister-group relationship exists between *Ogygioses luangensis* and the Taiwanese *Ogygioses* species. However, although the latter assemblage is phenetically homogeneous, concrete evidence for its monophyly is not obvious. If, as suggested above, the 'primitive type' antennal intercalary sclerite in Taiwanese *Ogygioses* is indeed a character reversal, then this trait is an autapomorphy supporting the monophyly of the three species.

Ogygioses Issiki & Stringer

Ogygioses Issiki & Stringer, 1932*a*: 72. — Issiki and Stringer, 1932*b*: 73; Kristensen, 1978*a*: 287; Kristensen, 1978*b*: 14; Davis, 1992: 62.

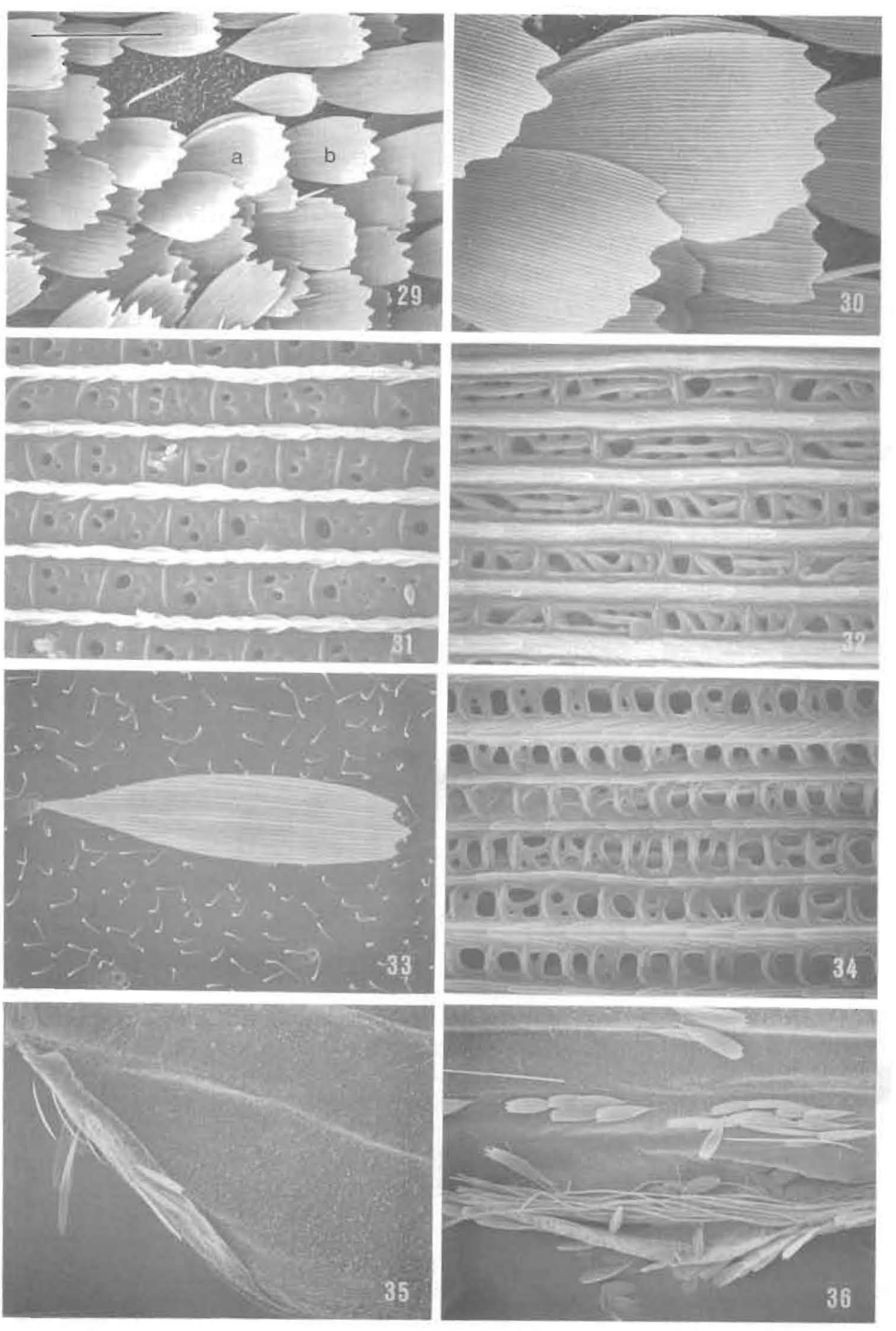
Type-species: *Ogygioses caliginosa* Issiki & Stringer, original designation.

Redescription

Adults (Figs 3–10)

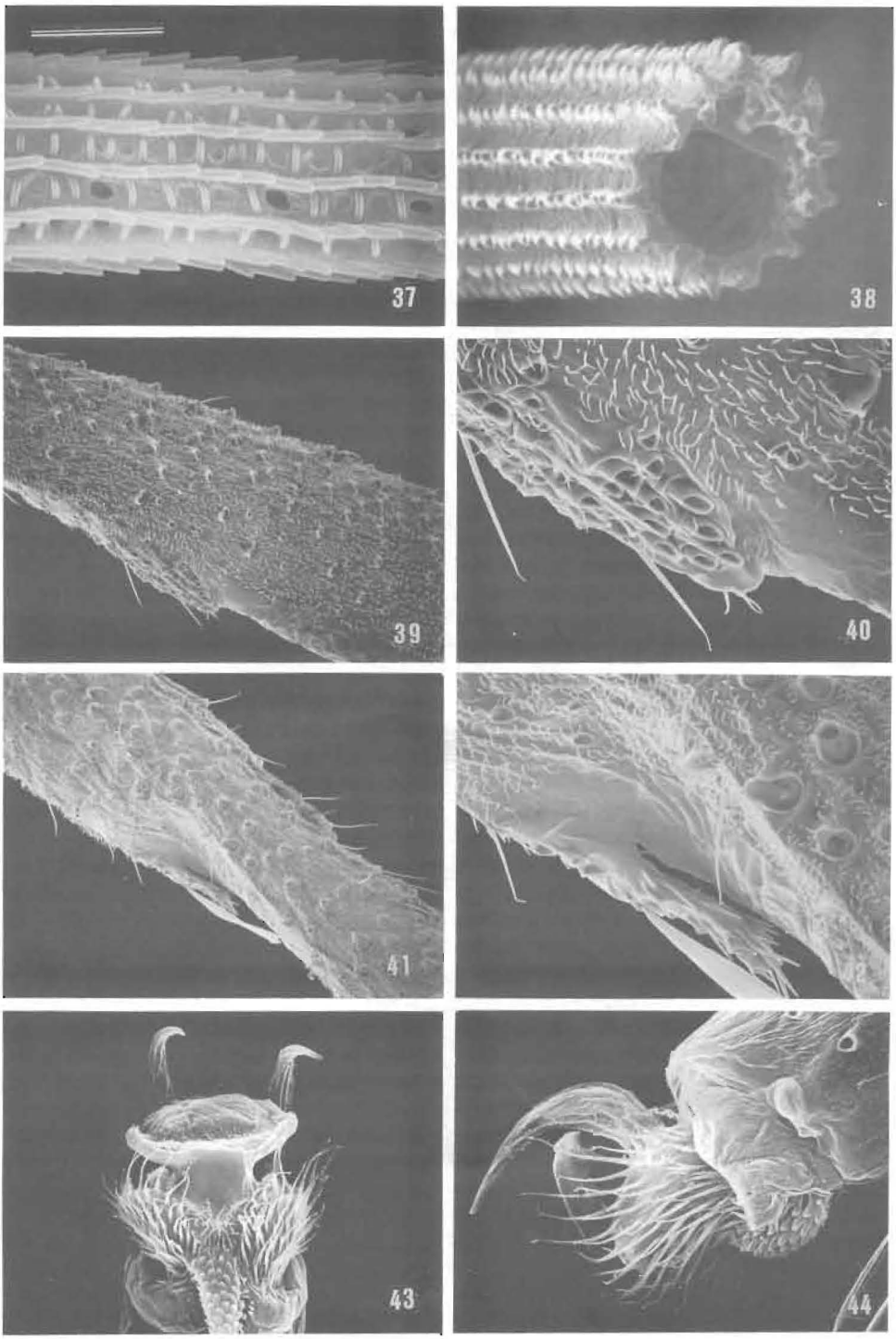
Relatively small moths with broad wings, often with 2–3 indistinct bands of small white spots obliquely traversing yellowish to dark brown forewings; wingspan 12·4–19·2 mm; jugum absent; anal margin of hindwing with an elongate dorsal fold and hairpencil.

Head (Fig. 11). Generally with rough vestiture; scales over frons erect and piliform with simple apices; vertex with divergent piliform scales concentrated immediately posterior to antenna, where they project over eyes, and caudad, tending to obscure (in unrubbed specimens) dense, appressed layer of broad, minutely serrated scales that cover most of vertex. Dorsal antennal condyle of cranium distinctly developed, strongly melanised. Antenna (Fig. 23) simple, filiform, extremely short, *c.* 0·15–0·2 the length of forewing, 17-segmented; scape cylindrical, enlarged, about twice the diameter of pedicel and 3 × the diameter of flagellomere, without pecten, with scattered erect, piliform to slender scales. Intercalary sclerite in lateral scapo-pedicellar membrane either (*O. luangensis*) of which might be termed the 'normal hepialoid type', viz. elongate, smooth and partly invaginated into a pocket in the membrane (Fig. 77), or (Taiwanese species) that might be termed the 'primitive lepidopteran type', viz, a small, microtrichiated and superficially located plate (Fig. 25) fused to opposing rims of scape and pedicel. Flagellum mostly covered with moderately broad scales that gradually become more slender and sparse toward apex; each flagellomere (Fig. 23) densely covered with numerous microtrichia *c.* 0·2 the diameter of the segment; sensilla trichodea less numerous, evenly scattered, *c.* equal to segment diameter, arising from relatively large, shallow follicles; sensilla coeloconica (Fig. 24) reduced, indistinct; sensory pit shallow, without encirclement of specialised spines, randomly scattered over flagellomere. Chaetosemata absent. Eyes moderately large but widely spaced (Fig. 11); interocular index *c.* 0·64; eye index *c.* 1·0; cornea without interfacetal microsetae. Vertex with 1–2 pairs of small cranial nipples (Figs 11, 21) directly caudad to antenna. Anterior tentorial pits arising high on frons (Fig. 11), closer to antenna than to mandible; dorsal arms of tentorium well developed, arising well anterior (Fig. 12); corporotentorium with prominent posteromedian tentorial process. Labrum undifferentiated; pilifer absent. Mandible (Figs 11, 26) reduced to a minute lobe covered with microtrichia. Maxilla (Fig. 26) reduced even smaller to a slender, minute lobe immediately below (caudad) and mesad of mandible; lobe probably rudiment of haustellum. Labial palpus 2-segmented; terminal segment elongate, nearly 3 × the length of short, triangular basal segment; terminal sensory pit (organ of vom Rath) not developed, with *c.* 12–14 short sensilla trichodea loosely concentrated subapically and arising from flush surface (Figs 27, 28); dorsum and distal half of terminal palpal segment also with numerous, large shallow sockets (Fig. 28), the smaller ones being the sockets of piliform scales, the larger sockets possibly functioning as other sensilla. Palpus arising from a prominent median lobe (prelabium).

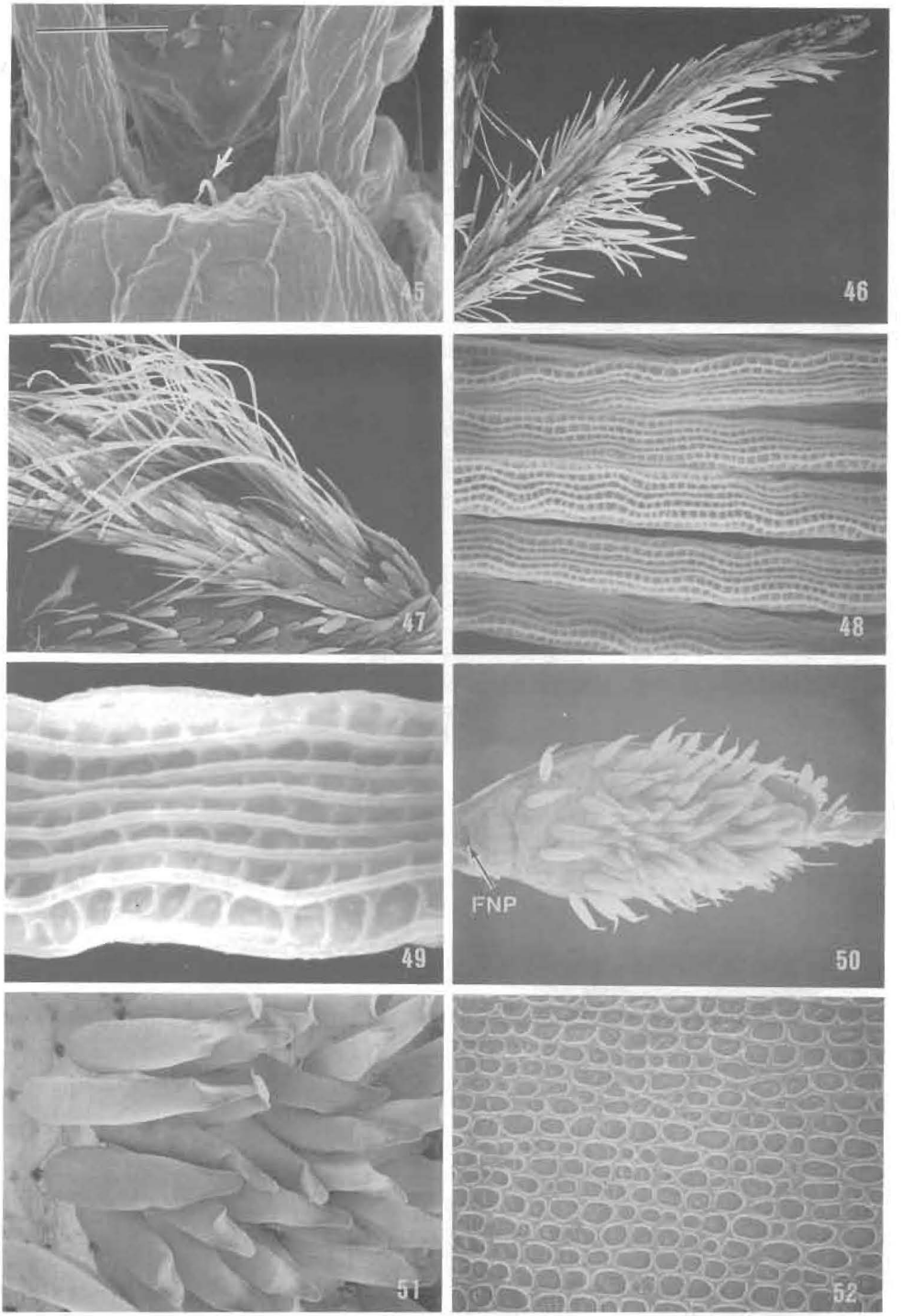


Figs 29–36. *Ogygioses caliginosa*, wing structure (scale lengths in parentheses): *29*, dorsal forewing scales at lower distal corner of discal cell (100 μm); *30*, detail of white scale (a) of *29*, note absence of longitudinal ridge dimorphism (38 μm); *31*, scale structure of white scale; see 'a' of *29* (3 μm); *32*, scale structure of brown scale; see 'b' of *29* (3 μm). *Ogygioses eurata*, wing structure: *33*, dorsal scale of hindwing discal cell (43 μm); *34*, scale structure of *33* (3·8 μm); *35*, hindwing, anal fold of the male (250 μm); *36*, detail of anal fold of the male, open to show hair pencil (250 μm). Bar scale for all photographs as shown in *29*.

Thorax. Prothorax (Fig. 16) with a thin, mostly internally inflected, laminate prosternum (discrimen); length of profurcal arms (Fig. 17) *c.* 3·5 × the width of conical base; laterocervical sclerite with relatively slender elongate median-lateral extension; pronotal wart extending to below dorsal apex of pleural wart, with acute, pronotal nipple (Figs 16, 22); anterior plate a sclerotised dorsal arch distinctly divided at midline by a low internal sulcus but not extended caudad between pronotal warts. Mesothorax (Fig. 18) with moderately long, acute mesofurcal arms; phragma with shallow ventromedian notch. Metafurcasternum (Fig. 19) moderately laterally compressed, with a relatively broad ventral keel that tapers to elongate, caudally projecting primary furcal arms; anterior process anterior to primary arms absent; common base of primary fucal arms arising midway on furcal stem; secondary arms separating well above common base of primary arms. Wingspan 12·4–19·2 mm. Forewing moderately broad, length *c.* 2·8 × the width; retinaculum absent; jugum absent; microtrichia distributed over all wing surfaces; forewing spinarea (*sensu* Minet 1989) small, but distinctive (Fig. 80). Venation homoneurous (Fig. 13) with humeral crossvein present; Sc unbranched (but site of vestigial Sc fork indicated by nerve branching, Fig. 79). R4 connate with base of R2 + 3; R5 connate with base of R2 + 3 + 4; discal cell relatively short, *c.* 0·5 the length of forewing; accessory cell absent, base of M not forked within cell; inter-M cross-vein (between M2 and 3) absent; base of CuP present to cross-vein or slightly beyond; 1A straight, without basal loop, not reaching margin. Basal part of 1A in *O. luangensis* with scale-bearing pocket (Figs 83–89). Scale covering of forewing upperside strikingly specialised (generic autapomorphy): in basal third, scales in front of M + Cu largely arranged in 'whorl' of concentric arcs (Fig. 82); toward midwidth of wing, scale axes becoming about normal to that of wing axis, or scale apices being even directed more or less distinctly toward wing base. Eventually scale rows 'straighten out', so scales come to be oriented more or less parallel to long axis of wing, as is usual in Lepidoptera. Forewing pattern ranging from pale golden yellowish brown to dark brownish fuscous, with numerous small bluish white spots bordering perimeter of wing and traversing wing in 2–3 indistinct oblique bands; also irrorated by darker brown scales; white scales (iridescing light blue) slightly broader than all other wing scales, with usually 6-dentate apices, indistinct ridge dimorphism, and reduced windows (Figs 29–31); yellowish to brown scales 4–5 dentate, with moderate longitudinal ridge dimorphism (2–6 secondary ridges between each primary ridge), and elongate, large, rectangular windows traversed by irregular cross ribs (Figs 29, 32). Hindwing with length *c.* 2·6 × maximum width; frenulum absent; Sc simple; radius as in forewing, with R2 and 3 dividing near apex, R4 stalked at base with R2+3; R5 arising from base of R2+3+4; discal cell short, *c.* 0·5 the total wing length; base of M not forked within cell; inter-M crossvein absent; anal lobe of male with an elongate dorsal fold (Figs 35, 36) containing a hair pencil; pencil composed of extremely long, tubular (hollow) scales (Figs 37, 38) capable of being raised vertically from the pocket; general surface of hindwing mostly covered by a relatively sparse, single layer of moderately slender, 3–4 dentate scales with rather pronounced ridge dimorphism (Figs 33, 34); darker scales over distal two-thirds of *O. issikii* hindwing as broad as forewing scales, usually with 5-dentate apices. Legs as shown (Fig. 14), with tarsi relatively short, *c.* equal to length of tibia; first (basal) tarsomere the longest, *c.* 2 × the length of second on fore and midleg and 3 × on hindleg; all tibial spurs (including epiphysis) absent; foreleg with median tibial notch or short spine as vestigial epiphysis (Figs 39–42); hindtibia of male enlarged, particularly in Taiwanese species, with prominent hair pencil (*c.* equal to length of tibia) arising near base and lying along a membranous, longitudinal, dorsal groove (Figs 14, 47); scales of pencil tubular with sinuate longitudinal ridges (Figs 48, 49); membranous groove apparently capable of inflation and covered with spindle-shaped androconia with low relief, reticulate surface pattern (Figs 50–52) lacking distinct longitudinal ribs and scutes; hindtibia of female not swollen, without hair pencil (Fig. 15). Pretarsus of all legs similar, with well-developed, simple claws, a broad arolium on a relatively short base, a symmetrical pair of moderately developed pulvilli (Figs 43, 44); unguitractor plate relatively slender with *c.* 6–7 somewhat staggered vertical rows of microscutes (Fig. 43); pseudempodial seta variable, reduced (Fig. 45) to moderately well developed.



Figs 37–44. *Ogygioses caliginosa*, scale and leg structure (scale lengths in parentheses): *37*, detail of hair pencil scale in *36* (2·5 μm); *38*, cross-sectional view of hair pencil scale in *37* (2·5 μm); *39*, foretibia, vestigial epiphysis (86 μm); *40*, detail of *39* (27 μm); *41*, foretibia, vestigial epiphysis (86 μm); *42*, detail of *41* (30 μm); *43*, foreleg pretarsus, ventral view (20 μm); *44*, lateral view of *43*. Bar scale for all photographs as shown in *37*.

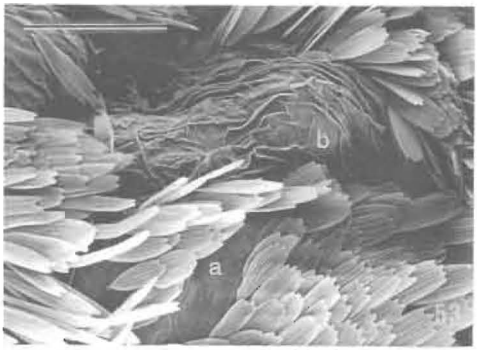


Figs 45–52. *Ogygioses caliginosa*, leg structure (scale lengths in parentheses): *45*, dorsal view of *43* showing reduced pseudempodial seta (arrow) (10 μm); *46*, foreleg showing rough scaling along tarsal segments (0·5 mm); *47*, hindtibia, hair pencil of the male (0·3 mm); *48*, hair pencil scales of *47* (13·6 μm); *49*, detail of single hair pencil scale in *48* (3 μm); *50*, hindtibia of the male showing dense array of underlying androconia, hair pencil removed (0·43 mm); *51*, androconia of *50* (120 μm); *52*, surface detail of androconial scale, *51* (6 μm). FNP, follicles of hair pencil. Bar scale for all photographs as shown in *45*.

Abdomen (Fig. 20). First tergum mostly membranous with strongly sclerotised lateral margins; vestiture sparse, largely naked with scattered small, slender scales over medial area, and more densely clothed with longer, piliform scales laterally. First sternum entirely membranous. Pleural region of A2 with a naked, slightly hollow trough (Fig. 53); ventral area of trough with a small (*c.* 75 μm long) ovoid, tuberculate plate possessing a reticulate surface (Fig. 54); surface of trough mostly covered with anastomosing microtubercles (Figs 55, 56); trough may receive hindwing hair pencil fold when wing is folded, as well as hindtibial hair pencil. Second sternum partially membranous with a more or less well-defined, narrow 'H'-shaped sternite that possesses a largely membranous anterior half and more sclerotised posterior half; a pair of rod-like anterior arms terminating in slightly swollen, clavate apices that articulate with latero-ventral processes from tergum I (Fig. 20) caudad of first abdominal spiracle. Spiracles present on first 8 segments.

Male genitalia (Figs 91, 93–99). Thin-walled eighth sternum differing from preceding sterna in having the anterior rim well melanised, strengthened by transverse suture (with somewhat variable course); median group of strong setae (unlike adjacent scales not easily removable after KOH maceration) present on posterior sternal area. Vinculum (ninth sternum) strongly reflexed caudally, forming a vincular pocket (Figs 91, 97); posteroventral rim of pocket (i.e. topographically caudal margin of vinculum) bilobed in Taiwanese species, nearly straight in *O. luangensis*. The vincular pocket is deeper in the Taiwanese species (Fig. 97) than in *O. luangensis* (Fig. 91); on the other hand the vinculum apodeme, which extends forward from the bottom of the pocket, is markedly longer in the latter. It is straightforward to assume, that the 'vinculum' portion that is morphologically anterior to (topographically posterior to/below) the apodemal invagination line, is a sclerotisation of the body wall area which at some ancestral stage formed the bulk of the ventral VIII–IX intersegmental membrane; similar modifications of the ventral VIII–IX transition are commonplace in hepialoids; internal lateral ridges of vinculum (Fig. 94) either parallel or slightly divergent toward dorsal caudal margin. Tegumen (ninth tergum) membranous (Nielsen and Kristensen 1989). Tergum X almost entirely membranous, except for a slender dorsal strip; small scale groups may demarcate the sites of vestigial tergal lobes. Pseudoteguminal plates with strong internal crests along lateral margins (Fig. 93), but without differentiation of 'intermediate plates' laterally; plates well separated, consisting of a pair of lateral, triangular sclerites tapering caudally as a pair of extremely slender pseudoteguminal arms that converge but do not join posteriorly (Figs 94–96); plates and arms loosely connected dorsally by a sheet of membrane. Trulleum reduced to an elongate (*c.* 0·5 the length of valva), well sclerotised spine-like process tapering to an acute or minutely bulbous apex; apical area more or less distinctly corrugated. Juxta articulating with broadened anterior base of trulleum, an elongate plate with median strengthening ridge, beneath and mesad of pseudoteguminal plates, then widening toward ventral articulation with morphologically caudal margin of vinculum. Valva simple, densely setose, with almost parallel margins or (*O. luangensis*) somewhat widening before tapering abruptly to a rounded apex. Phallus entirely membranous; gonopore immediately dorsad to trulleum.

Female genitalia. Ninth sternum moderately well developed, evenly rounded, without lateral or medial lobes, setose. Subanal plates (Fig. 101) slender, paired, extending caudally almost to midline where they are narrowly separated by shallow intergenital cleft. Bursa copulatrix elongate, *c.* 0·8 the length of expanded abdomen. Antrum conical and strongly asymmetrical: the sclerotised antrum floor, which posteriorly is continuous with the sternum IX plate, has the tapering anterior apex strongly directed toward the animal's right side. Ductus bursae slender, about same diameter from ostium to corpus, walls with scattered spicules; corpus bursae relatively small, usually gradually, sometimes abruptly enlarged, membranous, occasionally with wrinkled walls. Spermatheca (Figs 100, 103) arising from small, sclerotised, cupuliform papilla on an elongate moderately broad duct; entire spermatheca elongate, often exceeding length of bursa copulatrix, with efferent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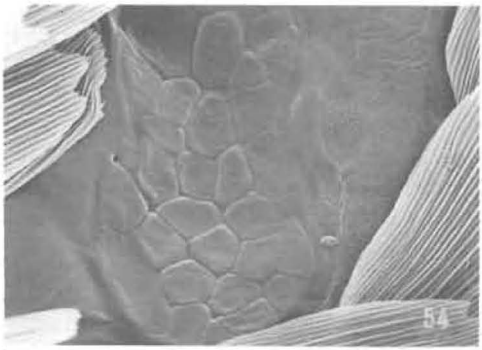
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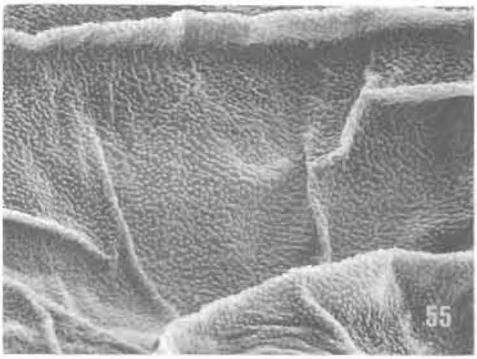
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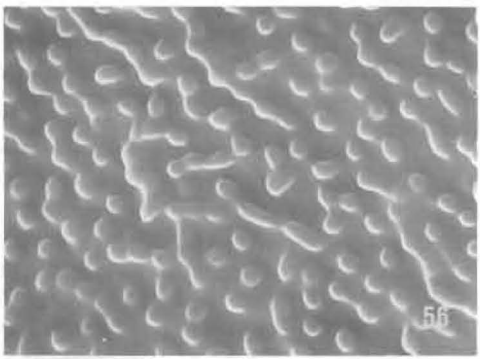
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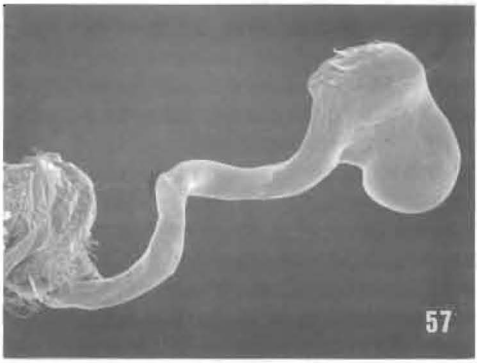
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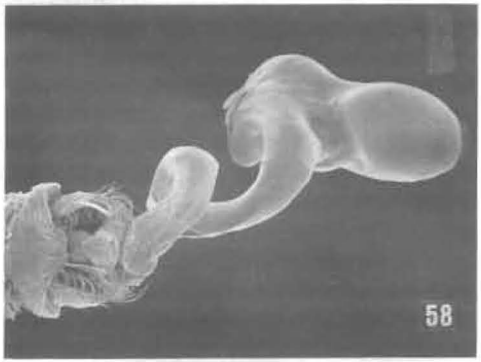
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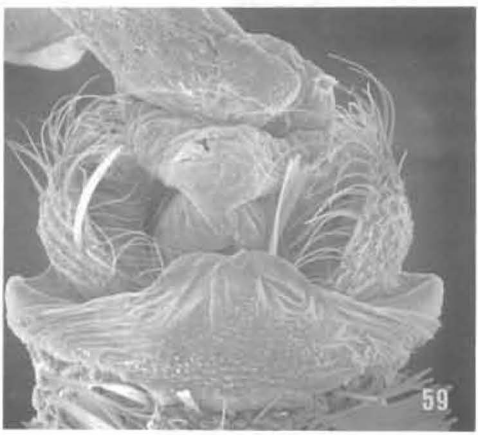
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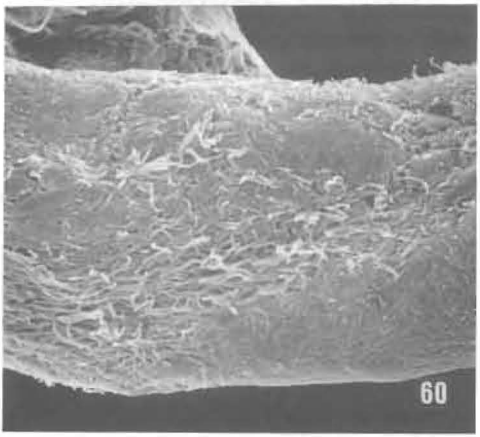
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(fertilisation) canal variable, tightly coiled in *c.* 7–8 whorls at anterior end near junction with vesicle to merely sinuate; utriculus long and slender, more than half the length of bursa copulatrix. Dorsal plate (tergum IX + X, Nielsen and Kristensen 1989) similar in development to sternum IX, setose, shallowly bilobed.

Viscera. An unexpected detail in the visceral anatomy of *Ogygioses* was noted during the examination of KOH-treated abdomen preparations: the presence of spiny, sclerotised plates on the cuticular intima of the anteriormost part of the hindgut in *O. caliginosa* as well as *O. luangensis*. The plates are arranged in a single circle around the gut. Each plate is a low sclerotised dome with a few (occasionally a single) blunt spines on top (Figs 90, 92).

Discussion

Largely due to unusual uniformity of genital morphology, no reliable character has been found to distinguish males of the three recognised Taiwanese species of *Ogygioses*. Minor differences in the orientation of internal ridges in the vinculum (Figs 94, 95) vary within populations. *Ogygioses issikii*, known only from males, is easily distinguished by its pale yellow forewings and distinctly marked hindwings (Figs 7, 8). Issiki and Stringer (1932) recognised two species on the basis of two features: forewings ochraceous orange with a straight costa (*O. eurata*), and forewings bronzy fuscous with slightly sinuate costa (*O. caliginosa*). No significant difference was observed in this study with regard to costal outline. The type series of *O. caliginosa* and *O. eurata* also consist only of males. Subsequent collections of females include at least two species based on differences in the ductus spermathecae (Figs 100, 103). The uniform brownish hindwings of these females indicate that they most probably represent *O. caliginosa* and *O. eurata* and not *O. issikii*. The problem is, then, one of association, which is complicated further by the poor condition of most females examined. Only 11 females from Taiwan were available for study. Five of these, all with mostly sinuate ductus spermathecae, were collected on Alishan. Although rubbed (three are preserved in alcohol), these females most resemble the darker holotype of *O. caliginosa*. Heppner collected seven males swarming with one female near Liukuei of the same species as from Alishan (with sinuate ductus spermathecae). Similarly, the single female with a coiled ductus from Hassenzan (= Pahsienshan), and particularly the relatively large series of associated males from the same population, most resemble the paler holotype of *O. eurata*. The latter association also is true of the single female examined from Taipingshan and the three pale males collected at Taiheisan (= Taipingshan).

A general attempt was made to group all Taiwanese males of *Ogygioses* according to colour even though there exists an almost continuous range from pale yellowish brown to brownish fuscous. Without associated females, identification of males remains questionable. Future emphasis should be directed toward collecting more pairs *in copula* at lekking sites. As more females become available for study, the morphological variation of the ductus spermathecae should be evaluated. No intermediacy between the multi-coiled and sinuate ductus was noted in the 11 females dissected. Within females possessing multi-coiled ducts and identified as *O. eurata*, variation in the form of the corpus bursae was observed (Figs 100, 102). This difference could indicate another species, or, as treated in this report, merely represent within-species variation.

Figs 53–60. *Ogygioses*, male structure (scale lengths in parentheses). *O. eurata*, second abdominal pleura, *53–56: 53*, naked 'trough' (100 μm); *54*, reticulate surface and pores of A2 tuberculate plate (area 'a' of *53*) (20 μm); *55*, surface of trough (area 'b' of *53*) (10 μm); *56*, detail of *55* (2 μm). *O. caliginosa*, spermatophore extruded from abdomen, *57–60: 57*, lateral view (0·43 mm); *58*, ventral view (0·33 mm); *59*, ventral view of genitalia and segment VIII (120 μm); *60*, exposed fibrous tissue of spermatophore stalk (38 μm). Bar scale for all photographs as shown in *53*.

Key of Species of *Ogygioses*

1. Forewing (Figs 3–8) in both sexes without prominent light central spot and postdiscal band; hindtibia of the male (Fig. 14) strongly swollen; male genitalia (Figs 94, 95, 98) with valvae almost parallel-sided, pseudoteguminal arms slender, with simple pointed apices; female genitalia (Fig. 100–104) without prominent broadening of ductus bursae; Taiwan 2

   Male forewing (Fig. 9) with prominent, light yellowish central spot and postdiscal band; hindtibia of the male (Fig. 81) not markedly swollen; male genitalia (Fig. 99) with valvae distinctly broadened subapically, pseudo-teguminal arm stout, strongly melanised, with concavity in apical region; female genitalia (Figs 105, 106) with prominent broadening of ductus bursae; continental South-east Asia ..... *O. luangensis*, sp. nov.
2. Hindwing, including fringe, uniformly grey to brown (Figs 3, 5) 3

   Hindwing with apical two-thirds dark brown; basal third and fringe contrastingly white to cream (Figs 7–8) ..... *O. issikii*, sp. nov.
3. Forewing usually paler (Figs 5, 6), often with light brown to yellowish suffusion; female with multi-coiled ductus spermathecae (Figs 100, 102) ..... *O. eurata* Issiki & Stringer

   Forewing generally darker and less contrastingly marked (Figs 3, 4); ductus spermathecae mostly sinuate, with no more than a single coil (Fig. 103) ..... *O. caliginosa* Issiki & Stringer

Ogygioses caliginosa Issiki and Stringer

(Figs 3, 4 ,16–32, 37–52, 57–76, 78, 94, 103, 104)

Ogygioses caliginosa Issiki & Stringer, 1932*a*: 72. — Issiki and Stringer, 1932*b*: 74; Heppner, 1987: 13; Davis, 1992: 62.

Material Examined

Holotype. Taiwan, Nantou District: Rantaisan [= ? Lantashan], 3–5.vi.1927, S. Issiki, slide 16602 (USNM).

Other material examined. **Taiwan**: specific locality unknown, 2♂, Mar. 1927, S. Issiki (USNM). **Baarun** [present name = ?]: 1♀, 25.vi.1927, S. Issiki, slides 16603, 30617 (USNM). **Chiayi District**: Alishan, 2400 m, 1♂, 1♀, 10.vii.1981, K. Ueda, slides DRD 3834, 3835 (KMNH); 2♂, 1♀, slide 30596 (USNM); 9♂, 2♀, 28.vi.1987, H. Kuroko, slides 31178, 31179 (USNM); 2274 m, 1♀, 17–23.vi.1988, H. Kuroko, slide NPK 914 (ZMUC). **Fennchihwu**: 1450 m, 6♂, 2–4.vii.1985, J. Heppner and Wang, slide DRD 3684 (FSCA). **Tattaka** [Tungpu]: 6♂, 8.vi.1943, S. Issiki, slide 30595 (USNM). **Hualien District**: Higasinoko [Tungnunkao], 4♂, 2–3.vi.1943, S. Issiki, slides 16154, 30976 (USNM). **Tzu en**: 2♂, 4–6.vi.1982, T. Tanabe (KMNH). **Koashiung District**: Shanpin Forestry Stn, nr Liukuei, 750 m, 8♂, 1♀, 29.iv.–3.v.1989, J. Heppner and H. Wang, slides DRD 3845–3847, 31119 (FSCA, USNM). **Nantou District**: Lushan, 1♂, 19.iii.1982, S. Hashimoto, slide DRD 3833 (FSCA). **Musya** [Jenai = Wushe]: 1♂, 23.v.1947, S. Issiki, slide NPK 916 (ZMUC), 1♂, slides 30568, 31083, 31117 (USNM). **Rantaisan** [? Randaizan = Lantashan]: 2♂ (paratypes), Mar. 1927, S. Issiki, (BMNH); 1♂ (holotype), 1♀ (paratype), 3–5.vi.1927, 1♂, 15.v.1933, S. Issiki, slides 16602, 30593 (USNM). **Taichung District**: Baibara [Meiyuan], 1♂, 23.iii.1943, S. Issiki, slide NPK 917 (ZMUC), 1♂, 1♀, slides 30967, 31172 (USNM). **Tainan District**: Kansirei [Kuantzuling, 300 m], 1♀, 16.x.1934, S. Issiki, slide 30594 (USNM).

Redescription

Male (Fig. 3)

Wingspan 13·5–15 mm. Head with scattered, erect, piliform, cream to dark brown scales over frons and rear of head; vertex covered by broad, appressed, equally mixed cream and brown scales. Antennal scape with broad to slender, cream scales irrorated with dark brown to fuscous; flagellum completely covered with moderately broad, mostly brown scales dorsally and cream ventrally. Labial palpus very rough, with long, divergent, slender cream scales heavily intermixed with brown to fuscous. Thorax with pro- and mesonota generally covered with smooth, broad, cream scales irrorated with brown to fuscous laterally; occasionally mesonota almost entirely brown; long, erect piliform brown to cream scales prominent at sides and posterior; venter sparsely covered with long, slender, mostly dull white scales. Forewing generally bronzy brown to fuscous, irrorated with small spots of

white scales with blue iridescence and dark brown scales; white spots scattered over wing but more or less arranged in 3 oblique rows (subterminal, medial and basal) also as many as 14 spots bordering entire wing margin from basal third of costa around termen to basal third of hind (dorsal) margin; dark brown to fuscous scaling often concentrated along base of costa and along a subterminal arch from below apex to basal half of hindmargin; fringe predominantly brownish fuscous to light brown interrupted by white at each marginal spot; venter of forewing uniformly light brown. hindwing uniformly grayish brown; fringe similar in colour. Foreleg with tibia and tarsus extremely rough scaled (Fig. 46) primarily over dorsal and lateral surfaces; scales mostly long, slender and brown irrorated with cream; scales becoming shorter and cream to white ventrally and toward apex of tarsus. Midleg similar but generally paler, with more white scaling toward tarsus. hindleg generally smoother, uniformly light brown, becoming paler over tarsus and venter of tibia; tibial hair pencil cream; clusters of long piliform scales at apex of tibia and some tarsomeres. Abdomen dark brown to fuscous dorsally and laterally; white to buff ventrally.

Male genitalia (Fig. 94). Pseudoteguminal arms very slender, tapering to acute apices that converge distally but are well separated by membrane. Trulleum likewise tapering to a slender, minutely rounded to acute apex. Vinculum with internal ridges either parallel or divergent caudally; ventrocaudal margin of vinculum bilobed. Valvae about as broad at base as near apex; abruptly narrowing to subacute apex. Spermatophore (Figs 57–60) terminating in an elliptical, swollen sac about 0·50 mm long and 0·23 mm in diameter; extending from the sac a slender, slightly coiled tube more than twice the length of the sac. Surface of spermatophore generally smooth except for fibrous texture where interior wall exposed (Fig. 60).

Female (Fig. 4)

Wingspan 13·5–19 mm. Similar in general colour to male but with less distinct pattern. Hindwing with anal pocket and pencil absent. Hindtibia normal, not swollen and without hair pencil (Fig. 15).

Female genitalia (Figs 103, 104). Caudal margin of sternum IX evenly rounded, without median depression evident in *O. luangensis*. Ductus bursae evenly tubular, with internal spicules evenly distributed throughout length, to elongate, smooth-walled corpus bursae. Ductus spermathecae mostly sinuate, with efferent canal forming only one complete coil before vesicle; caudal end of efferent canal terminating at a sclerotised ring.

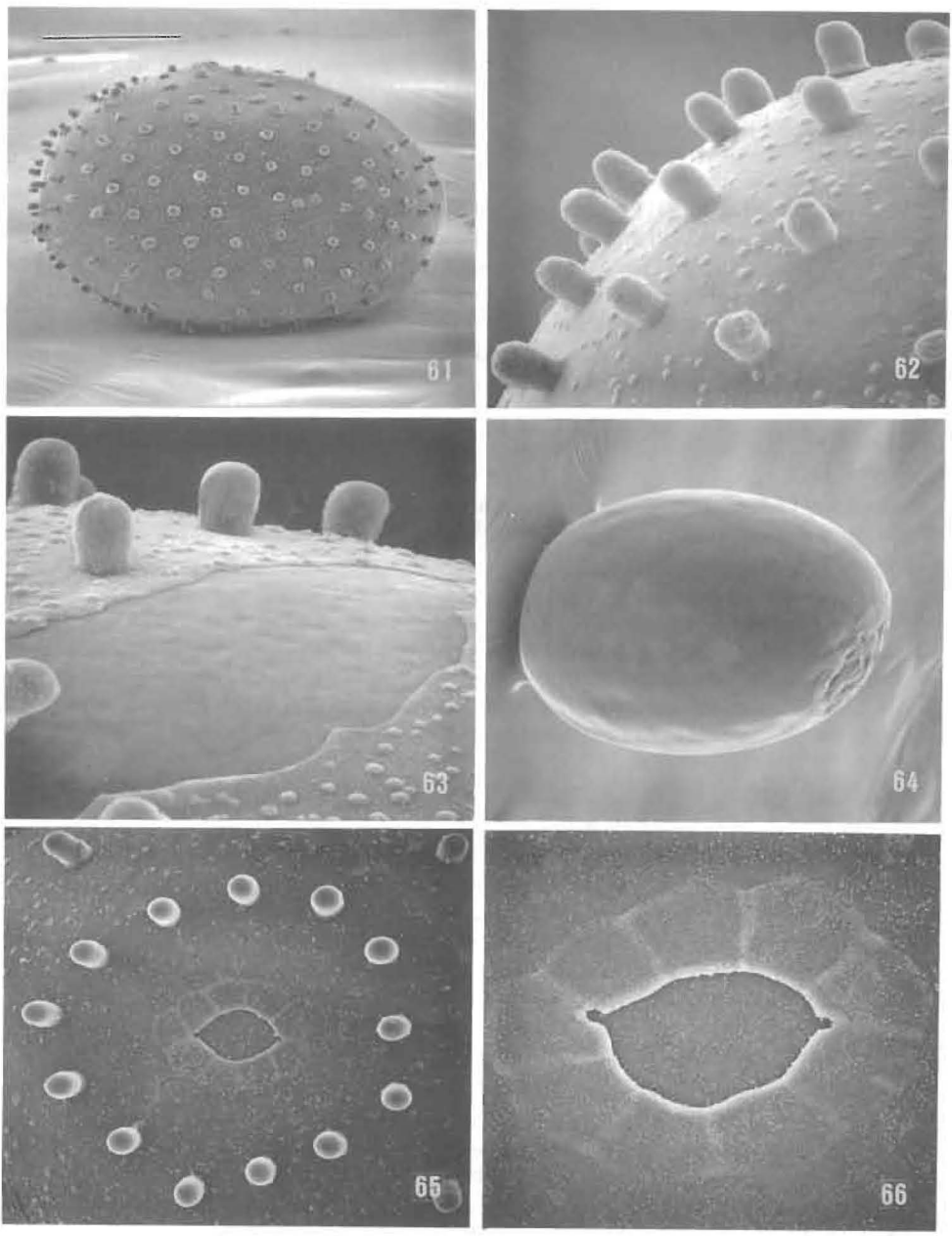
Egg (Figs 61–66)

Length 0·37–0·40 mm; width 0·25–0·27 mm (n = 3, from a single female). Eggs white when laid, turning black within a few hours. Chorion extremely thin, transparent, studded with a regular array of relatively prominent, rounded tubercles up to 13 μm in length and 9 μm in diameter (Figs 61–62), numerous, minute, low, rounded swellings *c.* 2–2·5 μm in diameter randomly scattered over chorion between tubercules (Fig. 62). Micropyle elliptical with 2 pores at opposite ends (Fig. 66), surrounded by 9 obscurely defined plates. Underlying vitelline envelope rigid and smooth except for wrinkled area at micropylar (?) end (Fig. 64).

First instar larva (Figs 67–76)

Maximum length 0·85 mm. Head with frontoclypeus extending nearly half the distance to epicranial notch. A3 located high on cranium dorsolaterally to P1. Labrum with deep medial cleft and 5 pairs of setae. Three pairs of rounded stemmata (Nos 3–5) closely bordering lateral rim of antennal socket. Antenna (Figs 71–72) with 3 short, strongly retracted segments; apex of II bearing 1 long, tactile, trichoid sensillum, 2 small sensilla trichoidea, and 2 stout sensilla basiconica about twice the length of the small trichoid sensilla. Segment III minute, bearing two sensilla: an elongate, digitate sensillum basiconicum about equal in length to largest basiconic sensillum of II but less than half its diameter, and a second sensillum about equal in length but with its basal half stout and distal half slender. Maxillary palpi 3-segmented (Figs 68, 73); apical segment elongate, exceeding combined length of

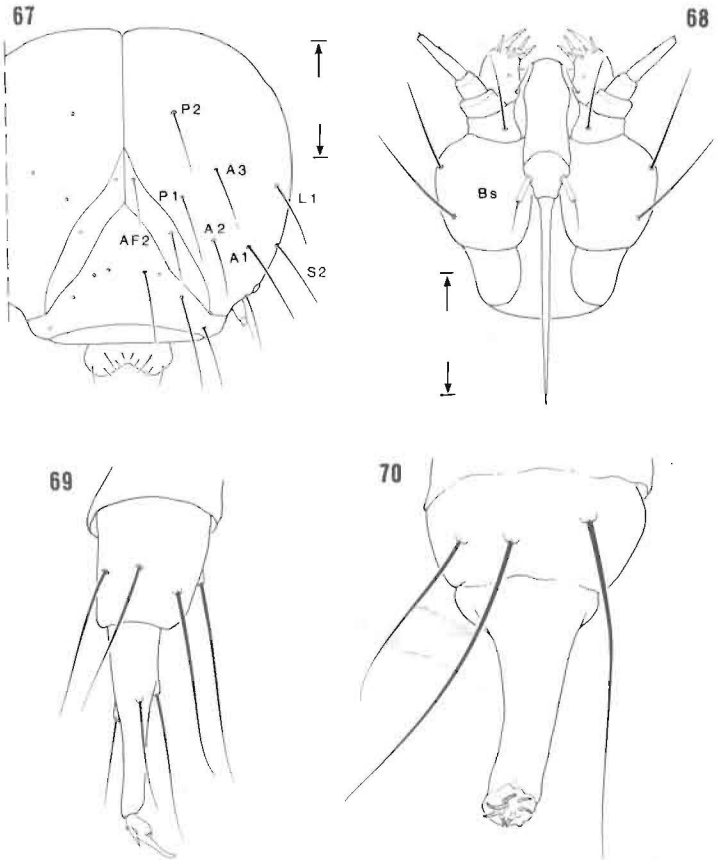
basal two segments, with 3 sensilla basiconica clustered dorsally near midlength (Fig. 74). Labial palpus 2-segmented, with slender apical segment equalling length of stouter base. Spinneret extremely long and slender as in Hepialidae (Wagner *et al.* 1989), extending to prosternum (Fig. 68). Thorax with relatively long slender legs (Fig. 69); tarsus slender, elongate, *c.* 2·3 × length of tibia; claw elongate, with secondary dorsal spines (Fig. 75). Abdomen with long, slender prolegs (Fig. 70) on A3–6 and 10 bearing 6–7 crochets in a uniordinal circle (Fig. 76).



Figs 61–66. *Ogygioses caliginosa*, egg structure (scale lengths in parentheses): *61*, egg with chorion mostly intact (136 μm); *62*, detail of chorion surface (27 μm); *63*, thin chorion partially torn exposing vitelline envelope (20 μm); *64*, egg with chorion completely removed (136 μm); *65*, micropyle area (38 μm); *66*, micropyle with 9 peripheral plates (15 μm). Bar scale for all photographs as shown in *61*.

Distribution

This species has been found in the Central Mountain Range from 300 m (Kwantzuling) to 2400 m on Alishan.



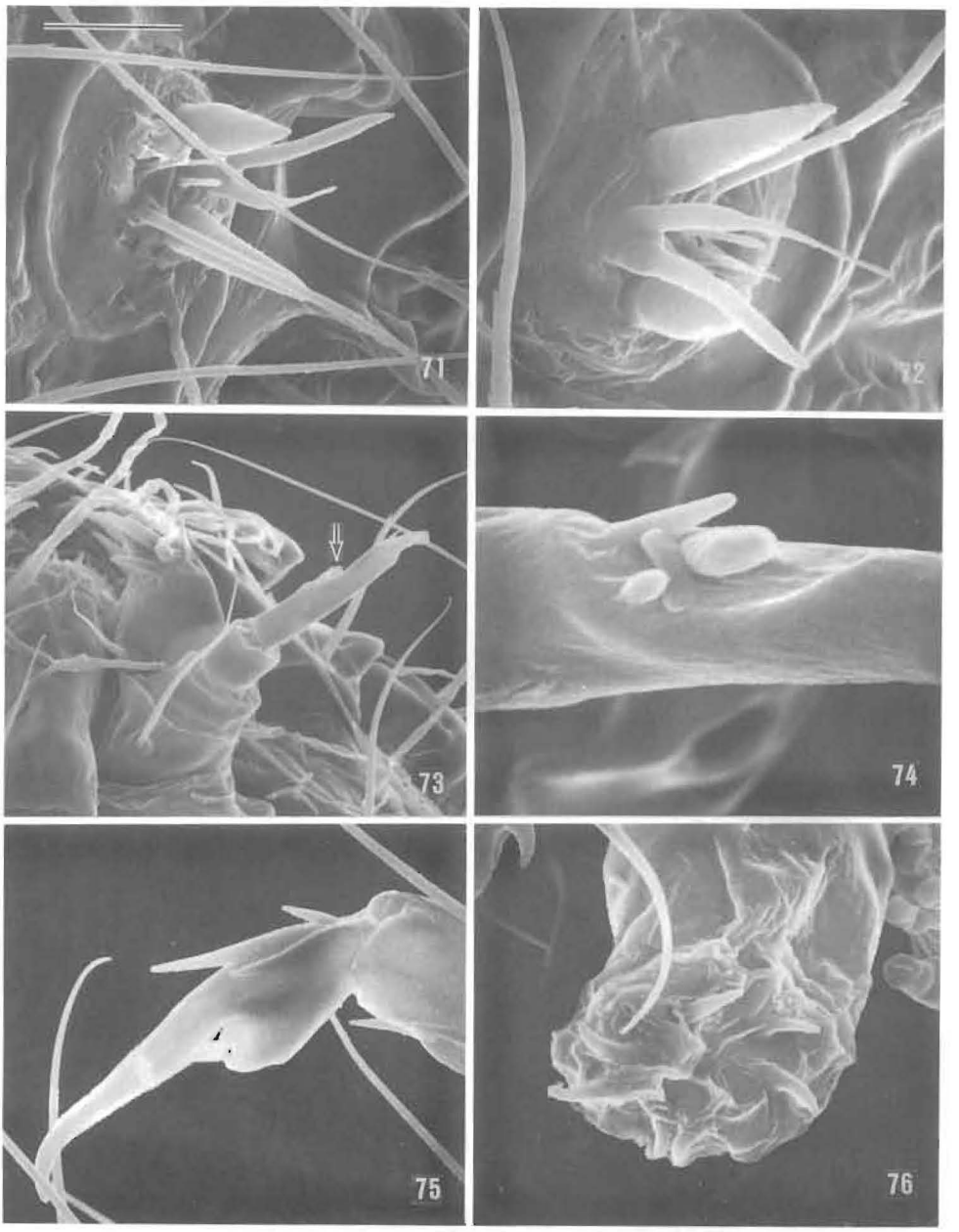
Figs 67–70. *Ogygioses caliginosa*, first instar larva (scale lengths in parentheses): *67*, head, dorsal view (75 μm); *68*, labium and maxilla, ventral view (43 μm) BS, basisternite; *69*, leg, T2; *70*, proleg, A4.

Flight Period

Adults have been collected from March to as late as October. The greatest number of captures has been in March ($n = 7$), April–May ($n = 11$), June ($n = 30$) and July ($n = 8$).

Discussion

Seven males and one female were collected by sweeping by J. Heppner near Liukuei, Taiwan. After mating with a male inside a vial, the female attached several eggs to the sides of the container. Within 6–7 days, several of these hatched and a few eggs along with first instar larvae were preserved in 70% EtOH. Attempts to rear the larvae on several local plants, including moss, were unsuccessful (Heppner, personal communication). Only six eggs and two larvae were available for this study. Both larvae were shrivelled and partially denuded as a result of being slide-mounted. Fungal hyphae also covered the specimens, thereby obscuring the chaetotaxy.



Figs 71–76. *Ogygioses caliginosa*, larval structure, first instar (scale lengths in parentheses): *71*, antenna (12 μm); *72*, antenna (8·6 μm); *73*, maxilla, ventral view (20 μm), subapical sensilla (arrow); *74*, maxillary palpus, subapical sensilla (3 μm); *75*, pretarsal claw, T2 (5 μm); *76*, crochets, A5 (5 μm). Bar scale for all photographs as shown in *71*.

The egg chorion of *Ogygioses* is extremely thin and easily loosened from the underlying vitelline envelope by immersion in alcohol. Most of the six eggs examined had lost much and in some cases all of their chorion (Figs 63, 64). The tuberculate sculpturing of

Ogygioses chorion (Fig. 61) differs markedly from the smoother type reported for Hepialidae (Chauvin and Barbier 1979; Fehrenbach 1989; Nielsen and Kristensen 1989; Wagner *et al.* 1989) and Mnesarchaeidae (Fehrenbach 1989). The larger, regularly arranged tubercles in *Ogygioses* appear to be autapomorphic.

Stemmatal reduction and longer legs and prolegs with crochet reduction may also represent autapomorphies, although more larvae in better condition and preferably of later instars should be examined.

Ogygioses eurata Issiki and Stringer

(Figs 5, 6, 11–15, 33–36, 53–56, 95–97, 100, 102)

Ogygioses eurata Issiki & Stringer, 1932*a*: 72. — Davis, 1992: 62.

Material Examined

Holotype. Taiwan, Taipei District: Urai [? = Wulai], May 1925, S. Issiki, slide 16599 (USNM).

Other material examined. **Taiwan**: Specific locality unknown: 11♂, 1♀, S. Issiki, slides 22942, 30559 (USNM). **Hualien District**: Kirai [Chilaichi], 3♂, 2.vi,1943, S. Issiki, slide 30974 (USNM). **Kirisato** [Tungli]: 1♂, 1.vi.1943, slide 31175 (USNM). **Ilan District**: Taiheisan [Taipingshan], 3♂, 6–10.v.1942, S. Issiki (USNM); Taipingshan, 1900 m, 1♂, 13.v.1989, J. Heppner and H. Wang, slide DRD 3802 (FSCA). **Nantou District**: Naifunpo [Hsini], 1♂ (paratype), 7.viii.1925, M. Kato (BMNH). **Sankakuho** [Meifung]: 1♂ (paratype), 25.v.1928 (BMNH); 1♂ (paratype), 25.v.1928, S. Issiki, slide 30616 (USNM). **Hassenzan** [Pahsienshan]: 1♂, Jun. 1942, S. Issiki, slide NPK 823 (ZMUC), 1♂, 7.vi.1942, S. Issiki, slide NPK 915, (ZMUC), 3♂, 4.vi.1942, 1♂, Jun. 1942, 10♂, 5.vii.1942, 1♀, S. Issiki, slides 30975, 16600 (USNM). **Tainan District**: Kansirei [Kuantzuling, 300 m], 1♂, 25.v.1928, S. Issiki (USNM). **Taipei District**: Rahau [? probably Hsihhsien]: 1♂, 1.v.1933, S. Issiki, slide 31173 (USNM). **Rarasan** [Loloshan or Lalashan]: 1♂, 27.vi.1943, S. Issiki, slide 31174 (USNM). Urai [?= Wulai]: 1♂ (holotype), May 1925, S. Issiki, slide 16599 (USNM).

Redescription

Male (Fig. 5)

Wingspan 12·4–19·2 mm. Head vestiture similar to *O. caliginosa*. Forewing also similar in pattern but with overall paler appearance due to greater suffusion of cream and golden brown scaling; pattern usually less pronounced (paler) basad to slightly paler subterminal band. Hindwing uniformly light gray to pale fuscous. Abdomen light brown to pale fuscous dorsally and laterally, dull white ventrally.

Male genitalia (Figs 95–97). Similar to *O. caliginosa*.

Female (Fig. 6)

Wingspan 13–18·5 mm. Similar to male except with less distinct pattern.

Female genitalia (Figs 100–102). Corpus bursae either elongate and spindle-shaped with smooth walls or oval with heavily wrinkled walls. Ductus spermathecae with efferent canal forming 7–8 coils before vesicle; caudal end with sclerotised ring as in *O. caliginosa*.

Distribution

This species ranges widely through the Central Mountain Range from 300 m in elevation (Kwantzuling) and possibly as low as 100 m (Wulai) to as high as 1900 m (Taipingshan).

Flight Period

Adults have been collected from May to October, with the most frequent collections in May ($n = 9$), June ($n = 10$) and July ($n = 10$).

Discussion

Only three females with multiple coiled ductus spermathecae are associated under *O. eurata*. Two of these (Pahsienshan, USNM 16600, Fig. 100, and Kuantzuling, USNM 30594) possess apparently shrivelled, shortened corpus bursae. The third female (Taipingshan, DRD 3802, Fig. 102) has an elongate corpus bursae and more cylindrical spermathecal vesicle similar to that of *O. caliginosa*. Until more females are available for study, it cannot be determined whether those females with shrivelled corpus bursae represent a distinct species, or whether this condition is merely an artefact of desiccation.

Ogygioses issikii Davis, sp. nov.

(Figs 7, 8, 98)

Material Examined

Holotype. ♂, Taiwan, Ilan District: Taiheisan [Taipingshan], 7.v.1942, S. Issiki (USNM).

Paratypes. **Taiwan**: same data as holotype, 3♂, 10.v.1942, slide 16604 (USNM), 1♂ (TPM). **Taipei District**: Rarasan [Lalashan or Loloshan], 2♂, 27.vi.1942, S. Issiki, slide 16605 (USNM).

Description

Male (Figs 7, 8)

Wingspan 15–17·5 mm. Vestiture of head with cream coloured piliform scales mostly covering broad, appressed, more white scales over vertex; broad scales occasionally suffused with brown. Antennal scape with long piliform cream scales; flagellum uniformly covered with moderately broad, cream scales irrorated with brown over basal half, with distal half sparsely covered with more slender scales mostly over dorsal surface. Vestiture of pro- and mesonota consisting of long, piliform, cream scales partially concealing underlayer of broad white scales. Forewing generally pale golden yellow with small, scattered patches of white scales with pale blue iridescence; white spots forming indistinct terminal, subterminal, medial, basal, and hindmarginal rows; a dark brownish fuscous spot near lower distal corner of discal cell and a suffusion of brown scales along basal third of costa; several white spots partially edged by brownish fuscous scales, particularly at upper apex of discal cell; fringe pale golden yellow interrupted with white which is confluent with white marginal spots; venter of forewing uniformly brown, sometimes paler (less scaled) at base. hindwing contrastingly lustrous dark brown over distal two-thirds with basal third white to cream; fringe white to cream. Foreleg with tibia and tarsus mostly light brown becoming more white ventrally. Midleg paler, mostly cream. hindleg cream to buff; tibial hair pencil white, with dense cluster of piliform cream scales at distal apex of tibia. Abdomen brown dorsally and laterally, cream ventrally.

Male genitalia (Fig. 98). Similar to *O. caliginosa* and *O. eurata*.

Female

Unknown.

Distribution

Known from only two montane localities in north-eastern Taiwan.

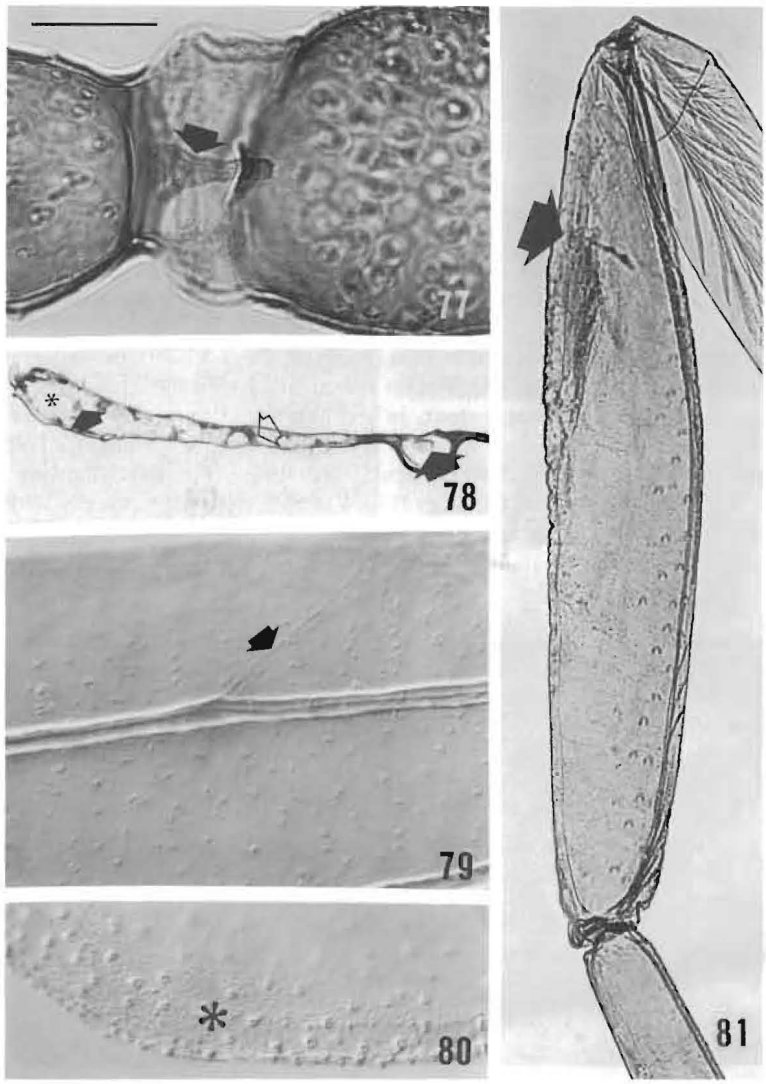
Flight Period

May and June.

Discussion

This species possesses the palest, most golden yellow forewings of any member of the genus. It is also the only species possessing hindwings with pale yellowish bases. The

species is named in honour of the late Professor Syuti Issiki, who collected most of the Taiwanese *Ogygioses* used in this study.



Figs 77–81. *Ogygioses*, details of antennal, wing, and leg structure (scale lengths in parentheses): *77*, *O. luangensis*, antennal scapus and pedicellus with 'typical hepialoid' intercalary sclerite (arrow) (71 μm); *78*, *O. caliginosa*, transverse section of forewing in pterostigma region, showing pterostigmatic lacuna (asterisk) with coagulated haemolymph, epidermal bridges (open arrow) between upper and lower wing wall and subcostal and radial nerve (small and large solid arrow respectively) (59 μm); *79*, *O. luangensis*, interference contrast photomicrograph of unstained forewing; note vestige of subcostal branch with nerve (arrow) (150 μm); *80*, as for preceding figure, showing spinarea (asterisk) (129 μm); *81*, *O. luangensis*, hindleg of the male with small, hair-bearing evaginable groove (arrow) in little-widened tibia (compare with *14*) (0·52 mm). Bar scale for all photographs as shown in *77*.

Ogygioses luangensis Kristensen, sp. nov.
(Figs 9, 10, 77, 79–93, 99, 105, 106)

Material Examined

Holotype. ♂, Thailand, Loei Province, Phu Luang Wildlife Sanctuary, 10–12.x.1984, 1400–1500 m, Karsholt, Lomholdt and [P.] Nielsen leg. (ZMUC).

Paratypes. 1♀, same data as holotype (ZMUC); 11♂ (ANIC, BMNH, USNM, ZMUC). Bouin-fixed, ethanol-preserved material not included in type series: 3♂, 3♀ (ZMUC).

Description

Male (Fig. 9)

Wingspan 13·4–14·5 mm. Forewing apex somewhat more rounded than in Taiwanese species. Forewing pattern markedly more contrast-rich than that of Taiwanese species. Large, light yellowish spot in wing centre (just beyond the level of the R/Rs fork) and similarly coloured postdiscal band, extending backwards to M1, particularly striking; a subterminal band distinctly darker yellowish. Light brownish ground colour richly suffused with dark scales, particularly on either side of light central spot. Transverse rows of small dark-edged, bluish white spots (formed by scales with a distinctive ultrastructure) present as in Taiwan species. Invaginated pocket in basal part of forewing vein 1A distinctive. Invagination identifiable as narrow slit in vein upperside (Figs 83–89), on underside pocket appearing as a marked bulge (Fig. 86). Pocket lumen filled with group of scales (Fig. 87). Scales (presumably scent emitters) stout, in semi-thin sections their contents staining intensely with toluidine blue, surface with low ridges and lacking normal-size perforations; sockets smooth, differing from adjacent tuberculate membrane (Fig. 89). Hindwing anal area modified as in Taiwanese species. Hindlegs (Fig. 81) with tibia not markedly widened, but as in Taiwanese species with membranous hair-bearing groove, which, when evaginated, forms a small bulge. Pleuron II similar to that of Taiwanese species.

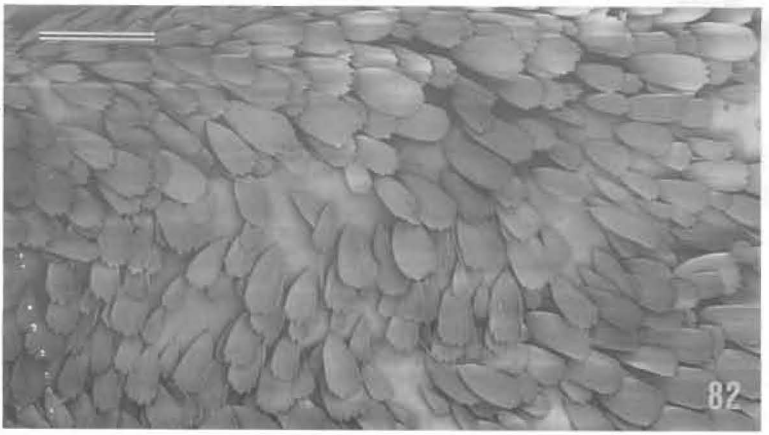
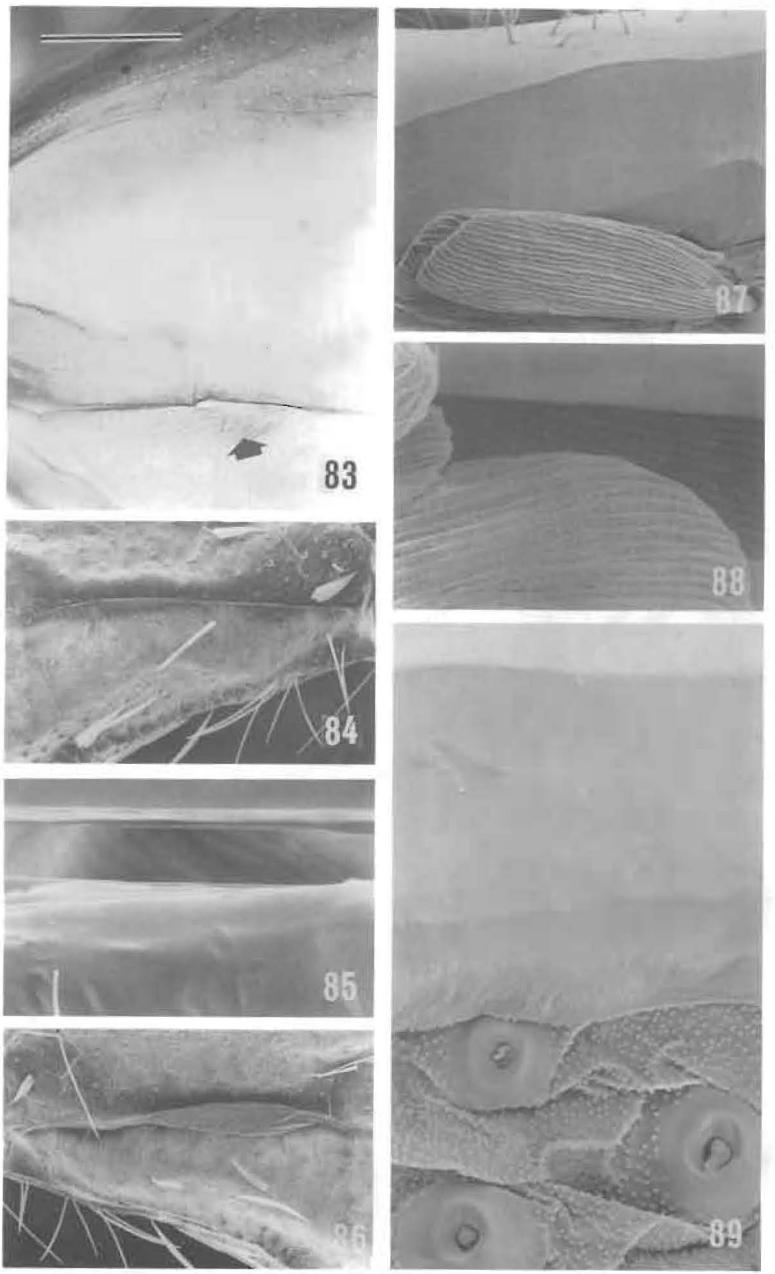


Fig. 82. *Ogygioses luangensis*, basal forewing area, showing scales in costal half arranged with long axis markedly deviating from wing axis. Scale = 0·2 mm.

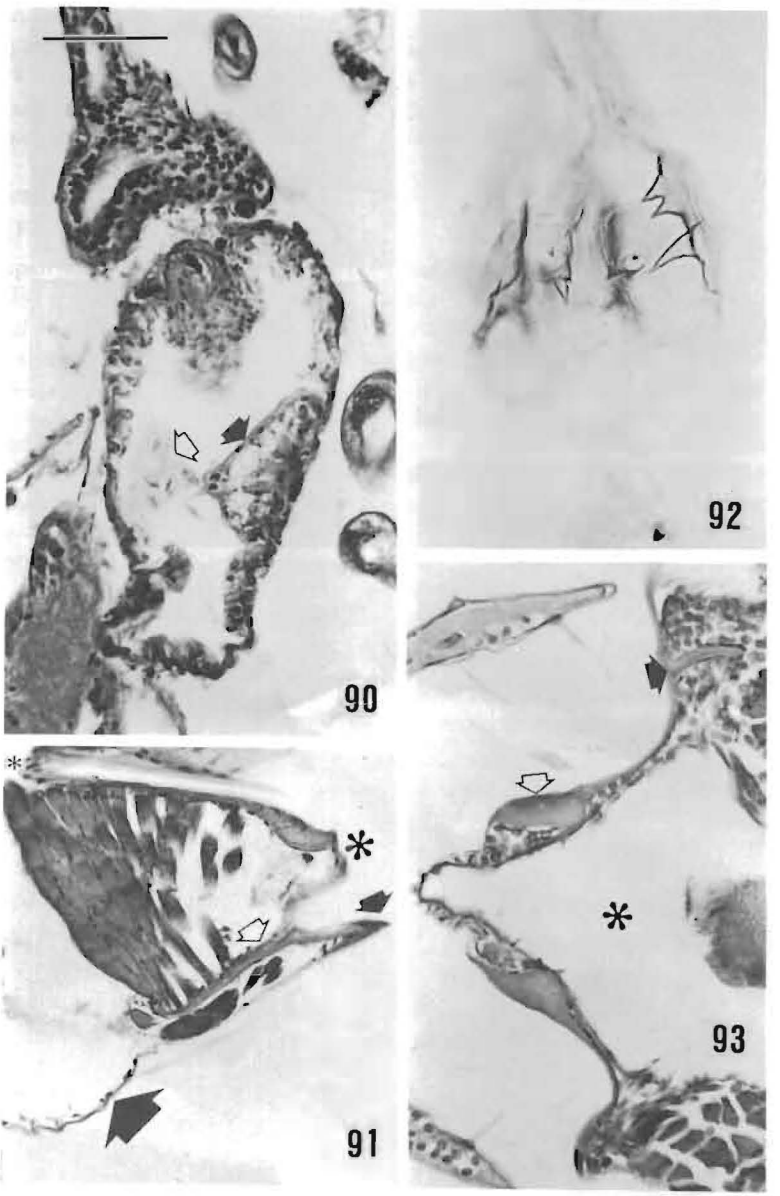
Male genitalia (Figs 91, 93, 99). Overall very similar to those of Taiwanese species. Pseudoteguminal arms stouter, more strongly sclerotised, particularly melanised apex with lateroventral concavity; slender arms of Taiwanese species taper towards simple pointed tips. Valve with basal part markedly narrower (i.e. less high) than distal part, in Taiwanese species valve almost parallel-sided. Topographically posterior margin of vinculum not bilobed.



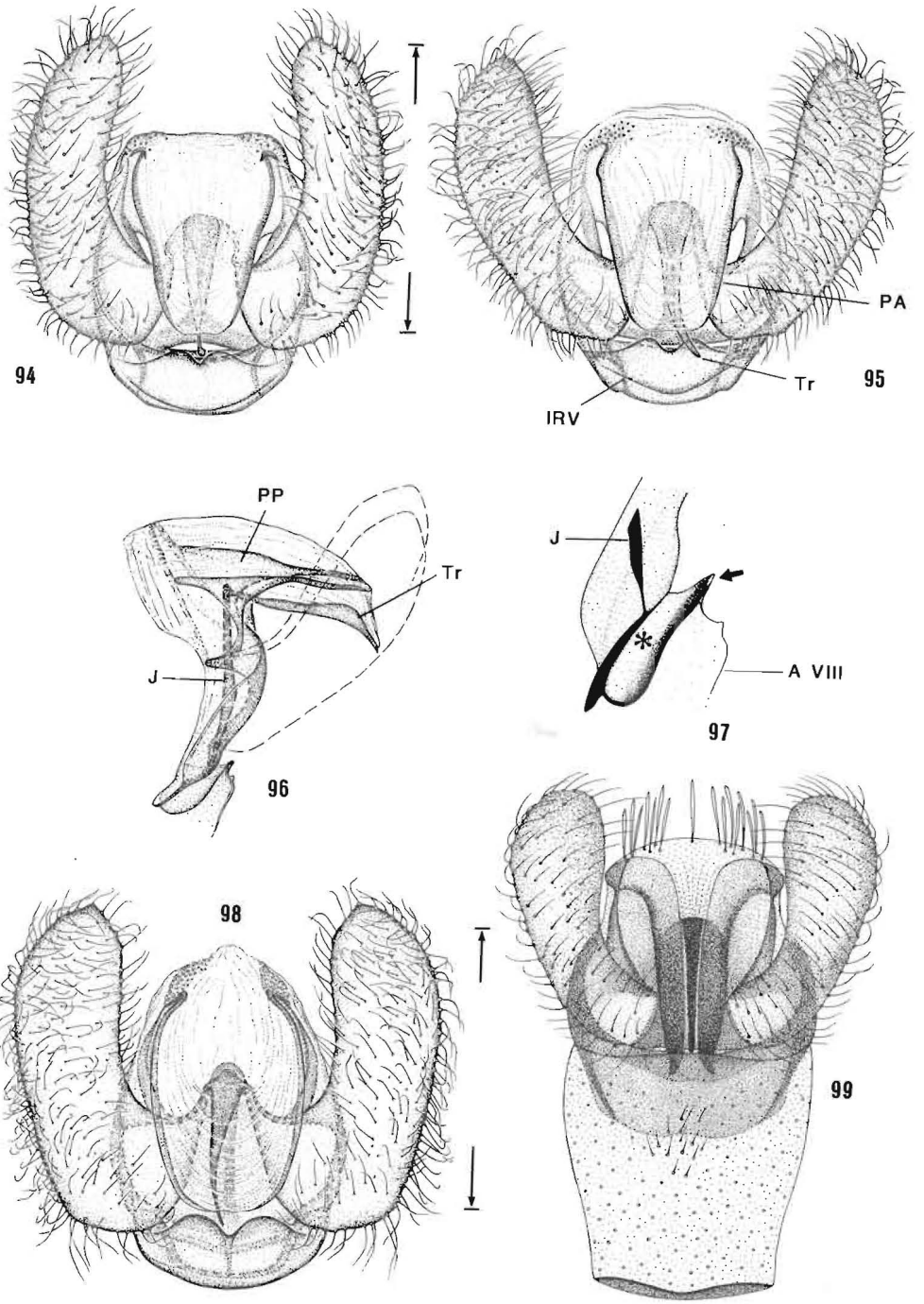
Figs 83–89. *Ogygioses luangensis*, scale pocket in vein 1A of forewing (scale lengths in parentheses): *83*, whole mount preparation, showing scale pocket (arrow) in optical section (214 μm); *84*, posterior part of forewing base in dorsal view, note slit-like opening of pocket (219 μm); *85*, as preceding, slit at higher magnification (7·4 μm); *86*, pocket in ventral view, spinarea visible at lower right (219 μm); *87*, pocket opened, showing specialised scales in bottom (22 μm); *88*, apices of scales in pocket (9 μm); *89*, bottom of pocket, scales removed, note smooth scale sockets in tuberculate membrane (10 μm). Bar scales for all photographs as shown in *83*.

Female (Fig. 10)

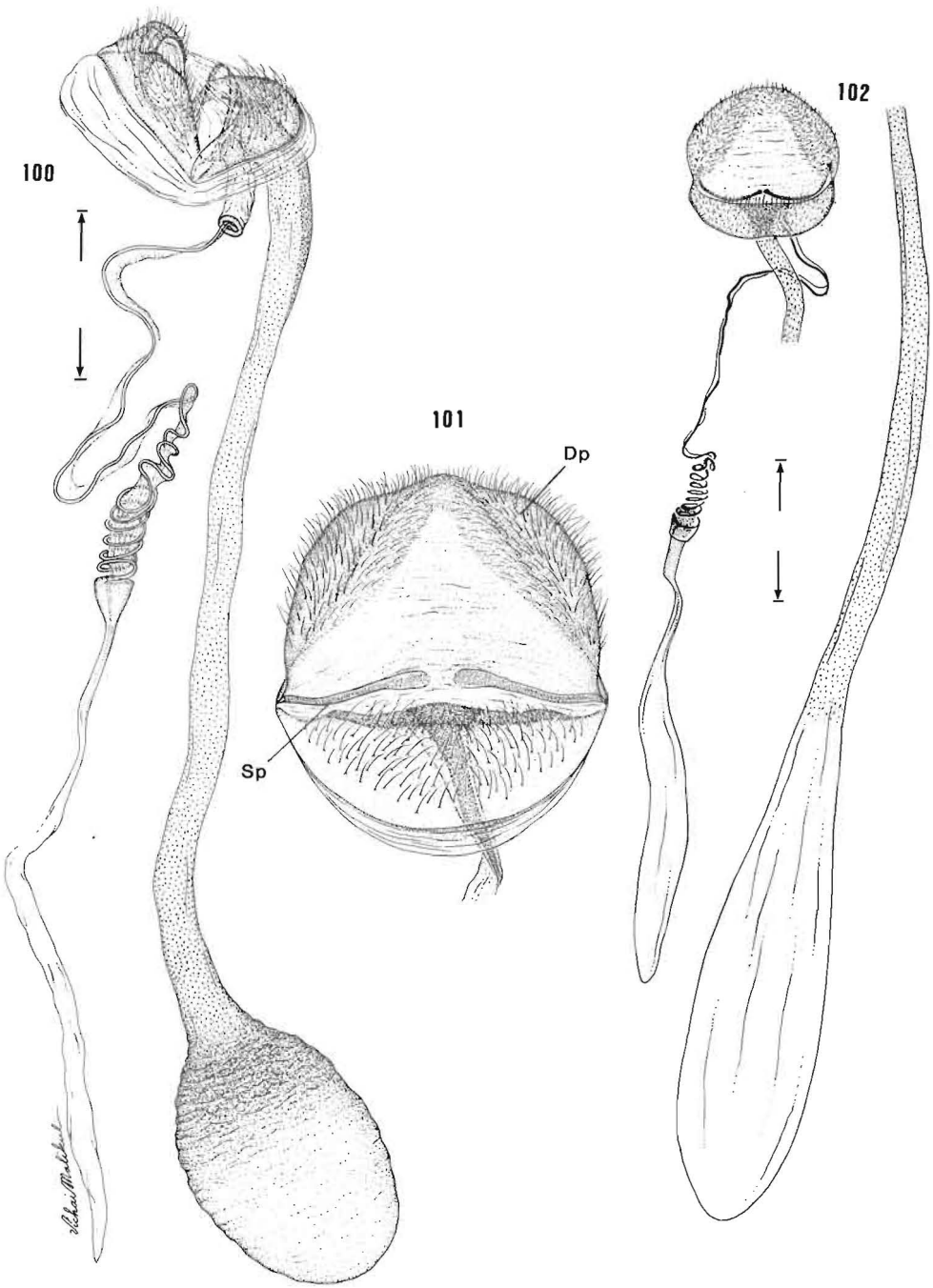
Wingspan 15·7 mm. Forewing pattern (only one specimen available) much less



Figs 90–93. *Ogygioses luangensis*, details of gut and male genitalia (scale lengths in parentheses): *90*, transition between midgut (upper left) and hindgut in sagittal section, showing two of the spiny sclerites in the anterior hindgut chamber, one (solid arrow) sectioned longitudinally, the other (open arrow) sectioned tangentially and seen in surface view (86 μm); *91*, lower part of abdominal apex of the male, admedian sagittal section, note sclerotised posterior part of eighth sternum (large solid arrow), sharply bent topographical hindmargin of vinculum (small solid arrow), apodemal part of vinculum (open arrow), vinculum/juxta hinge (large asterisk), juxta/trulleum hinge (small asterisk) (120 μm); *92*, whole mount preparation of KOH-macerated hindgut, showing cuticle of spiny sclerites in anterior chamber (90 μm); *93*, upper part of abdominal apex of the male, horizontal section, note thickened pseudoteguminal arm (open arrow) and strong internal crest (solid arrow) on pseudoteguminal plate near lateral margin, asterisk in rectal cavity (78 μm). Bar scale for all photographs as shown in *90*.

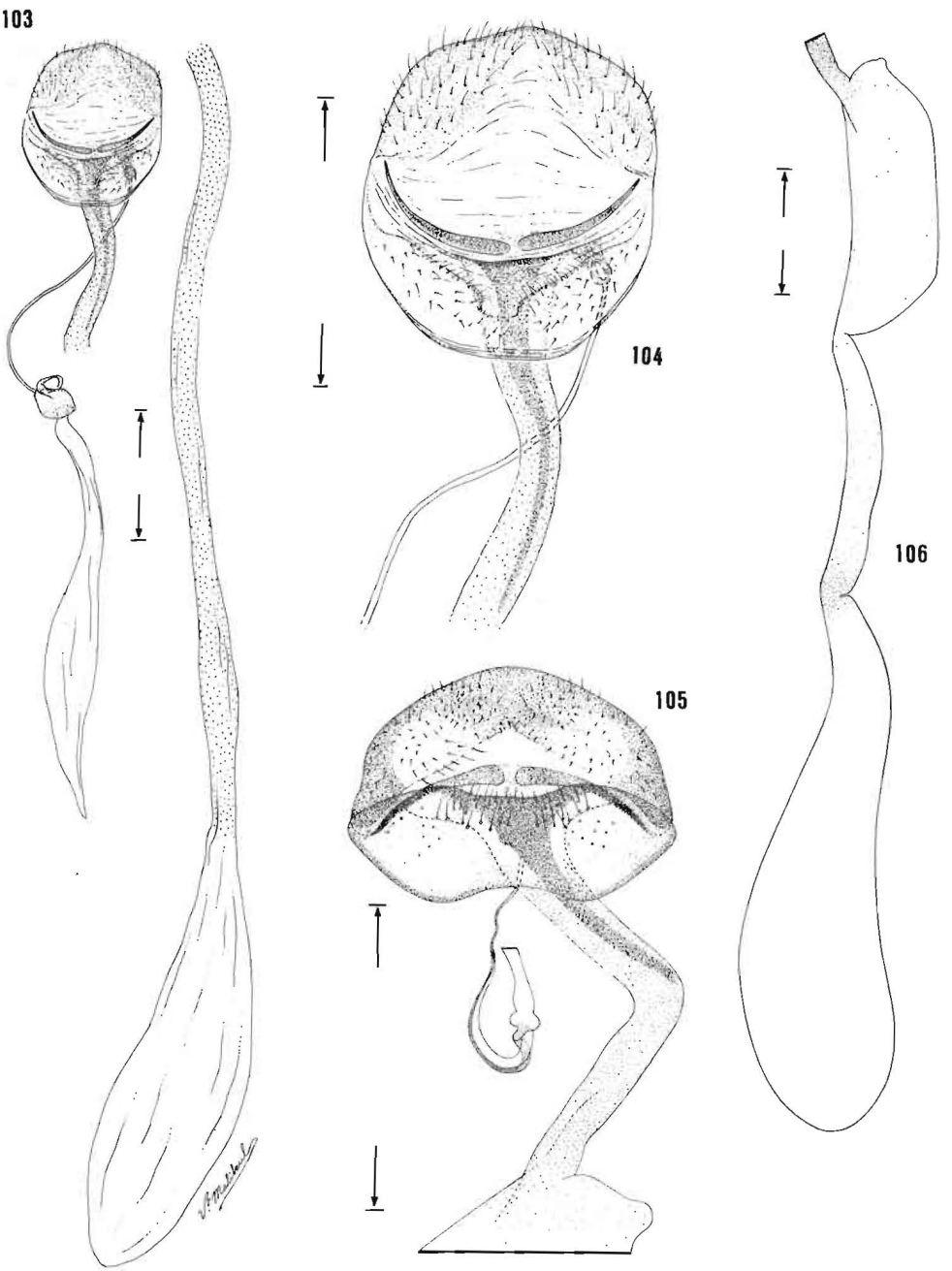


Figs 94–99. *Ogygioses*, male genitalia: *94*, *O. caliginosa*, ventroposterior view; *95*, *O. eurata*, ventroposterior view; *96*, lateral view of *95*; *97*, *O. eurata*, sagittal view of vincular pocket (asterisk) in *96*, bilobed ventrocaudal margin of vinculum (arrow); *98*, *O. issiki*, paratype, ventroposterior view; *99*, *O. luangensis*, paratype, ventroposterior view, segment VIII included. A VIII, eighth sternum; IRV, internal ridge of vinculum; J, juxta; PA, pseudoteguminal arm; PP, pseudoteguminal plate; Tr, trulleum. All scales = 0·5 mm.



Figs 100–102. *Ogygioses eurata*, female genitalia: *100*, lateral view, slide USNM 16600, Hassenzan, Taiwan; *101*, enlarged ventroposterior view; *102*, ventral view, slide DRD 3802, Taipingshan, Taiwan. Dp, dorsal plate; Sp, subanal plate. All scales = 0·5 mm.

distinctive than in male; central spot and postdiscal band smaller and light brown, hence not so markedly contrasting with surrounding areas.



Figs 103–106. *Ogygioses*, female genitalia: *103*, *O. caliginosa*, ventroposterior view; *104*, *O. caliginosa*, enlarged ventroposterior view; *105*, *O. luangensis*, paratype, genital segments and posterior portion of ductus bursae, distal part of utriculus spermathecae cannot be interpreted with certainty from preparation; *106*, *O. luangensis*, bursa copulatrix. All scales = 0·5 mm.

Female genitalia (Figs 105, 106) (only a single slide mount examined). Very close to those of Taiwanese *Ogygioses*. Sternum IX plate in posterior view with hindmargin

distinctly emarginate in middle (i.e. at entrance of antrum), not so in the Taiwanese species. Ductus bursae abruptly markedly dilated some distance in front of antrum sclerotisation; in Taiwanese species only a tiny hump present in corresponding position (this difference is evident in a well-inflated specimen, but it may be very difficult to discern if the duct has collapsed). Intima spinosity in ductus bursae distinctly weaker around midlength than in posterior and anterior portions; Taiwanese species without such marked difference. Spermathecal duct with efferent canal forming only one distinct coil before vesicle.

Distribution and Biology

Currently known only from a single locality in north-eastern Thailand; further details in introductory section.

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