



First fossil jacobsoniid beetle (Coleoptera): *Derolathrus groehni* n. sp. from Eocene Baltic amber

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Abstract.—Jacobsoniidae, comprising a small group of small-to-minute polyphagan beetles, is a family presently placed within Derodontiformia. No fossil jacobsoniid has been described to date. Here, we describe the first fossil jacobsoniid, *Derolathrus groehni* n. sp., based on two well-preserved individuals in middle Eocene Baltic amber. Micro-computed tomography (micro-CT) was used to reveal many diagnostic characters of the Recent genus *Derolathrus* Sharp. *Derolathrus groehni* is compared with modern *Derolathrus* species and is noteworthy for the well-developed eyes and elongate prothorax.

Introduction

With only 22 described species grouped in three genera (Háva and Löbl, 2005; Lawrence and Leschen, 2010; Peck, 2010), the family Jacobsoniidae is a small group of polyphagan beetles comprising small-to-minute species (0.65–2.5 mm long). The family was provisionally included in Bostrichiformia by Lawrence and Newton (1995) and Philips et al. (2002) and is currently placed in Derodontiformia (Lawrence et al., 2010), although it shares characters with staphyliniforms (Crowson, 1959, 1960; Lawrence et al., 2011). Löbl and Burckhardt (1988) and Háva and Löbl (2005) catalogued all extant species of the world and only one species has been described since then (Peck, 2010). Jacobsoniidae includes three extant genera: *Saphophagus* Sharp with one species (*S. minutus* Sharp) restricted to New Zealand; *Sarothrias* Grouvelle with 13 species in the Indo-Australian region; and *Derolathrus* Sharp, with eight described species known from Sri Lanka, North America (Florida) and mainly tropical islands (e.g., Barbados, Canary Islands, Guadeloupe, Fiji, Hawai'i, Madeira, Mauritius, Virgin Islands).

Derolathrus, like remaining jacobsoniid genera, are poorly represented in collections and little about their biology is known (Háva and Löbl, 2005). There is unstudied material and undescribed species from Africa, Australia, the Neotropics, New Caledonia, and the Solomon Islands (Arnett et al., 2000; Lawrence and Leschen, 2010; Peck, 2006, 2010; Philips et al., 2002; Leschen, personal observation). *Derolathrus* species are tiny (from about 0.65 mm to about 1.00 mm) and require detailed study, especially of their cuticular microsculpture. Some species may be more widespread than thought; for example, *Derolathrus atomus* Sharp was described from Hawaii

and was recently recorded and considered accidentally introduced to the West Indies by Peck (2010). *Derolathrus* species have been collected by mass collecting techniques (in flight intercept traps and sifting leaf litter), and in microhabitats (under bark, in rotten palm wood, from fungal fruiting bodies, in bat guano, and from bird nests; Lawrence and Leschen, 2010; Löbl and Burckhardt, 1988; Philips et al., 2002). To date, no fossils belonging to Jacobsoniidae have been recorded. Therefore, our discovery of a new *Derolathrus* species from the middle Eocene is of significance for understanding the origin and early evolution of the family.

Material and methods

The newly described species is known from two individuals preserved in two pieces of Baltic amber. The two specimens are in the collection of Carsten Gröhn (Glinde, Germany) and will be deposited at the Geologisch-Paläontologisches Institut und Museum der Universität Hamburg, Germany (GPIH). The pieces were not embedded in artificial resin. The precise age of Baltic amber is not determined (Weitschat and Wichard, 2010). Due to transportation and extensive re-deposition, no amber-bearing deposits can be considered as the primary depositional site. We follow Ritzkowski (1997) who considered Baltic amber to be of Bartonian-Lutetian-Ypresian (middle Eocene) age. Micro-CT was performed at the Zoological Institute and Museum of the Ernst-Moritz-Arndt University of Greifswald. The specimens were scanned using an XRadia XCT-200 (Carl Zeiss) equipped with switchable scintillator-objective lens units. Each amber piece was mounted on a holder and centered. A series of 1600 projections were performed using 10× magnification with the

X-ray source setting at 40 kV and 8 W for 10s acquisition time at each interval. Tomography projections were reconstructed with the reconstruction software provided by XRadia. The generated image stacks (TIFF format) have a system based on 1.9 μm pixel



Figure 1. *Derolathrus groehni* n. sp., holotype, dorsolateral view, with exposed hind wings shown. Scale bar represents 200 μm .

size. Images were cropped to 792 \times 360 px (GPIH no. 4570, coll. Gröhn no. 8052) and 980 \times 488 px (GPIH no. 4571, coll. Gröhn no. 8260). Both scans were performed using Binning 2 and subsequently reconstructed using Binning 1 (full resolution) to avoid information loss. Volume renderings were generated using Amira 5.4 (FEI). Recent material was made available from the following collections: Florida State Collection of Arthropods, Gainesville, Florida (Paul Skelley); Museum d'Histoire Naturelle, Geneva, Switzerland (Guilio Cuccodoro); and the New Zealand Arthropod Collection, Auckland.

Systematic paleontology

Order Coleoptera Linnaeus, 1758
 Family Jacobsoniidae Heller, 1926
 Subfamily Derolathrinae Sen Gupta, 1979
 Genus *Derolathrus* Sharp, 1908

Derolathrus groehni new species
 Figures 1–3

Material.—Holotype, one completely preserved adult; GPIH no. 4570, coll. Gröhn no. 8052. Paratype, GPIH no. 4571, coll. Gröhn no. 8260.

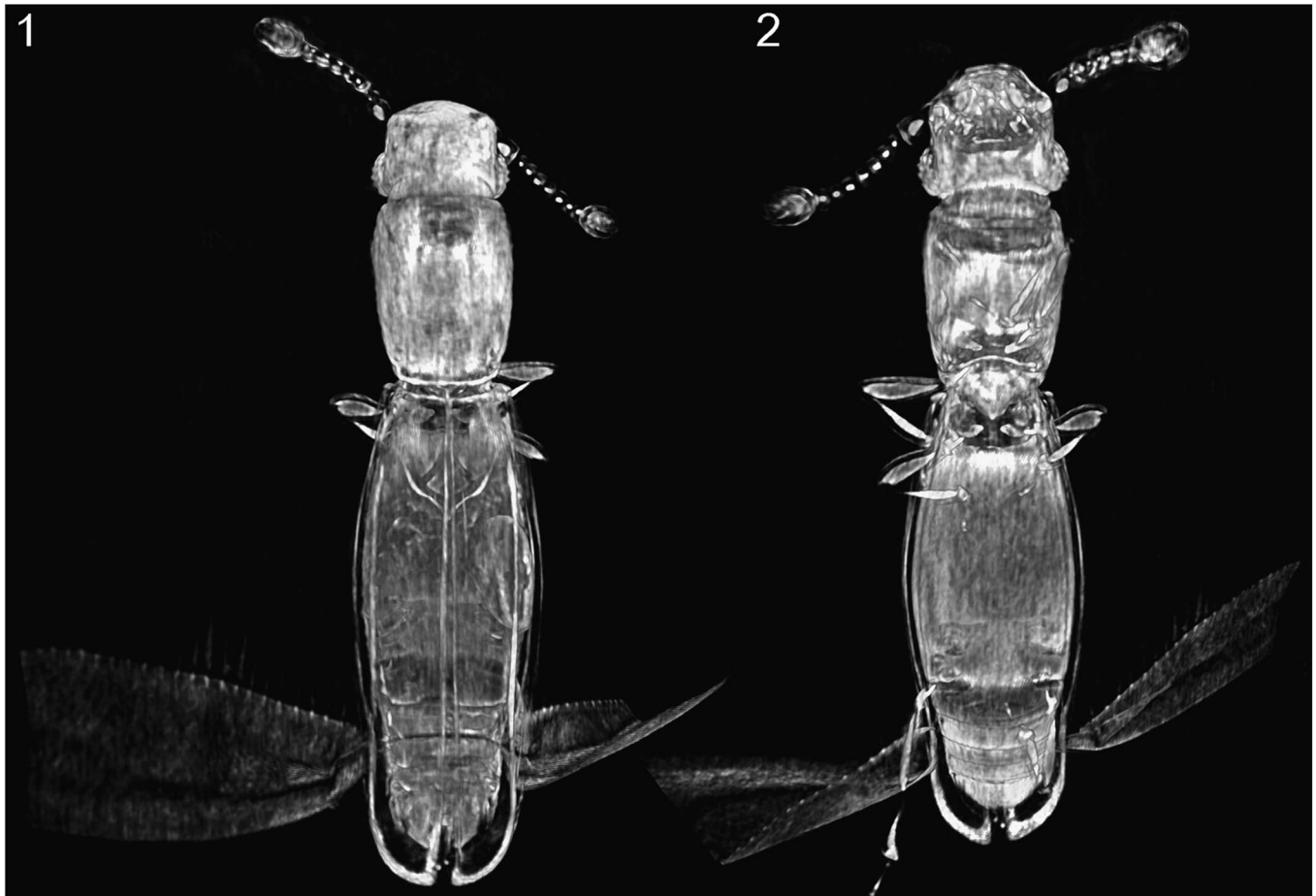


Figure 2. Micro-CT scan of *Derolathrus groehni* n. sp., holotype: (1) dorsal view, (2) ventral view.



Figure 3. *Derolathrus groehni* n. sp., paratype: (1) dorsal view, under normal light; (2) ventral view, under normal light; (3) dorsal view, micro-CT scan; (4) ventral view, micro-CT scan. Scale bars represent 200 μ m in (1) and (2).

Diagnosis.—Rugose microsculpture present on dorsal surfaces of head and pronotum, weaker microsculpture present on elytra; head with four aligned rows of small, non-setiferous punctures, temples well developed, vertex with a rim and lacking a basal fovea; eyes large, each eye with about 15 ommatidia; club 1-segmented with distinct sensory area about half the length of the club; pronotum about 1.4 times as long as wide and weakly constricted at base, disc with fine, dense, non-setiferous punctures and an elongate longitudinal median groove; elytra with nearly complete sutural striae, discal striae absent; hind wings well developed; abdominal ventrite I distinctly longer than ventrite II.

Occurrence.—Baltic amber, middle Eocene (ca. 37–54.5 Ma; Ritzkowski, 1997).

Description.—Body 0.90 mm long. Shape subcylindrical, dorsoventrally compressed, narrowly elongate (Fig. 1). Body color dark brown; surface mostly shiny with dorsal and ventral surfaces punctate and rugose microsculpture present on dorsal surfaces of head and pronotum.

Head oval, slightly deflexed, 0.18 mm long, broadest across eyes, 0.15 mm wide, distinctly constricted behind eyes with well-developed temples; dorsally covered with four longitudinally aligned rows of small non-setiferous punctures (Fig. 4.1); ridge on vertex, basal fovea absent. Labrum small, deflexed. Mandibles

small. Maxillary palps with apical palpomere aciculate, penultimate palpomere larger, swollen. Gular sutures not visible. Eyes large, laterally protruding; their diameter slightly longer than the distance from their anterior margin to antennal insertion; consisting of about 15 ommatidia. Antenna with 10 antennomeres; basal antennomere and antennal insertion concealed from above; antennomere 2 elongate, distinctly wider than antennomere 3, about two times as long as antennomere 3; antennomeres 3–8 moniliform; club 1-segmented with distinct sensory area about half the length of the club and demarcated by a visible rim.

Prothorax as wide as head, 0.22 mm long and 0.16 mm wide, about 1.4 times as long as wide, narrower than elytra, widest in anterior third, tapering weakly to hind margin, which is narrower than anterior margin and weakly constricted at base; dorso-lateral edge with complete carina; pronotum covered with a few short setae; disc with shallow longitudinal median groove (Fig. 4.1, 4.2); prosternum broad, weakly punctate; prosternal process long, with rounded apex slightly extending beyond globular. Mesoventrite densely punctate, process broad, apex rounded between mesocoxal cavities (Fig. 4.4). Mesocoxae globular, slightly closer than procoxae. Metaventrite about 3.5 times as long as mesoventrite, slightly convex, without discrimin. Metacoxae widely separated. Trochanters large, trapezoidal, gradually widened to apex. Femora slender and robust. Tibiae gradually widened to apex, apical spurs not

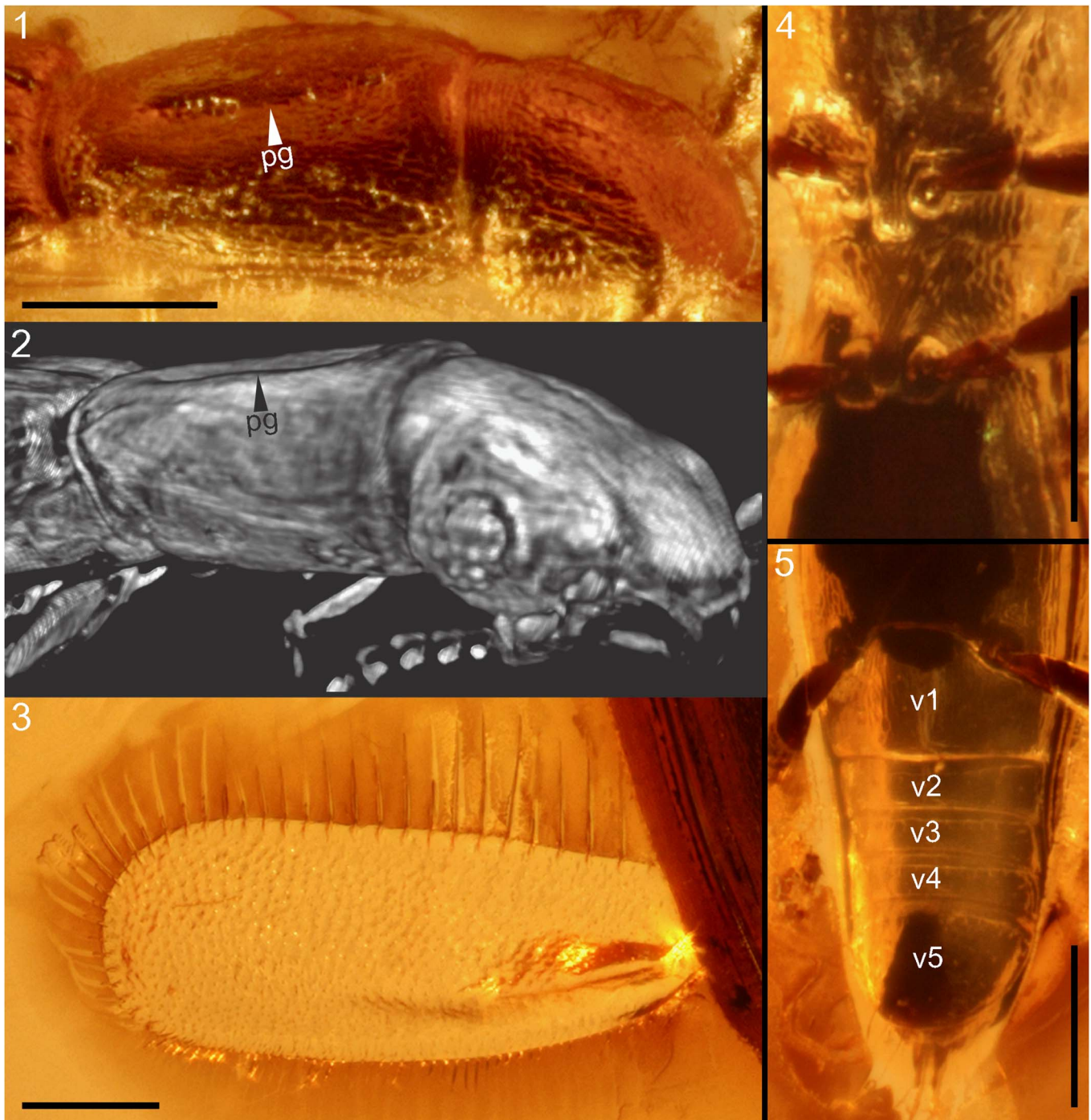


Figure 4. Enlargements of *Derolathrus groehni*. (1) Head and pronotum of holotype, showing the longitudinal median pronotal depression; (2) same as (1), showing pronotal depression; (3) left hind wing of holotype, showing setae surrounding its distal and posterior margins; (4) pro- and mesothorax of paratype, showing separated pro- and mesocoxae and well-developed prosternal and mesoventral processes; (5) abdomen of holotype, ventral view, showing elongate abdominal ventrite 1. pg, pronotal groove; v, ventrite. Scale bars represent 100 μm .

visible. First and second tarsomeres short, minute; third tarsomeres elongate, widened to apex, longer than the first two combined. Pretarsal claws long. Mesoscutellum not visible.

Elytra 0.52 mm long, broadest nearly at middle, each 0.11 mm wide, apices rounded; elytral striae present only as nearly complete sutural stria (discal striae absent), originating from pit near inner apical margin; surface with short setae in vague longitudinal rows; elytral epipleura, narrow, long,

ending at middle of ventrite 3. Hind wings (Fig. 4.3) large, venation highly reduced; ventral margin and apex with about 35 long hairs.

Abdominal ventrites I and V longer than ventrites II–IV (Fig. 4.5); ventrite I not connate with metaventrite, with suture distinct, about two times as long as ventrite II; ventrites 2–4 almost of same length; surface with a few short setae. Female genitalia with elongate coxites and styli.

Etymology.—The specific epithet is a patronym formed from the surname of Carsten Gröhn, recognizing his kind support of our study.

Remarks.—*Derolathrus groehni* is easily distinguished from the micropththalmic (small-eyed) and apterous species *D. anophthalmus* Franz (Canary Islands) by the well-developed eyes and presence of hind wings. *Derolathrus groehni* is easily separated from the *D. parvulus* Rücker (Madeira) and *D. troglophilus* Sen Gupta (Fiji) by the well-developed eyes with about 15 ommatidia each; from *D. atomus* (Hawai'i) and *D. ceylonicus* Sen Gupta (Sri Lanka) by having a well-developed longitudinal median groove (or depression) on the pronotum; from *D. sharpi* Grouvelle (Guadeloupe) by the absence of prothoracic dorso-lateral ridges and the presence of wrinkled microsculptures on pronotum; and from *D. insularis* Dajoz (Mauritius) by the presence of a well-developed mesocoxal process and a remarkably long abdominal ventrite I. The new species is very similar to the recently described species *D. cavernicolus* Peck; they both have relatively large eyes and a median longitudinal depression on the pronotum. However, *D. groehni* can be distinguished from *D. cavernicolus* by the shape of the pronotum, the free abdominal ventrite I which is not fused to the metaventrite and details of the punctuation (absence of densely scattered large setiferous punctures on head) and form of the median pronotal groove (in *D. groehni* the groove is longitudinal and straight whereas it is Y-shaped or subtriangular in *D. cavernicolus*). In addition, Lawrence and Leschen (2010) mentioned an unnamed *Derolathrus* species from New Zealand that has a basal fovea on the vertex of the head but also differs from *D. groehni* by having smaller eyes, having a shorter prothorax that lacks a median longitudinal groove on the pronotum, and a much shorter abdominal ventrite I.

Discussion

These fossil beetles are easily placed in the family Jacobsoniidae based on their distinctive small body size, elongate body shape, and more importantly, the greatly elongated metathorax combined with the relatively short abdomen and extremely slender metanepisterna, which are potential synapomorphies of Jacobsoniidae (Lawrence and Leschen, 2010). Another possible jacobsoniid synapomorphy (Lawrence and Leschen, 2010) is the wing structure with reduced venation and very long fringe hairs (as seen in the holotype of the new species), a feature also present in some staphylinoids (Crowson, 1960) to which jacobsoniids may be related (see Introduction). Among the three known jacobsoniid genera (*Derolathrus*, *Sarothrias*, and *Saphophagus*), the new fossil species can be readily excluded from *Saphophagus* by the three-segmented tarsi (tarsal formula 5–5–5 in *Saphophagus*) and abdomen with five free ventrites (basal two ventrites connate in *Saphophagus*); from *Sarothrias* by the well separated and broadly open procoxal cavities (contiguous and closed in *Sarothrias*) and the presence of a distinct antennal club (the club is not distinct in *Sarothrias*; e.g., Ślipiński and Löbl, 1995). These Eocene fossils can be attributed to the extant genus *Derolathrus* by the following combination of characters: body minute (less than 1 mm in length) and narrowly elongate, prothorax elongate and

posteriorly narrowed, mesoscutellum not visible, tarsal formula 3–3–3, and with a highly distinctive metaventrite as long as all five visible abdominal ventrites combined (Peck, 2010).

Members of *Derolathrus* have been collected in various parts of the world, but are particularly common in warmer areas (Lawrence and Leschen, 2010; Peck, 2010) with the only cool-temperate populations of the genus occurring in New Zealand (ranging from the northern portion of the North Island southward to Codfish Island; Leschen, personal observation). Like most modern *Derolathrus* species, *D. groehni* probably lived in a warm climate, since many other thermophilic insects are present in Baltic amber, including Embioidea, and warm-adapted lineages of other groups (e.g., Mantodea, Phasmatodea, etc.; Archibald and Farrell, 2003).

The widespread distributions of at least two species of *Derolathrus* have been attributed to either natural dispersal or accidental introductions (Peck, 2010). The hind wings of *D. groehni* and other flight-capable *Derolathrus* with a reduced surface area and a fringe of setae are like those that have repeatedly evolved in other minute insects, including many beetles like ptiliid beetles that have a fossil history dating to the Cretaceous (e.g., Shockley and Greenwalt, 2013). Instead of flapping their wings, these “featherwinged” insects may be “rowing” their wings, which is an adaptation to flight at low Reynolds numbers (Walker, 2002). The wing morphology implies that *D. groehni* was also probably capable of long-distance dispersal and might have been widely distributed in the Eocene. Meanwhile, a detailed comparative study of *Derolathrus* may help to determine more about the biology of the group, especially with regard to dispersal capability and how these minute beetles are able to colonize oceanic islands.

To date, no fossil representatives of Jacobsoniidae are known. Our discovery of a new *Derolathrus* species from 37–54.5 million years ago represents the sole fossil record for this small family, providing information about the morphological evolution of the group. It not only extends the geographical distribution of the Recent genus *Derolathrus*, but also will serve as a valuable calibration reference for future DNA-based phylogenetic studies.

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