THE RAFFLES BULLETIN OF ZOOLOGY 1996 **44**(1): 173-187

A NEW SPECIES OF NEOTENOUS BEETLE, *DULITICOLA HOISENI* (INSECTA: COLEOPTERA: CANTHAROIDEA: LYCIDAE) FROM PENINSULAR MALAYSIA AND SINGAPORE

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ABSTRACT. - A new species of neotenous lycid beetle ("trilobite larva"), *Duliticola hoiseni*, is described from Peninsular Malaysia and Singapore. Notes on its biology are provided.

INTRODUCTION

Some unusual members of Lycidae of the genus *Duliticola* Mjöberg, 1925, from South-east Asia have been popularly known as "trilobite larvae" due to their superficial resemblance to the extinct arthropods. The adult males are typical beetles while the females are neotenous remaining larviform throughout their life (see Ng & Yong, 1991; Wong, 1995).

The taxonomy of the Lycidae is based mainly on the external morphology of the adult males with emphasis on the genitalia (Crowson, 1972; Bocák & Bocáková 1990). Descriptions of females and larvae are seldom available. While there are clearly a large number of different species of "trilobite larvae" in South-east Asia (see Mjöberg, 1925; Ng & Yong, 1991; Wong, 1995), only three taxa have apparently been described. The main problem in resolving the taxonomy of "trilobite larvae" is that the males are usually not known. While female larvae are frequently encountered, obtaining males of the same species is a difficult task; especially since the male beetles do not respond to light traps (Mjöberg, 1925: 138; 1928:116). In fact, the only way to be sure that the two sexes are conspecific is to capture them while they are mating.

Only three nominate taxa have been recognised thus far: *Duliticola paradoxa* Mjöberg, 1925, *D. korinchiana* Blair, 1928, and *D. korinchiana robinsoni* Blair, 1928. Apart from describing *Duliticola paradoxa*, Mjöberg (1925, 1928) recognised six additional "forms" but he stopped short of describing and naming them due to the abscence of male specimens.

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As part of a revision of this group, the author has recently been able to obtain specimens of both sexes of one species of "trilobite larvae" frequently encountered in Peninsular Malaysia (see Ng & Yong, 1991; Wong, 1995). This paper serves to describe this species.

MATERIALS AND METHODS

The description of the male follows Kasantsev's (1991) protocol. A full description is supplied for the female larva due to present emphasis on larva characters.

Specimens of adult females and larvae were preserved in 70% alcohol. Males are pinned dry, with genitalia attached in a microvial of glycerol. Drawings were made using a Nikon SMZ10 microscope fitted with camera lucida. Abbreviations used: ZRC - Zoological Reference Collection, Deparment of Zoology, National University of Singapore; GFS - Gombak Field Station, Universiti Malaya; MNHN - Museum National d'Histoire Naturelle, Paris; NHM - Natural History Museum, London; NRM - Naturhistorika Riksmuseum, Stockholm; FMS - Federated Malay States; total length - TL.

TAXONOMY

Genus *Duliticola* Mjöberg, 1925

Remarks. - Mjöberg (1925) established *Duliticola* for one species *D. paradoxa*, and placed it within the Lycidae. Kleine (1941) felt that *Duliticola* was not a lycid and did not include the genus in his catalogue of the family. According to Kleine (1941), *Duliticola* is likely to be related to the Drilidae, and perhaps even represents distinct family by itself, considering that the male genitalia is such a peculiar structure. Following Crowson's (1972) revision of the Cantharoidea however, the current consensus is that *Duliticola* should be included in the Lycidae.

Pic (1921) established *Platerodrilus* with five species, but no type species was designated. Crowson (1972), while transferring *Platerodrilus* Pic, 1921, to the Lycidae, made the comment that the genus was known only from males. He also suggested that within Lycidae, the closest relatives to *Platerodrilus* were *Duliticola* and *Lyropaeus* Waterhouse, commenting that "a number of distinct types of "trilobite larvae" in the Indo-Malayan region... may well be of *Lyropaeus* or *Platerodrilus*" (Crowson, 1972: 48). The close affinity of *Duliticola* and *Platerodrilus* is reflected by their similar male genitalia (see Mjöberg, 1925: fig. 1D; Crowson, 1972: fig. 23; Kasantsev, 1991: fig. 43A).

After examining type specimens and specimens of both *Duliticola* and *Platerodrilus*, the author came to the conclusion that the males are certainly very closely related. The detailed taxonomy and affiliations (including the likely synonymy) of the two genera, however, is beyond the scope of the present paper. This matter is currently under joint study by Sergei Kasantsev and the author, and will be reported in a later paper.

Duliticola hoiseni, new species
(Figs. 1-7)

Mjöberg's 'No.7' - Mjöberg, 1925 : 144, Pl. 3, Fig.7.
Duliticola sp. - Ng & Yong, 1991 : 97, 97 (part), figs.
Duliticola sp. - Wong, 1995 : 97, 97 (part), figs.

Materials examined. - Holotype - Female, (TL 6.0 cm) (ZRC.6.18600), GFS, Selangor, Malaysia, coll. P. K. L. Ng & D. Kovac, 15 Apr.1991. — Allotype - Male, (TL 6.6 mm) (ZRC.6.18599), GFS, Selangor, Malaysia, coll. A. Wong, Sep.1993.

Paratypes - 7 females, (TL 3.2 - 4.7 cm) (ZRC.6.18602-18608), GFS, Selangor, Malaysia, coll. P. K. L. Ng & D. Kovac, 15 Apr.1991. — 1 female, (TL 5.2 cm) (NHM), GFS, Selangor, Malaysia, coll. A. Wong, Sep.1993. — 8 females, (TL 1.1 - 3.5 cm) (ZRC.6.18626-18633), GFS, Selangor, Malaysia, coll. A. Wong, Sep.1993. — 1 female, (TL 4.5 cm) (ZRC.6.18634), Jln. Tiup-Tiup, Bukit Timah Hill, Singapore, coll. A. Wong, Apr.1993. — 2 females, (TL 3.6, 4.8 cm) (ZRC.6.18635-18636), GFS, Selangor, Malaysia, coll. H. S. Yong. — 2 females, (TL 3.7, 4.4 cm) (ZRC.6.18637-18638), GFS, Selangor, Malaysia, coll. N. Sivasothi, 22 Sep.1991. — 1 male, (TL 6.6 mm) (ZRC..6.18601), Bukit Timah Hill, Singapore, coll. D. H. Murphy, 20 Jan.1973.

Others - 1 female, (ZRC.6.18639), Endau-Rompin, Malaysia, coll. A. Wong, 3 Apr.1995. — 1 female, (NHM 1955-354), Ex. Coll. FMS Museum, Malay Peninsula. — 1 female, (NHM 1955-354), Malay Peninsula, 14 Mar.1934. — 1 female, (NHM 1955-354), Kuala Tahan, Pahang, Malaysia, coll. F. N. Chasen, Sep.1921. — 1 female, (NHM 1955-354), RIM Malacca, Feb.1908 labelled at Selangor Museum. — 1 female, (NHM 1955-354), Ex. FMS Museum, Jor Camp 1800', Batang Padang, Perak, coll. H. M. Pendlebury, 25 Jan.1925. — 3 females, (NHM 1955-354), Malay Peninsula, Pahang FMS.

Description. - Adult male - Entirely black with dense pubescence.

Head flat behind antennal prominence; eyes rather small (diameter three times the distance between the eyes). Antenna filiform, laterally compressed; basal joint receiving base of second joint.

Pronotum transverse with raised carina on the anterior portion; lateral margins convex, curved; basally bisinuate (see Fig. 3B). Scutellum fusiform (0.3 mm).

Elytra short (three times longer than wide at the shoulder, three times longer than pronotum); widest behind the middle; with faint longitudinal costae; apex tapered and acute (see Fig. 3C). Legs with femora wider than tibia (3:2 ratio). Penultimate abdominal sternite fusiform.

Aedeagus long and slender; curves upwards with bulbous tip; more than twice the length of parameres (see Fig. 4). Parameres with unevenly distributed spines; basal portion wide and rounded with darkly pigmented denticles (see Fig. 4P).

Length - 6.6 mm

Female larva - Head: Retractable within prothorax. Antenna retractable, two jointed with round terminal joint (see Fig. 6B). Ocellus behind antenna. Mandibles curved, sickle-shaped, longitudinally divided into two halves (see Figs. 6C, 6D).

Thorax: Edges of segments bending downwards; overall convex, helmeted shape. Prothorax: Wide-based triangular shape, posterior angle obtuse (see Figs. 1, 2A). Two small tubercles on front margin, where head protrudes. Two large black tubercles on either side

of midline, center of the segment. Two small tubercles on posterior margin. Two small black tubercles on the edge on the prothoracic venter. Mesothorax: Broader than prothorax. Posterior margin straight; edge of anterior margin rounded. Four large, tear-drop shaped, bulging tubercles in the middle of the segment; the anterior pair aligned longitudinally, posterior pair laterally. Two small tubercles on the posterior margin. Metathorax: Posterior edge swept-back, anterior edge rounded. Arrangement of tubercles similar to mesothorax. Mesothorax & metathorax : large, round, and shiny granule on the sternite. Large spiracle atrium on the upper edge of the pleurite; many rib-like costae within atria. Small, shiny granule near the posterior edge of pleurite.

Abdomen: Nine segments. Back and upward pointing processes originating from the edge of the posterior margin of each segment. Processes are curved at the tips, with same thickness except towards the base; light cinnamon colour. Two small tubercles on median posterior margin, becoming fainter, indistinct from the sixth segment onwards, with no tubercles on the last segment. Posterior margin of last segment is straight. Ventral: (see Figs. 2C, 2D) Backward pointing, cinnamon-coloured processes, shorter than the dorsal ones, on the posterior edges of the sternites; with tufts of hair on tips. Pleurites with similar processes except more rounded at the apex and without apical bristles. Parasternal sclerite, between sternite and pleurite, small and indistinct. Deep spiracle atrium with rib-like ornamentation around the internal spiracle opening on upper edge of pleurite. Eighth sternite clefted by muscular anal sucker.

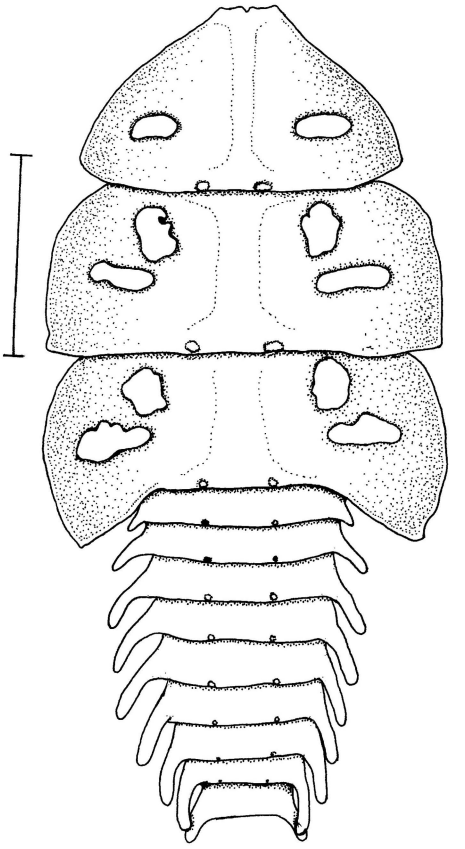

Fig. 1. *Duliticola hoiseni,* new species. Paratype female (TL 4.7cm) (ZRC.6.18602); Dorsal View. Scale = 1 cm

Colour. - Body dark-brown except for lateral margins of thoracic segments, abdominal tergal, pleural and sternal processes cinnamon coloured. Mature female: Appears similar to larvae except completely unsclerotised and yellowish in colour (see Figs. 7A, 7B).

Etymology. - Named after Prof. Yong Hoi Sen, Universiti Malaya; for his early collection of this species at the Gombak Field Station, UM and for all his kind help.

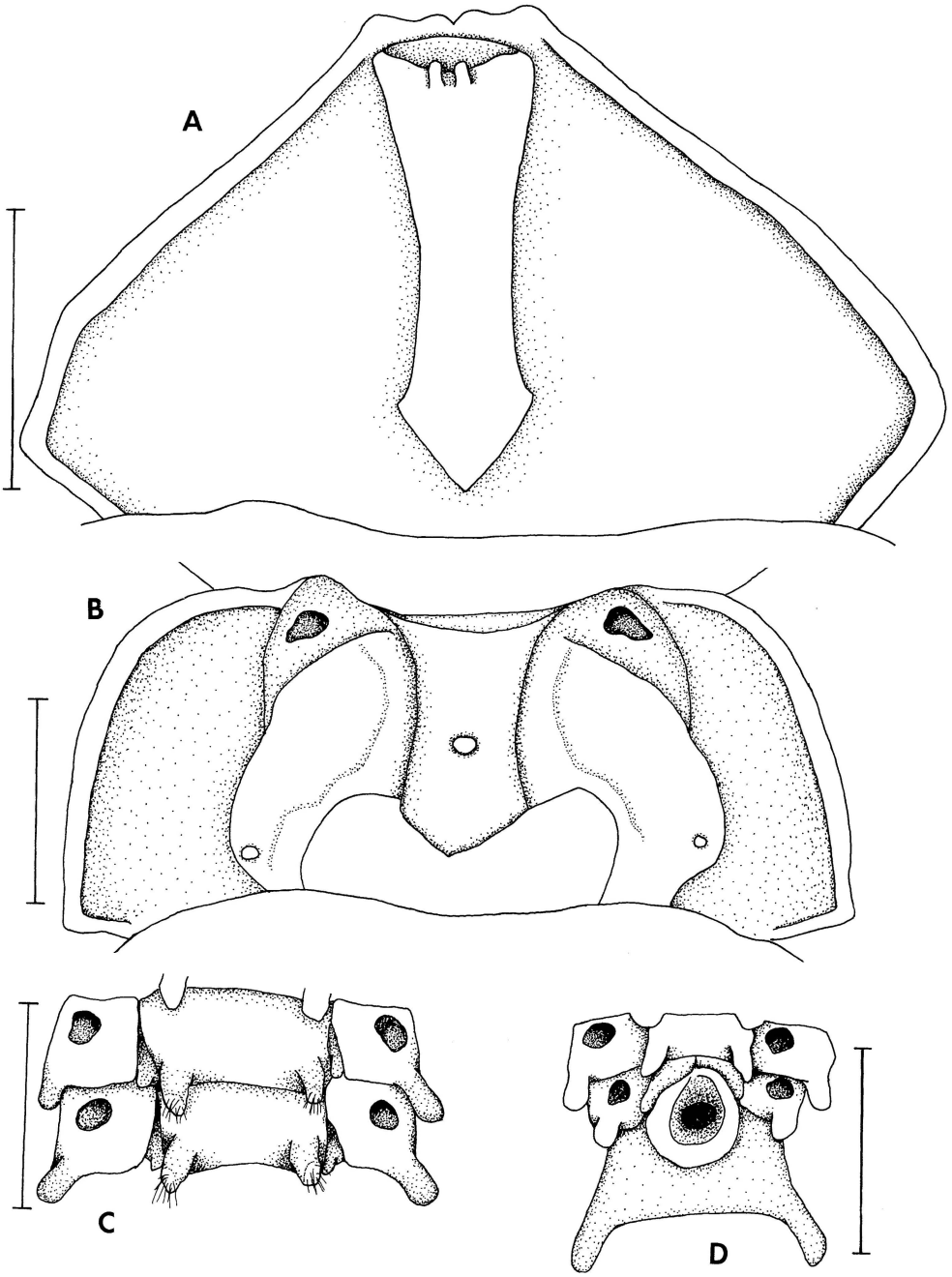

Fig. 2. *Duliticola hoiseni,* new species. Paratype female (TL 4.7cm) (ZRC.6.18602); Ventral view; A. Prothorax; B. Mesothorax; C. 3rd & 4th abdominal segments; D. 7th, 8th and 9th abdominal segments. Scale = 5 mm

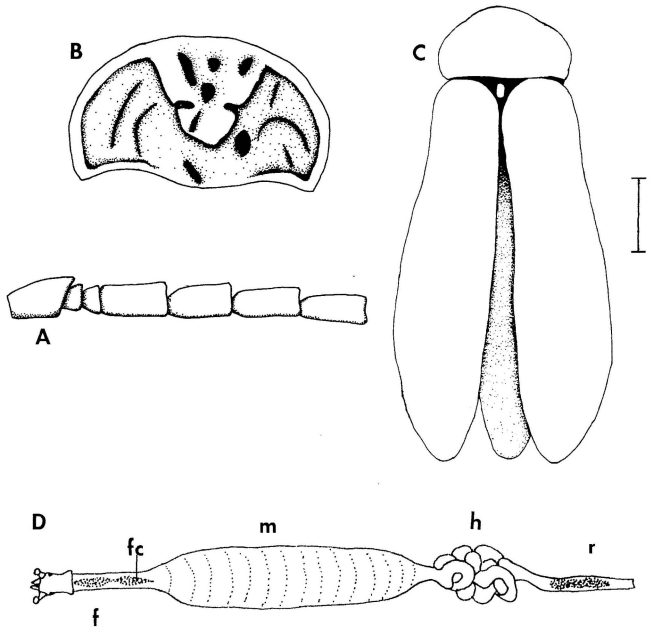

Fig. 3. *Duliticola hoiseni,* new species. Allotype male (TL 6.6 mm) (ZRC.6.18599); A. Antenna; B. Prothorax; C. Prothorax and elytra; Scale = 1mm; D. Sketch of digestive tract. f. Foregut; m. Midgut; h. Hindgut; fc. Foregut contents; r. Rectum

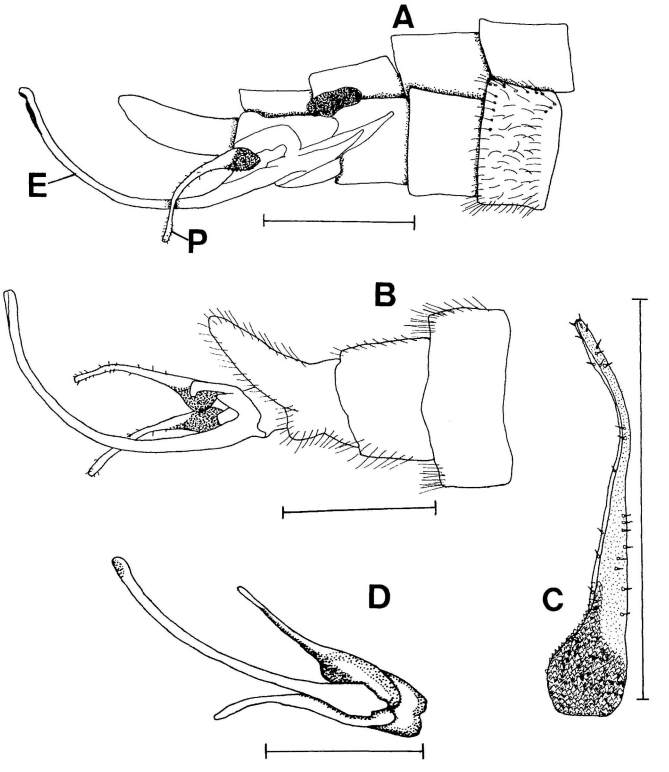

Fig. 4. *Duliticola hoiseni,* new species. Allotype male (TL 6.6 m) (ZRC.6.18599); A. Genitalia; B. Genitalia in extruded position; C. Paramere; D. Aedeagus, ventral view; E. Aedeagus; P. Paramere. Scale = 1 mm

DISCUSSION

Of the three nominal species and subspecies of *Duliticola*, *D. paradoxa* was described in detail with good figures by Mjöberg (1925), but the descriptions for *D. korinchiana* and *D. korinchiana* var. *robinsoni* leave much to be desired, being very brief and not accompanied by figures. The male genitalia of both taxa were also not figured or described. For the present study, all the types have been examined.

The larviform females of *D. hoiseni* closely resemble Mjöberg's species number 7 from Malaya (= Peninsular Malaysia) (Mjöberg, 1925: pl. 3 fig. 7; Mjöberg, 1928: pl. 40; Ng & Yong, 1991), in all observable features, and are almost certainly the same species.

Duliticola hoiseni is markedly different from all three known species of *Duliticola*, not only with regard to the larviform females but in the males as well. The larviform females of *D. hoiseni* differ from *D. paradoxa* in appearing more robust, with well developed and prominent tubercles on the thoracic tergite (vs. absent) and with thoracic tergites strongly convex transversely (vs. almost flat). The overall colouration of *D. hoiseni* is dark brown with the lateral margins of the thoracic segments and the abdominal processes being cinnamon coloured, while that of *D. paradoxa* is black with lateral margins of thoracic segments and abdominal processes being yellow; a whitish patch being present between the two tubercles on the posterior margin of the thoracic and abdominal tergites. We have examined a large series of larviform female specimens of *D. hoiseni* ranging from 1.1 to 6.0 cm TL and all but one of the above-mentioned differences are valid for all size groups. With regard to the convexity of the thorax, this structure appears relatively flat in specimens of earlier instars (1.1 to 2.5 cm TL), and cannot be used as a differentiating character. This character is only obvious in specimens larger than 2.5 cm TL.

Dissection of a paratype male of *D. paradoxa* confirms the accuracy of Mjöberg's (1925: Fig. 1) original figure of the male genitalia. The male genitalia of *D. hoiseni* differ from those of *D. paradoxa* in having the aedeagus substantially longer than the parameres (vs. subequal in length). The parameres of the male genitalia of *D. paradoxa* are also gently serrated along their outer lateral margins (vs. smooth in *D. hoiseni*). The male specimens of *D. hoiseni* from Singapore and Gombak do not differ substantially, although the carina on the prothorax of the male from Singapore differs slightly from that from Gombak in position and strength. I do not regard these differences as specifically significant. In any case, their genitalia are identical.

K. G. Blair (1928) described two taxa from Korinchi (Kerinci), Sumatra: *Duliticola korinchianus* and *Duliticola korinchianus* var. *robinsoni*. Since the gender of *Duliticola* is feminine, "*korinchiana*" should be used instead of *korinchianus*.

Comparisons of *D. hoiseni*, with *D. korinchiana* s. str. and *D. korinchiana robinsoni* are more difficult. The male types of both these taxa (only one male of each taxon known) are not in good condition, and their genitalia could not be removed without badly damaging the specimens. The validity of *D. korinchiana* s. str. and *D. korinchiana robinsoni* is questionable, as the only apparent difference between them is the colouration of the adult males. Blair (1928), in separating the two species, commented that in *D. korinchiana* s. str., the base of the elytra was testaceous (orange brown colour) and the rest of the elytra black. In *D. korinchiana robinsoni*, the entire elytra was testaceous. This is still evident on the type males of both taxa examined. In all other respects (genitalia not investigated) and

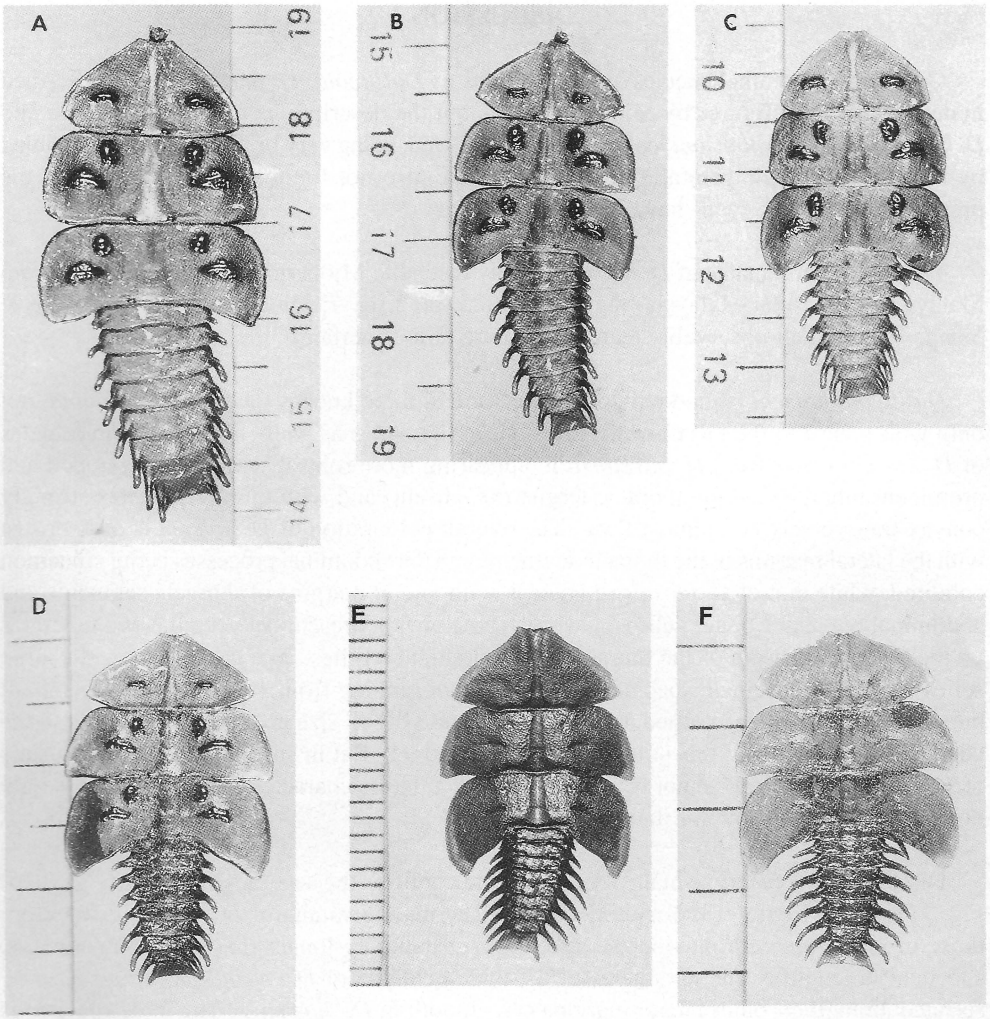

Fig 5. Series of instars of *Duliticola hoiseni*, new species. A-C (ZRC.6.18603-18605), D-F (ZRC.6.18626-18628). A-F; E and F - early instar. Scale in centimetres, except E in millimetres.

considering the poor condition of the specimens, they certainly appear very similar. However, at the moment, the status of the two taxa cannot be ascertained conclusively. The male of *D. hoiseni* is uniform black throughout and does not show any trace of testaceous colouration.

A problem here is that one cannot be sure that the larviform females (2 specimens in NHM were examined) obtained from Sumatra and reported by Blair (1928) are in fact the same species with the type males of *D. korinchiana* s. str. and *D. korinchiana robinsoni*. While they were collected in the same locality (Sungei Kumbang, Korinchi), the only way to be sure that they are conspecific would be to to catch them while mating. Whether the females belong to *D. korinchiana* s. str. or *D. korinchiana robinsoni* or still another species cannot be ascertained. From our experience, we have collected two quite different species of *Duliticola* from one area in Peninsular Malaysia and Singapore (unpublished data).

The larviform females which have been attributed by Blair (1928) to *D. korinchiana* belong to a hitherto undescribed species from Sumatra (which will be dealt with by the

author at a later date). According to Blair this larva "differs considerably from the larva of *D. paradoxa*, but approach very closely to Mjöberg's No. 7 from the Malay Peninsula... " This Korinchi larva differs in "being a little narrower, i.e., the mesothorax is exactly twice as wide as its median length". Though the position and arrangement of the tubercles on the thoracic tergites is similar to that of the larva of *D. hoiseni*; the Korinchi larva is pale brown overall, while the tubercles on the thoracic and abdominal tergites are black.

Females and larvae of *Platerodrilus* species are not yet known, while several species were described by Pic (1921, 1939, 1943) from Peninsular Malaysia and its environs. Since the two genera are obviously closely related (see earlier), comparisons of members of this genus with *D. hoiseni* are necessary. Four taxa of *Platerodrilus* have been described from Peninsular Malaysia, viz. *P. sinuatus* Pic, 1921 ("Malaya"), *P. sinuatus* var. *latebasalis* Pic, 1939 ("Malaya", Pulau Tioman), *P. atricolor* Pic, 1938 (Cameron Highlands: Pahang), and *P. atronotatus* Pic, 1943 ("Malaya"). I have examined the types of these four species in the Museum National d'Histoire Naturelle in Paris, and are confident that none of these species are conspecific with *D. hoiseni*. Compared to *P. atricolor*, which is also a uniformly black species, *D. hoiseni* differs in being a smaller species (6.5, 6.6 mm vs. 8.2, 8.3 mm TL); the carinae on the elytra becoming fainter towards the posterior (vs. more pronounced carina along entire length of elytra); and a fusiform scutellum (vs. broad inverted triangle). *P. sinuatus* is of similar size, but is black with pronotum and base of elytra being rufous. *P. sinuatus* var. *latebasalis* is larger than *D. hoiseni* (7.7 mm TL); while its elytra are black with base of the elytra orange yellow in colour. *P. atronotatus* (10-11 mm TL) is also much larger than *D. hoiseni*; and its elytra are black and orange in colour.

BIOLOGY

The following observations were made in Gombak Field Station during the period between April and September 1993.

Habitat. - The larvae of *D. hoiseni* were found on rotting logs within lowland forests of Peninsular Malaysia and (on one occasion) Singapore. There was no clear preference for any particular group of trees, but the stage of decomposition does seem to matter. No larvae were found on logs at an advanced stage of decay. Relatively intact logs seem to be preferred. Larvae were present on the surface of rotting logs, no evidence of burrowing were noted. Activity is not restricted by nocturnal or diurnal patterns, they have been seen at all hours of the day.

Feeding Behaviour and Diet. - The feeding biology of Lycidae larvae has not been fully understood nor well documented. Shelford (1916: 166) described the feeding behaviour of *Lycostomus* larva and suggested that they were preying on either "mollusca,... and perhaps dipterous larvae". Subsequently, following the observations of McCabe & Johnson (1979), who reported the larva of *Platycis sculptilis* (Say) feeding on decaying juices of rotting White Pine (*Pinus strobus*) wood. More recent work by Miller (1988) who observed *Calopteron reticulatum* feeding on mollusks, suggested that at least some lycid larvae are indeed predatory in nature. As such, we are still at too early a stage to make generalizations about the food sources of larvae of Lycidae.

There had been considerable speculation and confusion over the food source of trilobite larvae; whether they are predators or feed on fungi, slime mould, or suck juices from rotting

wood. Gahan (1913: 62) remarked that "on no occasion have I been able to see them feed; and it is still doubtful whether their food be vegetable or animal matter". Gravely (1915: 363) suggested that "presumably therefore they must eat something which they need not grasp securely, such as snails or planarians. It is also possible that they may feed on the juices of decaying wood, etc."

Mjöberg (1925: 140) stated more conclusively that they "feed on the juices of decaying wood." This was justified from gut contents and direct observations. Ng & Yong (1991: 95) "found specimens on fungi (Basidiomycetes), observed some of them apparently grazing on the fungal growths on rotting wood".

Observations of feeding behaviour, both in the field and in captivity, were made by the author. Larvae can be seen moving on the surface of fallen logs with the head and antennae (Figs. 5A, 5B) extended. From time to time, the animal would lower its head and probe the surface with its antennae. The antennae may be serving a sensory function in which the texture or the dampness of the wood may be assessed. Individuals have been observed with their heads and mouthparts jammed into crevices apparently in the act of feeding. Similar feeding actions were observed in animals left on wet tissue papers.

A drop of liquid was squeezed from a piece of wood collected together with *D. hoiseni* larvae, and observed under the microscope. A large amount of organic detritus in the form of wood fibres, fungal hyphae and spores can be seen. In addition, a wide spectrum of living organisms exists in the juice; these include protozoa, rotifers, nematode worms, copepods and nauplii larvae, and mites. Presumably, the larvae were feeding on the micro-organisms within the juices of rotting wood.

Gut morphology and contents of *D. hoiseni* larvae were examined. Specimens were dissected and the digestive tract removed. Gut contents within each part of the gut were examined.

The gut is of a simple tubular form (see Fig. 3D), coiled in the hindgut portion. The foregut is thin walled such that the clear, brown fluid content is visible. This fluid is similar to juices extracted from rotting wood. In freshly dissected specimens, the fluid can be seen to be pulsating back and forth. This is due to the pumping action of the midgut which has thick muscular walls. The contents of the midgut appears to be the same brown fluid. The hindgut is thin-walled and coiled, while the rectum is a short, straight thin-walled section. Within the hindgut, a light brown, soft solid substance is present. The contents of the hindgut is similar to the material excreted by the larvae. The body cavity, both in the thoracic and abdominal portions, was full of white fat bodies; and as the larvae were in captivity for several months, this indicates that the larvae had been feeding consistently.

In conclusion, with evidence from gut contents and anatomy, together with observations of feeding behaviour, the female larva of *Duliticola hoiseni* does indeed feed on micro-fauna associated with the juices of rotting wood.

Lycidae larvae have the characteristic feature of mandibles which are divided longitudinally into two parts. Boving & Craighead (1931) provided figures of the two part-mandibles of *Eros humeralis* and *Calopteron reticulatum*. McCabe & Johnson (1979) noted that "the larval mandibles of *Platycis sculptilis* are fused at the base and incapable of apposition, seemingly eliminating the possibilty of any predatory habits. Crowson (1981:

129) referred to "extraordinary modifications are seen in Lycidae where each mandible is split into two nearly straight pointed sclerites which together enclose a suctorial tube...".

Specimens of mandibles were observed under the Scanning Electron Microscope at low KV values and at magnifications of between 100X and 350X (see Figs. 6C, 6D).

The mandibles are diametrically opposite, sharp, sickle shaped, and dorso-ventrally flattened. Each mandible is made up of two separate parts which are tightly fitted together. The inner part, M2, is deeply grooved along the midline; and it is along this groove that the outer part, M1, fits.

Life History and Reproduction. - After five months, many larvae of *D. hoiseni* had moulted. However, none underwent a second moult. Therefore, the time span between

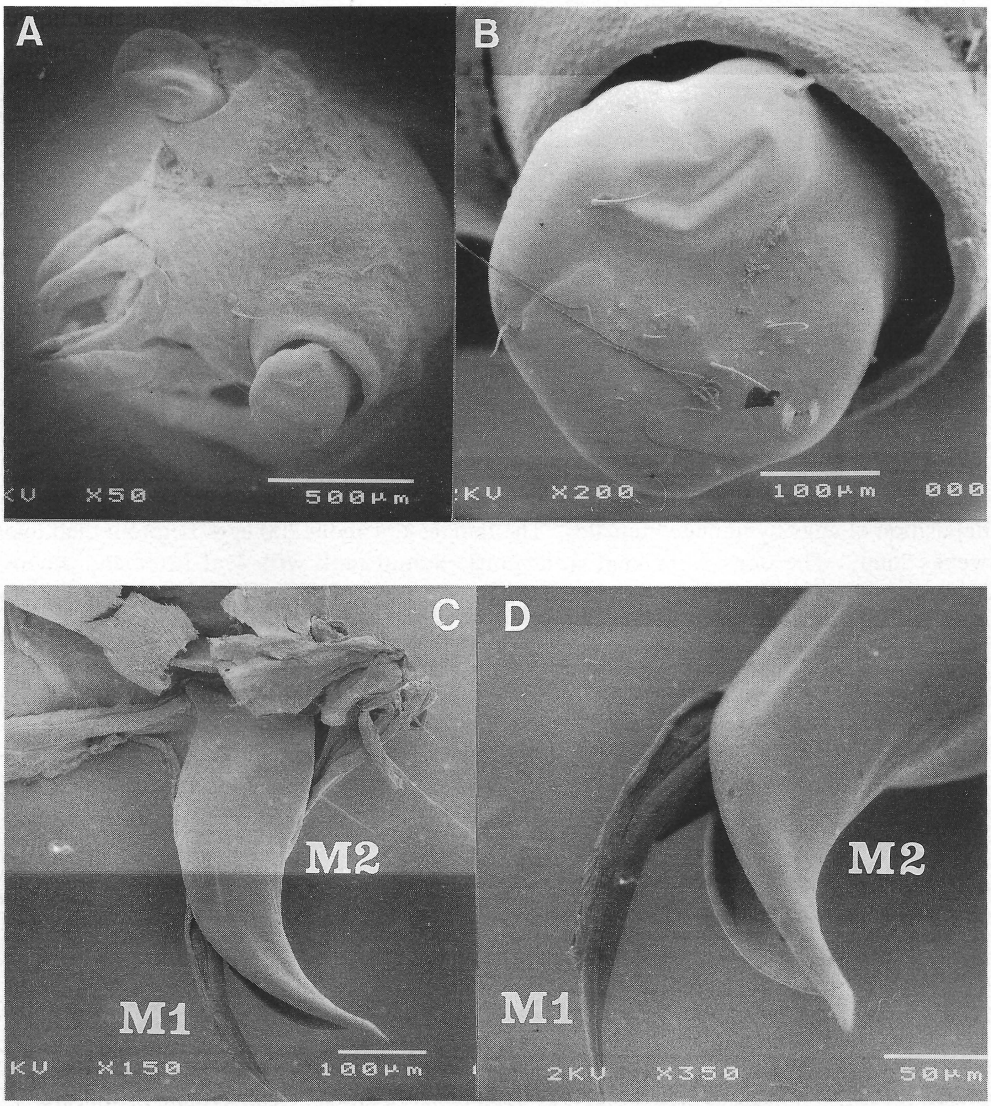

Fig 6. Scanning electron micrographs. *Duliticola hoiseni*, new species. A. Head, 50X; B. Antenna, 200X; C. Right mandible, 150X; D. Right mandible, 350X. Specimen TL 5cm, GFS, not preserved.

moults could be more than five months. Since it is not known how many instars there are till the terminal moult and whether the durations of the instars are uniform, the life span could exceed one year or even longer.

Just before moulting, the larva would appear bloated with the membranes visibly stretched. It would then curl up under a piece of wood and remain immobile for two to three days. After shedding the old exoskeleton, it would be white in colour. The larva would sclerotise rapidly within a day. However, if the larva was at the terminal moult, it would remain immobile for about three days and turn yellowish, without sclerotising (Fig. 7A). The thoracic segments appear to be turgid with haemolymph or fat bodies; but after a week, the abdomen appears to be swollen with eggs.

After the resting period following the terminal moult, the female would climb onto the wood surface. It would then raise its abdomen until almost above the thorax; exposing the gonopore, before the anal sucker. Mjöberg (1925: 125) described that a drop of clear liquid exudes from the genital opening. However, this was not observed in the case of the females of *D.hoiseni*. Such display may help disperse pheromone to attract the males. After four to five days of display, the unmated female began to lay eggs. These are laid on the surface of wood as the female moved around which corresponds with Mjöberg's account for *D. paradoxa*. The eggs were whitish yellow in colour and are about one millimetre in diameter. The lifespan of the mature female was between six to eight weeks.

With the mature female available, trapping of the hitherto unknown male beetle was attempted using the female as bait. The female was observed for the prescence of the male every few hours. The trapping excercise was conducted at Gombak Field Station and Bukit Timah Hill. Success was achieved at Gombak Field Station. A male beetle was found tightly attached to the gonopore of the female. The long, curved genitalia of the male were firmly inserted into the female gonopore. The male held on for about five hours. It died three to four hours after releasing the female. On the next day, the female laid a mass of eggs which stuck together in a sticky clump (Figs. 7B, 7C). This was quite unlike the sparse deposition of eggs by unmated females. The female laid about 200 eggs before it died two weeks later. The eggs were kept in a moist, humid tank with leaf litter and wood. Unfortunately, the eggs failed to hatch. Microscopic examination of some of the eggs revealed that there was no embryonic developement.

Three young larvae were hatched from eggs contained in some wood from Gombak Field Station. Upon hatching, the larvae measured 6.6, 7.7, 7.9 mm respectively. This is the first time that succesful hatching of trilobite larvae from eggs has been documented! However, the larvae died after three weeks. Therefore, the early life cycle is still largely unknown. Questions in this area were asked by Mjöberg (1925: 131): "Are the male larvae already *ab ovo* different to the female-larvae and of what shape and form are they? And how large a percentage of a female's 300-400 eggs turn into males, how many to females and where and how the male-larvae live...".

COMPARATIVE MATERIAL EXAMINED

Duliticola paradoxa — 1 male and 1 female (in copula, preserved in alcohol), (NRM), coll. E. Mjöberg, 1924. — 1 male, co-type (NHM1927-225), Lundu, Sarawak, Malaysia, coll. E. Mjöberg. — 1 male, paratype, (NRM), Borneo, coll. Mjöberg. — 1 female, (NHM), coll. G. E. Bryant, 6 Jan.1914. — 1 female, (ZRC.6.18625), Batu Puteh village along Lower Sungei Kinabatangan, Sandakan district,

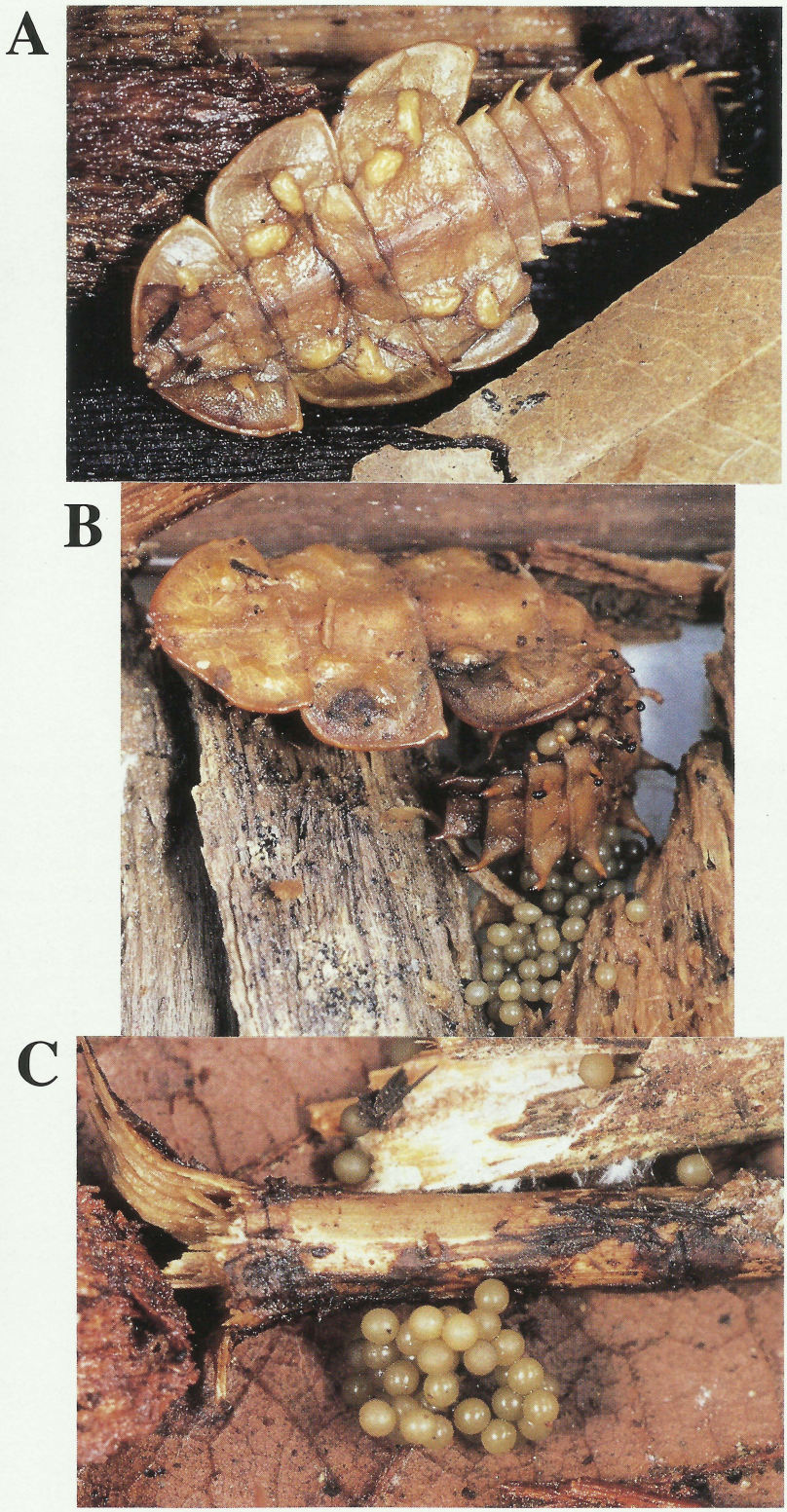

Fig 7. *Duliticola hoiseni,* new species. A. Mature female (ZRC.6.18629); B. Mature female with eggs; C. Eggs, diameter 1 mm.

Sabah, Malaysia, coll. H. H. Tan, 9 Apr.1994. — 1 female, (NHM1933-254), Primary forest, R. Koyan 2500', Mt. Dulit, Sarawak, Malaysia, coll. B. M. Hobby & A. W. Moore, Oxford Univ. Exp., 19 Nov.1932. — 1 female, (NHM1933-254), junction of rivers Tinjar & Lejok, foot of Mt. Dulit, Sarawak, Malaysia, coll. B. M. Hobby & A. W. Moore, Oxford Univ. Exp., 22 Aug.1932.

Duliticola korinchiana — 1 male, type (NHM 1929-205), Sg. Kumbang, Korinchi, Sumatra, 4500', coll. K. G. Blair, Sep.1914. — 1 female (NHM 1929-205), Sg. Kumbang, Korinchi, Sumatra, 4500', det. K. G. Blair, Apr.1914. — 1 female (NHM 1955-354), Ex F. M. S., Sg. Kumbang, Korinchi, Sumatra, 4600', Apr.1914.

Duliticola korinchiana var. *robinsoni* — 1 male, type (NHM 1929-205), Sg. Kumbang, Korinchi, Sumatra, 4500', coll. K. G. Blair, Nov.1914.

Platerodrilus sinuatus — 1 male, type, (MNHN), Perak, coll. Doherty, Collection M. Pic. — 1 male, MNHN, Bukit Kutu, Selangor, Malay Penin., 3500', coll. H. M. Pendlebury, 9 Sep.1927, Collection M. Pic.

Platerodrilus sinuatus var. *latebasalis* — 1 male, possible type, (MNHN), Collection M. Pic.

Platerodrilus atricolor — 1 male, type, (MNHN), Cameron's Highlands, Pahang F.M.S., 4500-5000', coll. H. M. Pendlebury, 19 Jun.1935., Collection M. Pic. — 1 male, (MNHN), G. Terbakar, Cameron's Highlands, Pahang F.M.S., 4481', coll. H. M. Pendlebury, 9 May.1939., Collection M. Pic. — 1 male, (MNHN), G. Jasar, Cameron's Highlands, Pahang F.M.S., 5565', coll. H. M. Pendlebury, 19 May.1939., Collection M. Pic.

ACKNOWLEDGEMENTS

This study was made possible by assistance from Prof. Yong Hoi Sen, Universiti Malaya; Economic Planning Unit, Prime Minister's Office, Malaysia, for granting the research permit; National Parks Board, Singapore for granting the collection permit. The author is also grateful to Mrs C. M. Yang, ZRC; Prof. J. J. Menier, MNHM; Mrs Jane Beard, Department of Entomology, NHM; Dr. J. Krikken, Nationaal Natuurhistorisch Museum, Leiden; Dr. Sandberg, NRM, Stockholm for the loan of types and specimens. Dr. Ladislav Bocak, Dr. Sergei Kasantsev and Prof. W. Wittmer for their kind advice and insights into Lycidae taxonomy. Much thanks is owed to Tommy Tan, Kelvin Lim, N. Sivasothi, Prof. D. H. Murphy and Dr. Peter Ng for their help and support. This paper is contribution no. 14/95 from the Ecology and Systematics Laboratory, Department of Zoology, National University of Singapore.

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Received 23 Oct 1995
Accepted 07 Mar 1996