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Eucnemid larvae of the Nearctic region. Part VI: Descriptions of the fifth instar and prepupal larval stages of *Stethon pectorosus* LeConte, 1866 (Coleoptera: Eucnemidae: Eucneminae: Mesogenini), with notes on their biology

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Abstract. Descriptions and illustrations of the fifth instar and prepupal larval stages of *Stethon pectorosus* LeConte, 1866 (Coleoptera: Eucnemidae: Eucneminae: Mesogenini) are provided. These are the first larval descriptions for the genus *Stethon* LeConte within the subfamily Eucneminae in the Nearctic region. Biological information is provided and comparison with larval morphology of other Eucnemidae is briefly discussed.

Key Words. Larval morphology, natural history, *Ulmus*, purple-colored stain, Wisconsin.

Introduction

An aggregation of adult *S. pectorosus* in a southwestern Wisconsin mixed hardwood forest was discovered by the junior author in July 2014. A follow-up trip next spring resulted in the discovery of two larval forms of *S. pectorosus*.

Stethon currently is a monotypic genus restricted to the Nearctic region. Much of the known biology was based on field observations of adults collected through various means. Larval information and much of the biology were unknown until this study. The following account for *S. pectorosus* is the sixth paper in a long-term series of papers (Otto 2012a, 2012b, 2013, 2014, 2015) covering descriptions of larval Eucnemidae in the Nearctic region, with notes on their biology.

Materials and Methods

A limb was selected in search of eucnemid larvae. Pieces of wood determined as likely to contain larvae were placed in 3.8 L plastic Ziploc® bags with collection data. The bags were left open for several days to prevent molding and sealed after the wood dried. Pieces of wood were carefully examined for presence of reared adults.

Representative larvae were temporarily stored in a plastic box and then preserved by initial immersion in a hot water bath for 15–20 minutes. Dimensions were measured using a ruler. Length was measured from the lateral projections of the head capsule to the apex of the ninth abdominal segment. Width was measured across the prothoracic region. All specimens were subsequently placed in labeled 1 dram vials filled with 70% ethanol for permanent storage. They are deposited in the collection of the Global Eucnemid Research Project (GERP) and the Wisconsin Insect Research Collection (WIRC), University of Wisconsin-Madison.

Specimens to be imaged were suspended in Germ–X® hand-sanitizer during the imaging process. Images were taken with a JVC KY–F75U digital camera attached to a Leica® Z16 APO dissecting mi-

croscope with apochromatic zoom objective and motor focus drive, using a Synchroscopy Auto-Montage® System and software. Imaged larval specimens were triple-rinsed with distilled water to remove any gel before returning them to the vials.

Terminology of Muona and Teräväinen (2008) was used in descriptions. An additional term, circumanal asperities, is used to describe the shape of the outer line around the top of the anus. Numbering of lateral projections starts near the base of the head and concludes at the apex of the head capsule. Mandibles are not included as lateral projections in the descriptions. Mandibular descriptions, if any, are provided separately.

Systematics

Subfamily Eucneminae Eschscholtz, 1829
Tribe Mesogenini Muona, 1993

Genus *Stethon* LeConte, 1866

Adult Diagnosis. Characters of Mesogenini, with apical margin of frontoclypeal region evenly rounded and less than twice as wide as the distance between antennal sockets; well-developed, basally closed, deep, lateral antennal grooves present; male prothoracic tarsomere I simple, without sex combs; metathoracic coxal plates 1.2–2.5 times wider medially than laterally; last visible ventrite produced; lateral pronotal ridges complete; lateral surfaces of mesothoracic and metathoracic tibiae with setae only; male aedeagus dorsoventrally compressed; basal piece dorsally closed; lateral lobes entire and directed dorsocaudad; median lobe simple, deeply and with separate apical median sclerite either entire or bifid; flagellum simple.

Stethon pectorosus LeConte, 1866

Larval Diagnosis. Buprestiform shape, along with structure of the head capsule, will distinguish both stages from any known eucnemid larvae in the Nearctic region.

Specimens Examined. Six larvae collected at **USA:** WISCONSIN: La Crosse County, Coulee Experimental Forest, N43°51.711' W-91°01.460', 21 March 2015, in hard, dried *Ulmus* limb, leg. Robert L. Otto & Jeff Gruber (2 fifth instars, 4 prepupal larval stages).

Fifth Instar
(Fig. 1–5)

Description. Length 12.5–15.0 mm. Width 3.0 mm, at prothoracic/mesothoracic region. Orthosomatic, buprestiform (Fig. 1). Body subcylindrical, sides parallel with fused head/prothorax and mesothorax wider; creamy yellow with head and thoracic sclerome patches dark brown. Setae either indistinct or absent. Legs reduced to setal clusters. Dorsal and ventral microtrichial patches slightly darker than surrounding areas.

Head (Fig. 2)**:** Strongly flattened, prognathous, heavily sclerotized and deeply inserted into prothorax. Dorsal surface rugose, with several elevated, vertical ridges extending from base to apex. Venter rugose, with several vertical ridges. Each lateral side of head capsule consists of three projections. Basal lateral projections short, subtriangular and arising near anterior end. Second lateral projection directed anterolaterally. Third lateral projection arising close to second, directed anteriorly. Antennae minute, arising near base of basal lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum subequal in length. Sensory papillae indistinct. Mandibles indistinct. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

Prothorax (Fig. 3–4)**:** Subequal to mesothorax, much wider than metathorax. Tergum with pair of small, circular scleromes at anterior end; pair of moderately sized oval scleromes near center of segment. Lateral sides of scleromes lightly pigmented, extending to sides. Sternum with pair of small,

circular scleromes at anterior end; pair of enlarged, oval scleromes near center of segment. Lateral sides of scleromes lightly pigmented, extending to sides. Microtrichial patch absent on both surfaces. Both surfaces with small, circular areoles present near base. Spiracle circular; spiracular collar cranially expanded, truncate.

Mesothorax: Much wider than metathorax. Tergum and sternum with transverse, caudally bilobed microtrichial patch near anterior end; enlarged, circular areole present near center. Lightly pigmented triangular scleromes present at center, laterad of areole, with diagonal plicae and carinae. Spiracles absent.

Metathorax: Tergum and sternum with transverse, comma-shaped microtrichial patch near anterior end; enlarged, circular areole present near center. Very lightly pigmented triangular scleromes present at center, laterad of areole. Spiracle circular; spiracular collar cranially pointed.

Abdomen: Segments I–VIII slightly wider than long. Terga and sterna I–VIII with transverse, cranially bilobed microtrichial patch near anterior end. Terga and sterna I–VIII with enlarged areole near center, close to microtrichial patch, gradually change from enlarged triangle on segment I to enlarged transverse areole on segment VIII. Segment VIII slightly enclosing IX laterally. Segment IX shorter, caudally rounded, dorsoventrally flattened. Tergum IX with median ridge extending from base to apex, without microtrichial patch and areole; sternum (Fig. 5) lightly sclerotized, with U-shaped microtrichial patch above complete ring of circumanal asperities. Urogomphi absent on segment IX. Spiracles circular; spiracular collar cranially pointed.

Prepupal Larval Stage
(Fig. 6–10)

Description. Length 10.0–14.0 mm. Width 3.0 mm at prothoracic/mesothoracic region. Orthosomatic, buprestiform (Fig. 6). Body subcylindrical, sides parallel with fused head/prothorax and mesothorax wider; white with head and prothoracic sclerome patches dark brown. Dense, erect, short setae confined to anterolateral areas of prothorax. Legs reduced to setal clusters.

Head (Fig. 7)**:** Strongly flattened, prognathous and deeply inserted into prothorax. Dorsal surface simple, without ridges; posterior end unsclerotized, anterior end heavily sclerotized. Venter simple, heavily sclerotized. Each lateral side of head capsule consists of four projections. Basal lateral projections short, triangular. Second through four lateral projections directed anteriorly. Fourth lateral projections narrowly separated at apex. Buccal orifice present beneath fourth lateral projections on ventral side. Antennae minute, arising near base of basal lateral projections. Scape not visible. Pedicel elongate. Sensorum and flagellum subequal in length. Sensory papillae indistinct. Mandibles indistinct. Labial and maxillary palpi indistinct. Ligula, mala, lacinia and galea not visible. Hypostomal rods absent.

Prothorax (Fig. 8–9)**:** Subequal to mesothorax, much wider than metathorax. Tergum with pair of indistinct transverse microtrichial patches near anterior end and a pair of small circular scleromes near anterolateral side. Sternum with deep median triangular furrow extending from base of head at apex down 3/4 the length, without microtrichial patch. Pair of vertical, concaved scleromes present below the head, extending entire length of segment. Both surfaces without areoles. Spiracle circular; spiracular collar cranially expanded, truncate.

Mesothorax: Much wider than metathorax. Tergum and sternum without areole. Tergum with pair of indistinct transverse microtrichial patches near anterior end. Sternum with pair of angulated subtriangular scleromes. Sternum with indistinct transverse microtrichial patch near anterior end and a pair of small, circular scleromes near center. Spiracles absent.

Metathorax: Tergum and sternum without areoles. Tergum with pair of indistinct transverse microtrichial patches near anterior end. Sternum with indistinct transverse microtrichial patch near anterior end. Spiracle circular; spiracular collar rounded.

Abdomen: Segments I–VIII slightly wider than long, each with lateral warts. Terga I–VIII with pair of indistinct microtrichial patches near anterior end. Sterna I–VIII with indistinct transverse microtrichial patch near anterior end. Both surfaces without areoles. Segment VIII slightly enclosing IX laterally. Segment IX shorter, caudally rounded. Tergum IX without microtrichial patch and areole; sternum (Fig. 10) lightly sclerotized, without circumanal asperities. Urogomphi absent on segment IX. Spiracles circular; spiracular collar rounded.

Distribution. *Stethon pectorosus* is known from **CANADA:** New Brunswick, Ontario, Québec; **USA:** Alabama (**New State Record**), Arkansas, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New York, Ohio, Oklahoma (**New State Record**), Pennsylvania, Texas, Virginia and Wisconsin (Muona 2000; Hoffman et al. 2009; Webster et al. 2012; Webster 2014; Otto pers. obs.). All specimens used in this study came from Wisconsin.

Biology. *Stethon pectorosus* is a widespread, uncommon species, although many records are relatively old (Muona 2000). Some biological information is known. Horn (1886) reported finding a specimen beneath the bark of shellbark hickory (*Carya laciniosa* (Miller) K. Koch; Juglandaceae). Dury (1888) found *S. pectorosus* on a fungus on the underside of poplar log (*Populus* sp.; Salaceae). Dury (1904) also found the species on a dead elm (*Ulmus* sp.; Ulmaceae). Blatchley (1910) noted the species occurred beneath the hickory (*Carya* sp.) bark. Muona (2000) wrote that *S. pectorosus* is common in UVCC-light traps in Indiana, based on a correspondence from Downie. Webster et al. (2012) have taken one specimen from a Lindgren funnel trap placed in an old silver maple (*Acer saccharinum* L.; Aceraceae) forest from late July to early August in New Brunswick.

Stethon pectorosus has been found in a couple of forest systems in Wisconsin, which includes the southern dry-mesic and southern mesic forest systems. The collecting site, Coulee Experimental Forest, is a state-owned property located 15 miles east of La Crosse, within the driftless ecological region of the state. Its terrain is hilly, consisting of black oaks (*Quercus velutina* Lamarck; Fagaceae) along with American elm (*Ulmus americana* L.), shagbark hickory (*Carya ovata* (Miller) K. Koch) and small numbers of big tooth aspens (*Populus grandidentata* Michaux), white ash (*Fraxinus americana* L.; Oleaceae) and basswood (*Tilia americana* L.; Tiliaceae) as associates.

Eight adult specimens were taken by the junior author on 17 July 2014. An aggregation of adult beetles was observed beneath loose bark laying atop a fallen hardwood limb, later identified as *Ulmus* sp. Numerous beetles scattered to avoid capture after loose bark was removed from the surface. At least two mating pairs were observed crawling on the limb beneath the loose bark. One pair was taken, while the other pair evaded capture. Additionally, one specimen was in the process of emerging from its exit hole. Attempt to extract the emerging specimen failed because it had not emerged far enough from its exit hole.

A follow-up trip took place on 21 March 2015, in search of larvae in the limb (Fig. 11) from which eight adults had been taken in the previous season. Numerous small exit holes were present on the upper and left lateral side of the limb (Fig. 12). The senior author (Fig. 13–14) spent several hours splitting a six foot section with a maul and hatchet, concentrating on the upper and left lateral side of the limb as well as the lower right side. Adult cadavers were observed in their exit holes (Fig. 15), as these beetles attempted to reach the surface from the previous season.

Many fifth instars and prepupal larval stages were extracted from more than 3.0 cm underneath the surface, within the hard, firm sapwood closest to the heartwood. No larvae of other eucnemid species have been found in the vicinity of *S. pectorosus* in the limb. All prepupal larval stages assumed a U-shaped position inside the pupal cell (Fig. 16). Larvae were observed tunneling against and along the wood grain, leaving behind a short, flat gallery. Each gallery was packed with fine sawdust. Purple-colored stains were observed in fine sawdust, along the gallery walls and pupal chamber (Fig. 17). Two fifth instars and four prepupal larval stages were extracted from the limb (Fig. 18) during the collection event. Four specimens were extracted near the base of a knot on the left side of the limb. Two other specimens were found on the right lower side of the limb. Sapwood has undergone some rotting, with presence of black fungus developing in the wood fibers near the surface. All extracted immatures were taken far below the surface, from where rotting began. *Stethon pectorosus* overwinter as fifth instars and prepupal larval stages, as they continue their development in the following spring.

A third trip in search of *S. pectorosus* took place on 15 July 2015. No adults were found at the site. All examined downed logs at the site had moisture and many ant (Formicidae) activities beneath the bark, rendering these habitats undesirable for adult *S. pectorosus*. Based on our collecting efforts and senior author's previous encounter of the species at the Madison School Forest in 1994, desired habitats to find adult *S. pectorosus* should be drier surfaces devoid of any debris, frass and ant activities beneath loose bark of any dead hardwood tree or limb.

Attempts to obtain reared adults in wood pieces collected from the Coulee Experimental forest were unsuccessful. Based on label information in the GERP and WIRC collections, collectors in Wisconsin have found other *S. pectorosus* at blacklight, beneath loose bark, on a dead tree and recently from purple prism traps (Synegy Semiochemicals Company, British Columbia) while monitoring for the adventive Emerald Ash Borer (EAB) (*Agrilus planipennis* Fairmaire; Buprestidae) in southern Wisconsin from late July through late August.

Discussion. Fifth instars of *S. pectorosus* are quite similar to larval illustrations of *Isorhipis obliqua* (Say), *Melasis pectinicornis* Melsheimer and *Hylochares nigricornis* (Say), all in Peterson (1951; fig. C17A–B, F–J), as well as *Melasis balwanti* Fleutiaux in Gardner (1935; Plate I, fig. 14–15, p. 93). Structural differences among these five species are outlined in table 1.

Prepupal larval stage is similar to prepupal larval illustrations of Southeast Asian *Poecilochrus bengalensis* Fleutiaux in Gardner (1935; pl. I, fig. 10–13, p. 93), Russian *Eucnemis zaitsevi* Mamaev in Mamaev (1976; fig. 1–6, p. 138) and European *Eucnemis capucina* Ahrens in Burakowski (1991; fig. 134–137, p. 39). Structural differences among these four species are outlined in Table 2.

A strongly expanded prothoracic region is more evident in *S. pectorosus* than in the other three species. According to Muona (*in litt.*) the pronotal expansion of prepupal larvae suggests that *S. pectorosus* were actively boring into the wood much earlier than other eucnemid groups (i.e. *Isorhipis*, *Melasis* or *Hylochares*) or other coleopterous families (e.g. some Buprestidae and Cerambycidae) utilizing harder, seasoned wood for development.

One of the most interesting observations is the presence of purple-colored stain intermixed in fine sawdust and along the walls of the gallery and pupal chamber. A sample of the wood with purple stain was analyzed at the Forest Products Lab on the University of Wisconsin-Madison campus. According to Rachel Arrango of the Forest Products Lab in the Department of Forestry (*in litt.*), analysis of the purple stain came back inconclusive due to its older age. Presence of the purple-colored stain observed in the sawdust, gallery and pupal chamber still remains a mystery. One possibility is that the stain results from a chemical reaction between the wood and the fluids the larva excretes as it either extra-orally feeds in the surrounding area, or that it acts as a lubricant for exoskeletal surfaces as the larva moves within its gallery or pupal chamber in the drier sapwood.

Another possibility is that the purple stain is a type of unknown fungus highly localized in the gallery, possibly provisioned or contact made by an adult constructing an exit hole to escape from the pupal chamber. Dispersal of fungi in the wood is facilitated through mycangial pits present on exoskeletal surfaces, usually located on the elytra, ventral side of the head near the mandibles or along lateral sides. Grebennikov and Leschen (2010) concluded that these structures are well documented among some species of bark and ambrosia beetles (Coleoptera: Curculionidae: Scolytinae) and to some degree in a small number of other coleopterous families (i.e. Sphindidae, Erotylidae, Silvanidae, Latridiidae and Attelabidae).

The senior author has examined adult *S. pectorosus* (Fig. 19) and discovered a deep, V-shaped exoskeletal cavity near the apices of each elytron (Fig. 20) in both male and female specimens. No fungal spores or conidia were detected inside these deep cavities during the examination. A number of different eucnemids were also examined in the GERP collection and similar structures have been observed in species of *Mesogenus* Bonvouloir taken in the Indo-Malaya, Australasia, and Oceania ecozones. These structures varied in size and depth from different *Mesogenus* species present in the GERP collection. It is unknown whether these cavities have a role in the storage and distribution of fungal spores or serve a different purpose altogether. Further research to ascertain the morphology and determine the exact nature of these structures –whether these exoskeletal cavities are mycangial in nature or some other feature– is considered for the future.

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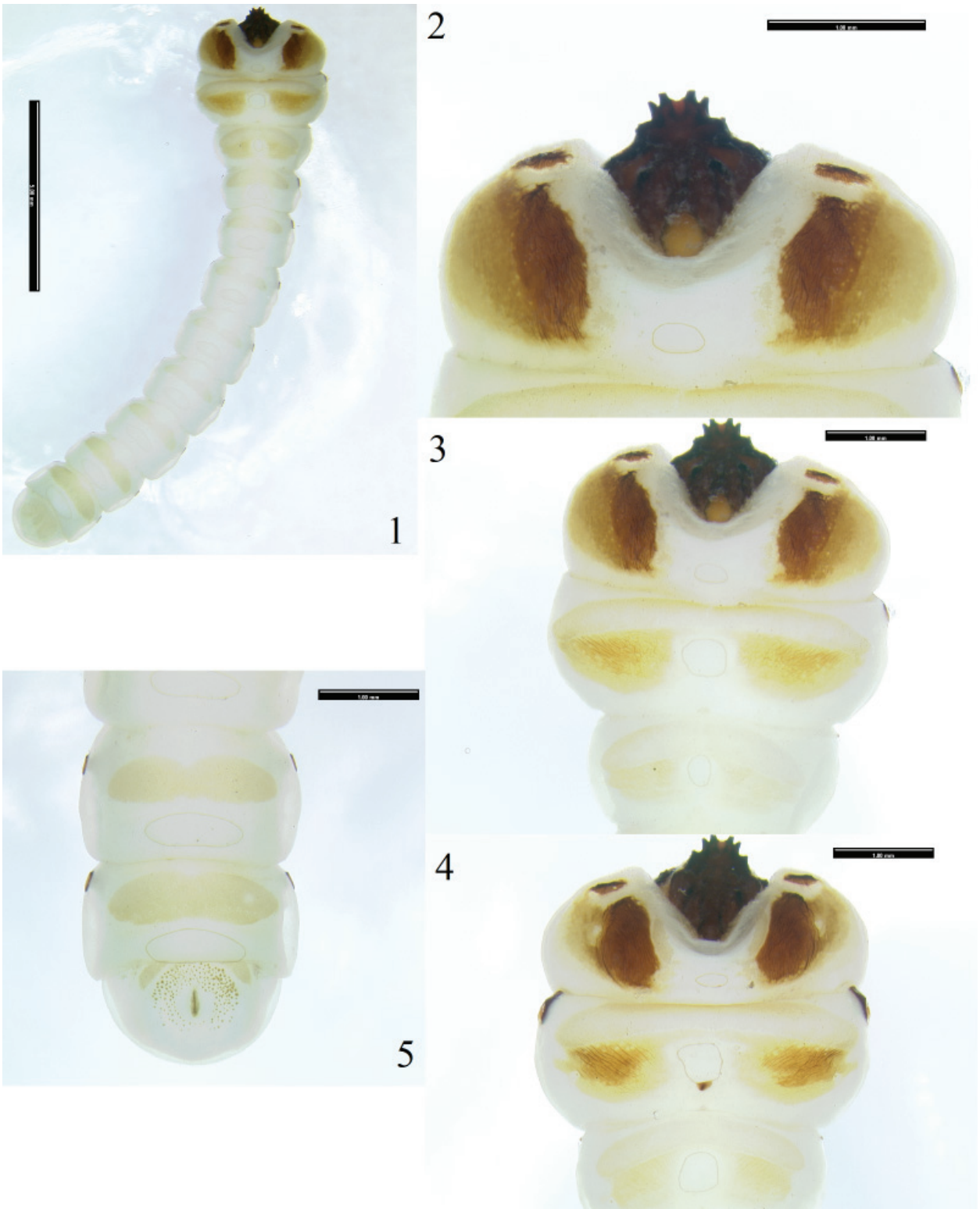
Table 1. Summary of comparative structural differences among fifth instars for five species.

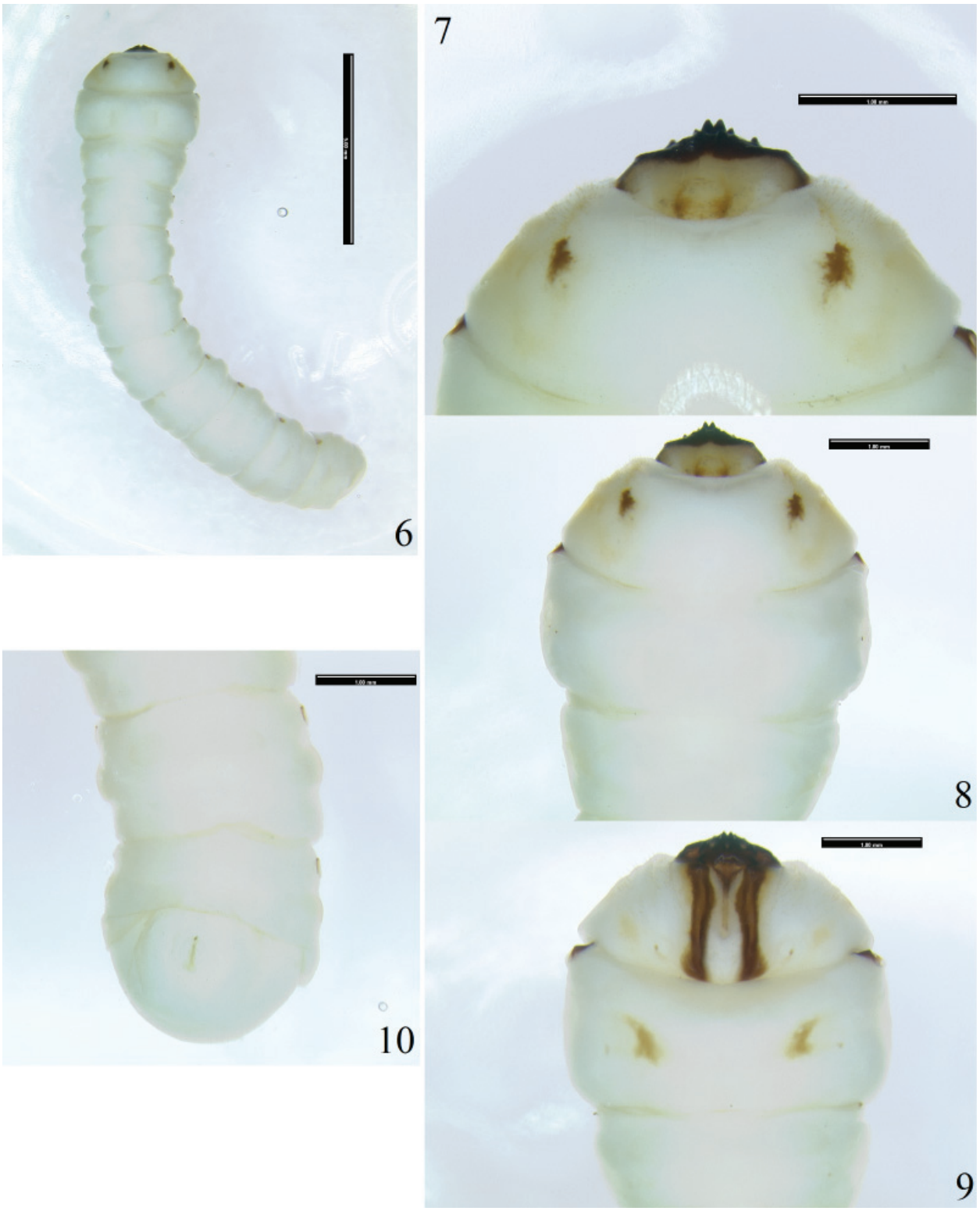
	I. obliqua	*M. balwanti*	*M. pectinicornis*	*H. nigricornis*	*S. pectorosus*
Lateral projections on head	absent	absent	absent	absent	present with 3
Annulets	present	present	present	absent	absent
Microtrichial patches	present	absent	present	present	present
Thoracic scleromes	confined to prothorax	confined to prothorax	confined to prothorax	confined to prothorax	present on all
Mandibular structures	present	present	present	present	indistinct
Rudimentary legs	absent	absent	absent	absent	present

Table 2. Summary of comparative structural differences among prepupal larval stages for four species.

	S. pectorosus	*P. bengalensis*	*E. capucina*	*E. zaitsevi*
Scleromes on prothoracic tergum	rounded	longitudinal linear	absent	absent
Prothoracic region	swollen/rounded	swollen/rounded	parallel-sided	slightly expanded
Areoles	absent	present	present	inconclusive
Microtrichial patches present on thoracic & abdominal segments	transverse pair present near anterior end of each segment	no well-defined patches observed in publication	transverse pair present on thorax & abdominal segments	not discernible

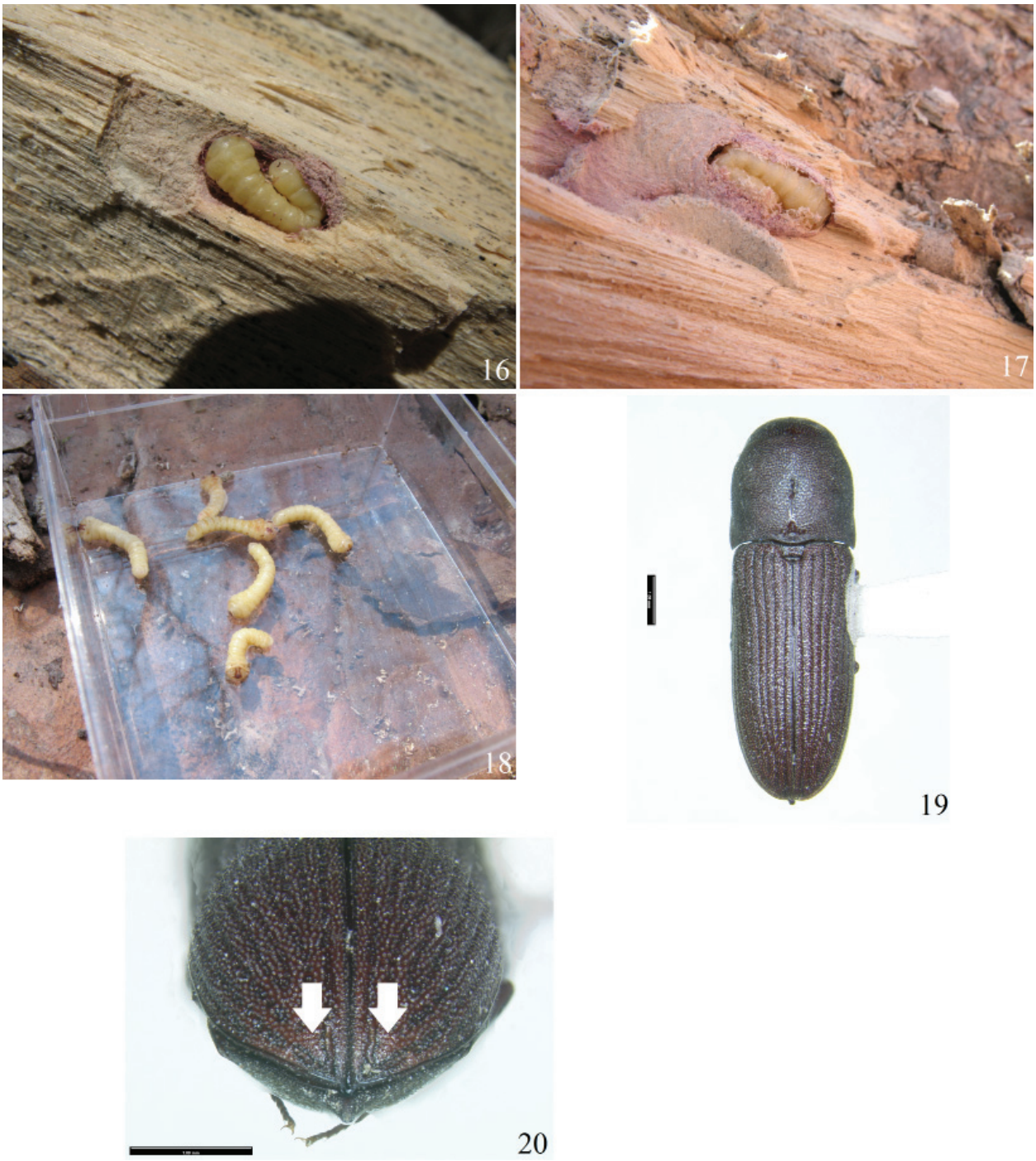


Figures 1–5. *Stethon pectorosus*, fifth instar. **1)** Dorsal habitus. Scale line = 5.0 mm. **2)** Head, dorsal view. **3)** Head and thoracic region, dorsal view. **4)** Head and thoracic region, ventral view. **5)** Abdominal segments VII-IX, ventral view. Scale line = 1.0 mm.



Figures 6–10. *Stethon pectorosus*, prepupal stage. **6)** Dorsal habitus. Scale line = 5.0 mm. **7)** Head, dorsal view. **8)** Head and thoracic region, dorsal view. **9)** Head and thoracic region, ventral view. **10)** Abdominal segments VII-IX, ventral view. Scale line = 1.0 mm.

Figures 11–15. *Stethon pectorosus* collecting event. **11)** Rotten elm limb. **12)** Exit holes. **13)** Senior author preparing to split the limb. **14)** Senior author splitting tree limb. **15)** Adult cadaver in exit hole.



Figures 16–20. *Stethon pectorosus* collecting event and adult. **16)** Prepupal larval stage in pupal cell. **17)** Prepupal larval stage with purple- colored stain. **18)** Collected fifth instar and prepupal larval stages. **19)** Dorsal habitus. **20)** Posterior habitus of adult illustrating deep, V-shaped exoskeletal cavities at elytral apices as indicated with white arrows. Scale line = 1.0 mm.