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New data on the taxonomy and distribution of Philippine Ochodaeidae
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(Coleoptera: Scarabaeoidea)

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New data on the taxonomy and distribution of Philippine Ochodaeidae and description of a new species from Central Visayas (Coleoptera: Scarabaeoidea)

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Abstract. The status of the taxon *Ceratochodaeus* Huchet, 2017 (Coleoptera: Scarabaeoidea), initially described as a subgenus of *Nothochodaeus* Nikolajev, 2005, is reconsidered and raised to generic level. New information on the distribution of *Ceratochodaeus eliotti* (Huchet, 2014), new combination, in the Philippine archipelago is provided. *Ceratochodaeus darlingi* Huchet, a new species from Negros island, Central Visayas (region VII), is described and illustrated.

Key words. Taxonomy, beetle, scarab, Ochodaeinae, Negros, Philippines.

Introduction

Lying in the western Pacific Ocean about 850 km off the southeast coast of Asia, the over 7,000 islands of the Philippine archipelago figure among the world's leading biodiversity hotspots with one of the highest rates of endemism in the world (Myers et al. 2000; Mittermeier et al. 2004). This rate is particularly remarkable within the order Coleoptera since, for the 7000 species listed for the archipelago, 79% are endemic (Baltazar 2001).

The first discovery of a representative of the family Ochodaeidae in the Philippines is relatively recent (Ochi 1990). This first new species was described from Luzon, the northernmost island in the archipelago. Since then, the study of material from Mindanao, the southernmost island, led me to describe three new species initially placed in the genus *Nothochodaeus* Nikolajev, 2004 (Huchet 2014a, 2014b, 2017). On the basis of several original morphological characteristics, a new subgenus named *Ceratochodaeus* Huchet, 2017, initially considered as a single endemic of Mindanao, was then proposed to accommodate some of these new species (Huchet 2017). The recent discovery of a representative of this new subgenus in Luzon (Huchet 2018) has shown that this endemic taxon had a much wider distribution than originally thought and that it probably occupies a large part of the archipelago. These hypotheses are reinforced here by the discovery of representatives of this subgenus in the central and eastern Visayas (respectively Negros and Leyte islands), both located in the central Philippines. The study of this material from the Visayas has proved interesting in more than one way by providing new data on the distribution of a species previously only known from Mindanao and by adding a new species from the island of Negros, described hereafter.

A detailed examination of this new material including all the species previously placed in the subgenus *Ceratochodaeus*, lead me herein to reconsider the status of this taxon and to propose to raise it to generic level. This reassessment will be detailed below.

Taking into account this taxonomic rearrangement, two distinct genera occur within the Philippines. Nevertheless, if the species placed in the genus *Ceratochodaeus* are morphologically very close, and very likely derived from the same lineage, both species of *Nothochodaeus* Nikolajev inhabiting the archipelago [namely *N. matsudai* (Ochi 1990) occupying the northern part of the Philippines (Luzon) and *N. mindanaoensis* Huchet, 2014, from the southernmost island] are revealed to be morphologically very different, suggesting a distinct evolutionary and/or biogeographical history. Some hypotheses have recently been proposed to understand the affinities of these two species with other continental taxa and their possible biogeographical origins (Huchet 2018).

Materials and Methods

Specimens and taxonomic material. The specimens described and mentioned in this study originated from the Royal Ontario Museum, Toronto, Canada (ROM), and compared with other Filipino species deposited in the Muséum national d'Histoire naturelle, Paris, France (MNHN) and in the author's private collection.

Genitalia treatment. After a whole removal of the abdomen to avoid any damage of the genital parts and other useful features, the genital apparatus was treated with 10% potassium hydroxide solution (KOH) to destroy and remove the unneeded soft tissues, disassociate the aedeagus from the genital segment (urite IX) and evidence the inner copulatory sclerites of the endophallus. The cleaned genital parts were then placed in 10% acetic acid to neutralize the effects of the KOH, rinsed with ethanol, and stored in a small glycerol vial, pinned under the specimen. Finally, the abdomen is replaced and maintained in anatomical position using a small drop of hydrosoluble glue.

Illustrations. Digital images of the habitus and genital parts were taken at the Entomology Department (MNHN, Paris) with a Canon E0S 6D digital camera (zoom MP-E 65 mm) mounted on a Kaiser RTx column. The z-stepper was controlled through the focus stacking software Helicon Remote 3.8.6w and images were processed using Helicon focus 6. The digital images were finally imported into Adobe Photoshop CS4 for post-processing, labeling and plate composition.

Taxonomic Treatment

Elevation of subgenus *Ceratochodaeus* Huchet, 2017 to generic rank

Ochodaeidae Mulsant and Rey, 1871

Ochodaeinae Mulsant and Rey, 1871

Nothochodaeini Nikolajev, 2015

Ceratochodaeus Huchet, 2017, new status

Ceratochodaeus Huchet, 2017, described as a subgenus of *Nothochodaeus* Nikolajev, 2005

Type species. *Nothochodaeus eliotti* Huchet, 2014, by original designation (Huchet 2017).

Etymology. From the Greek *keratos*, genitive of κέρασ (horn), combined with the root *Ochodaeus*, in view of the strong frontal horn in males.

Diagnosis. This genus, endemic to the Philippines, differs from the genus *Nothochodaeus*, to which it was previously considered as a subgenus, by the following characters: large size, greater than 10 mm, a strong and curved cephalic horn, truncated and excavated at the top in males, the apical truncation of variable shape depending on the species (see Fig. 1, 3, 6), pronotum very convex, strongly declivous forward, protibiae invariably quadridentate externally. As unique feature within the family, males of the genus *Ceratochodaeus* have a strong median spiniform process originating on the sternite IV and ending in a protruding "keel" at the sternite VII (depending on the species, this process is sometimes placed asymmetrically (generally on the left side, in ventral view), and flanked on either side by a strong hollow depression (see Fig. 8).

Unlike other Asian genera, such as *Nothochodaeus* Nikolajev, 2005 or *Mimochodaeus* Nikolajev, 2009, whose endophallus copulatory pieces consist of one to several tightly curved toothed sclerites or sclerotized setae, species of the genus *Ceratochodaeus* possess one or two strong main sclerites (ScP), tubular or not, always smooth, frequently associated with 2 to 3 accessory sclerites (ScA) of variable shape, without toothed or serrated edges.

The conformation of the trapezoidal interlocking mechanism located on the tergite VII (propygidium), the mesocoxae widely separated by the metasternal process, and finally the hind wing venation places this new genus within the Nothochodaeini Nikolajev, 2015.

Specific composition

With the new species herein described, the genus *Ceratochodaeus* now includes 4 species: *C. eliotti* (Huchet, 2014), new combination, from Mindanao and Leyte, *C. vulcanodon* (Huchet, 2017), new combination, from Mindanao, *C. montgomeryi* (Huchet, 2018), new combination, from Luzon and finally *C. darlingi* Huchet, new species from Negros.

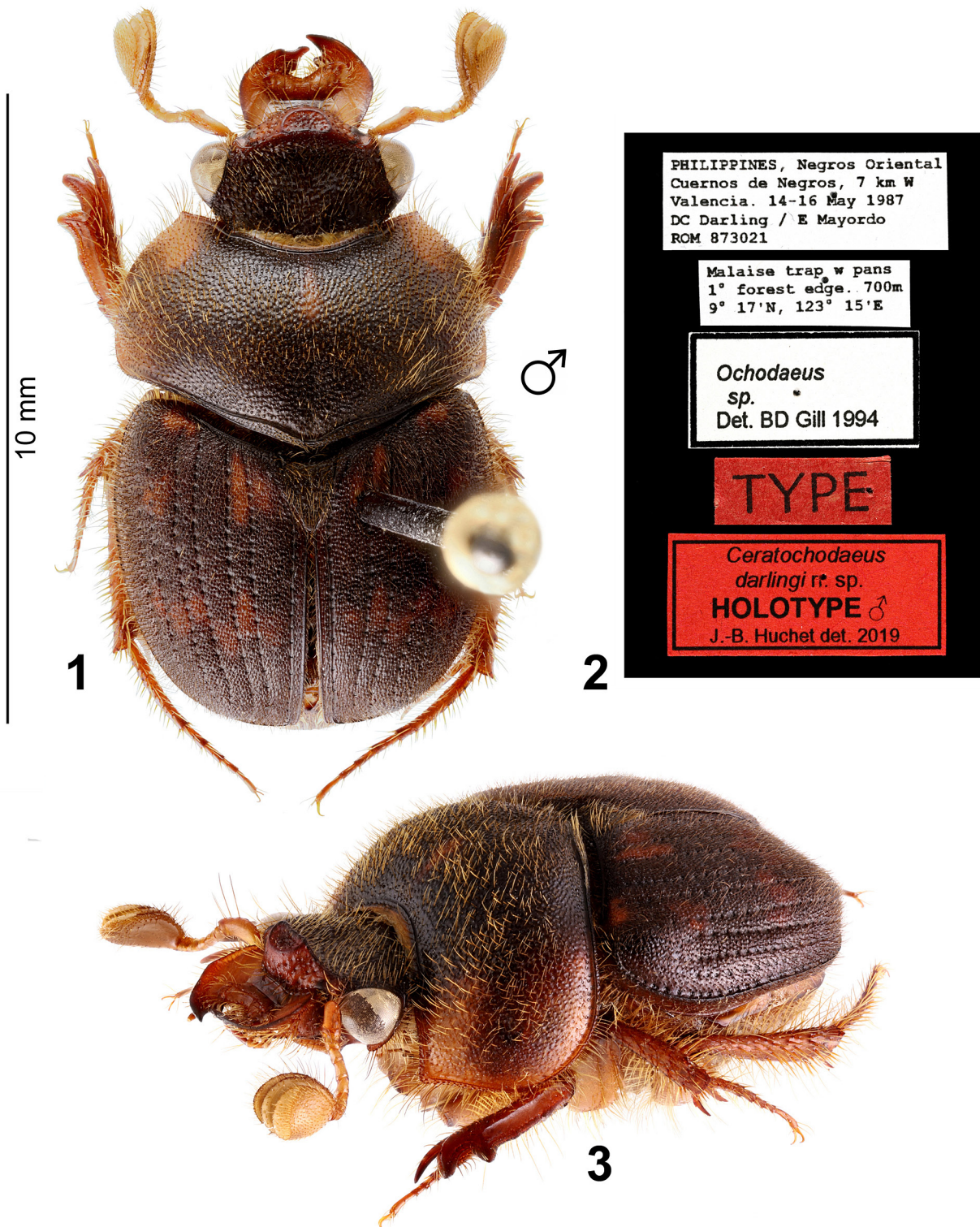
Ceratochodaeus darlingi Huchet, new species (Fig. 1–9)

Type material. Holotype male (ROM), labeled: a) “PHILIPPINES, Negros Oriental / Cuernos de Negros, 7 km W / Valencia. 14-16 May 1987 / DC Darling / E Mayordo / ROM 873021; b) “Malaise trap w pans / 1° forest edge. 700m / 9° 17'N, 123° 15'E; c) “*Ochodaeus* / sp. / det BD Gill 1994”; d) rectangular, red paper: “TYPE”; e) red paper: “*Ceratochodaeus* / *darlingi* n. sp. / HOLOTYPE ♂ / J.-B. Huchet det. 2019”. Genitalia stored in a small glycerol vial, pinned under the specimen.

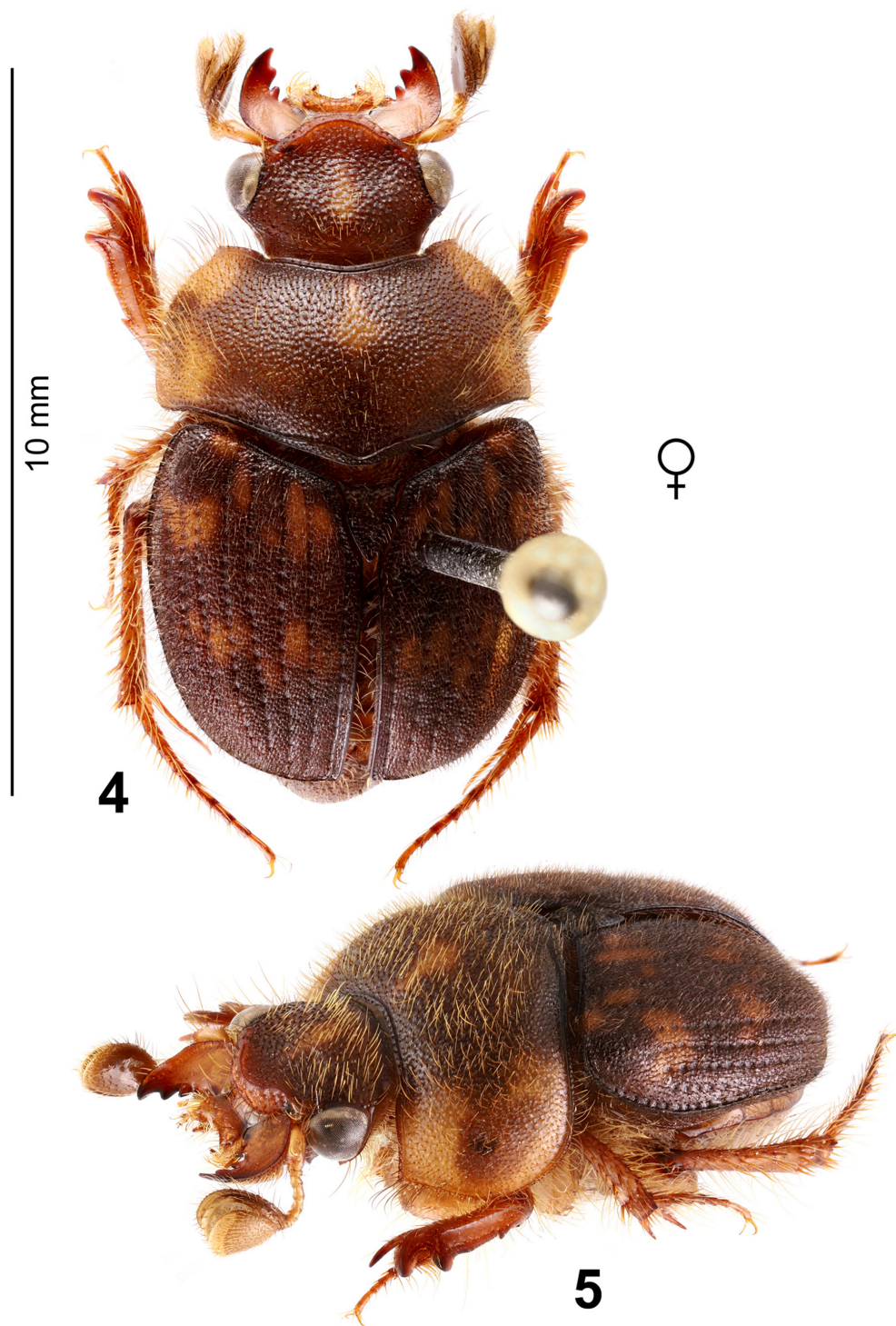
Allotype female (ROM) labeled a–c as holotype; d) “*Ceratochodaeus* / *darlingi* n. sp. / ALLOTYPE ♀ / J.-B. Huchet det. 2019”. (Fig. 4–5)

Diagnosis. This species has the body short, robust, strongly convex, and densely pubescent. It is predominantly dark reddish brown, but with orange-colored mandibles, clypeus, sides of the pronotum, anteromedian triangular patch on the pronotum, and two transverse elytral patches arranged in staggered rows. The underside and legs are orange-brown, and the antennae testaceous yellow. The stridulatory peg is present.

Description. Holotype male (Fig. 1–3, 6–9). Coleoptera: Scarabaeoidea: Ochodaeidae. **Length:** 10.6mm (from the apex of the mandibles to the apical part of the tergite VIII). **Width:** 5.9 mm. **Head:** Transverse, sub-hexagonal, dark reddish-brown, gradually narrowed behind the eyes. Surface shiny, long pubescent, the setae obliquely directed backwards; surface microreticulate with medium setiferous granules separated from each other by a distance substantially equal to their diameter. Labrum transverse, dorsally convex, hyaline, long pubescent, strongly emarginate in the middle front. Eyes large, globose, strongly produced laterad. Anterior clypeal membrane transverse, trapezoidal, in thin tegumentary plate overhanging the labrum. Frontoclypeus elevated, obliquely sloping forward, arched rearward, surmounted by a strong sub-pyramidal horn, abruptly truncated at apex. In upper view, the truncation delineates a transverse, concave, kidney-shape area (Fig. 6). Mandibles subequal, falciform, slightly concave dorsally, the apex and outer edge distinctly darkened. Mentum oblong, subquadrangular, emarginate and weakly depressed in front, the surface finely microreticulate, pubescent along the lateral margins (see Fig. 7). Antenna 10-segmented, 3-antennomere club, testaceous, shiny, the outer club segment distinctly brightened and pubescent at the upper edge. **Pronotum** transverse, strongly convex, the lateral edges and base fringed with setae, the outline entirely margined, the margin distinctly widening in the middle of the base forming a transverse bulge in a portion extending on both sides up to the level of the humeral callus. Anterior margin deeply emarginate behind the head, with a thin hyaline membrane in front. Front angles obtuse, projecting forward, the posterior ones regularly rounded. A short median longitudinal furrow at base, not reaching the middle forward. Pronotal surface densely granulate; granules shiny, setose, the setae obliquely directed anteriorly; surface shiny, bicolored, dark reddish brown with two orange-colored lateral areas and a distinct darkened fovea in the middle of each side; a longitudinal orange-colored medio-discal macule not reaching the anterior edge in front. **Elytra** transverse, their color coarsely similar to that of the pronotum with two rows of orange transverse patches. The first row located at the ¼ front, the second one located behind the middle (Fig. 1, 3). The anterior band extending from interstria II to VII, interrupted on interstria III. The second row, arranged in staggered orange spots, extending from interstria II to VII. Surface with well impressed striae, consisting of sunken medium points, separated by 1.5 to 2 x their diameter; elytral punctuation strong and tight consisting of small setose granules on a microreticulate background, the minute setae oriented backward. Humeral callus well developed; a second callus present in the apical declivity at the level of the 5th and 6th interstriae. Scutellum in elongated triangle, the lateral edges slightly convex, the surface with few scattered setose medium punctures. **Abdomen** strongly convex with six visible



Figures 1–3. *Ceratochodaeus darlingi* Huchet, new species, male holotype. 1) Habitus, dorsal view. 2) Labels. 3) Habitus, latero-dorsal view.



Figures 4–5. *Ceratochodaes darlingi* Huchet, new species, female allotype. **4)** Habitus, dorsal view. **5)** Habitus, lateral-dorsal view.

sternites (III–VIII). Surface smooth, with few scattered minute setose granules. The anterior margin of each sternite with a line of coarse granules bearing long setae, distant from each other by at least $1\times$ their diameter. A median process originating on the sternite IV as a convex bulge, extending backwards, ending acutely at the level of the penultimate sternite (sternite VII) (this feature is absent in females). This process, asymmetrical, is located, in ventral view, on the left side, flanked on either side by a strong longitudinal depression, this depression clearly more marked on the right side. Tergite VIII (pygidium) pubescent, the punctuation consisting of small close granules embedded on a microreticulate background. Metasternal process subplanar with a thin median darkened groove in the anterior half; mesocoxae widely separated. Stridulatory apparatus (sternite VI) present. **Legs:** Protibia quadridentate externally, the median tooth barely visible, the basal tooth very reduced; internal side with a strong acute pollex obliquely directed forward, darkened apically. Femurs without accessory teeth, their surface with two parallel rows of setose punctures. Upper spur of metatibia of equal length to that of the first metatarsus. **Genitalia:** Aedeagus with elongated phallobase, curved dorsoventrally, acuminate apically; parameres short, symmetrical, distinctly divergent at apex. Endophallus well developed with two main sclerites (Fig. 9) and two barely perceptible accessory sclerites.

Sexual dimorphism. As described for the genus, namely the presence, in males, of a strong frontoclypeal horn, truncated apically (Fig. 1, 3, 6) [the female with a single arched carina (Fig. 4–5)], the pronotum more convex dorsoventrally, and by the presence of a median abdominal apophysis acuminate posteriorly (absent in females).

Etymology. This taxon is dedicated to my colleague Christopher Darling, Royal Ontario Museum, Canada, who collected this new species on Negros Island.

Distribution. Philippines, Central Visayas, Negros Oriental (Fig. 10).

Both specimens were obtained from Malaise trap at a forest edge, an ecotone on ridge between a pristine valley and disturbed habitat (Fig. 11a, b).

Remarks. This new species is morphologically close to *Ceratochodaeus montgomeryi* from Luzon. The species differ by the shape of the apical truncature of the horn, kidney-shaped in *C. darlingi* **new species**, suboval with the outline distinctly sinuous in the middle of the front and basal margins in *C. montgomeryi*. Male protibiae slender in *C. darlingi*, distinctly broader and stout in *C. montgomeryi*. Finally, although both of very reduced size compared to other species of the genus (*C. eliotti* and *C. vulcanodon*), the endophallic sclerites of *C. darlingi* and *C. montgomeryi* are morphologically distinct.

Ecology. Little is known about the natural history of Ochodaecidae. Most species are nocturnal and strongly attracted to light, but sometimes also collected in ground traps containing beer or vinegar. In recent years, the systematic use of Flight Interception Traps (FIT) and Malaise traps has provided many specimens of species previously considered very rare and only represented in collections by a small number of individuals, or even by the single holotype. From the discovery of basidiomycete spores within the intestinal content of *Pseudochodaeus estriatus* (Schaeffer), Carlson and Ritcher (1974) suggested that these insects are mycophagous and feed upon hypogean fungi. The presence of numerous basidiomycete basidiospores within the intestinal contents of *C. darlingi* **new species** confirms herein the fungal habits of these insects.

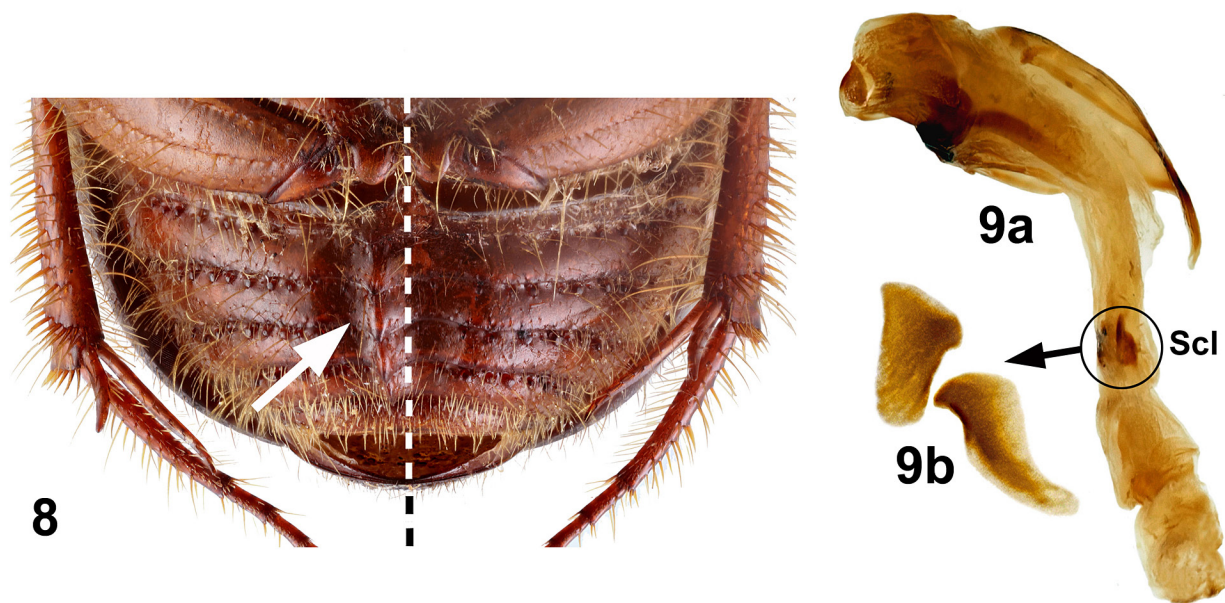
New data on the distribution of *Ceratochodaeus eliotti* (Huchet, 2014), new combination

Initially described from Mindanao, *C. eliotti* is known from several localities: Bukidnon, Cabanglasan (type locality), Mount Kalatungan, Dominorog and Lanao del Sur (Wao). Among the specimens originated from the Royal Ontario Museum, two males, collected in Leyte island at 7 km N of BayBay, Pangasugan (250 m), $10^{\circ}45'N / 124^{\circ} 50'E$, between 28–30 may 1987 (ROM 873055), could be indisputably related to this species (Fig. 12). Both specimens were collected using a Malaise trap placed on a slope, above a disturbed forest area actively logged and partially burned (Fig. 13).

From a biogeographic point of view, this interesting discovery testifies of close relationships between Mindanao and Leyte. As noticed by Racheli and Biondi (1989), the southern islands (Cebu, Leyte and



Figures 6–7. *Ceratochodaeus darlingi* Huchet, new species, male holotype. **6)** Head, dorsal view. **7)** Head, ventral view.



Figures 8–9. *Ceratochodaeus darlingi* Huchet, new species, male holotype. **8)** Abdomen in ventral view, the median acuminate process located on the ventrites indicated by an arrow, the median dotted line emphasizing the asymmetric location of the process. **9)** Male genitalia. **a)** Aedeagus in lateral-dorsal view, the inner sac not everted (Scl: endophallic sclerite). **b)** Close-up view of the two main sclerites of the endophallus.

Bohol) present a high faunistic affinity with Mindanao, while the northern ones (Mindoro, Panay, Samar and Negros) are more similar to Luzon. During the late Pleistocene period of low sea level (from 126,000 ($\pm 5,000$) to 11,700 years ago), many Philippine islands were more extensive, with groups connecting into larger islands. Mindanao, Samar, Leyte, and Bohol were all one island referred to Greater Mindanao and their faunal affinities to each other persist to this day (Heaney 1986; Heaney and Regalado 1998; Peterson et al. 2000).

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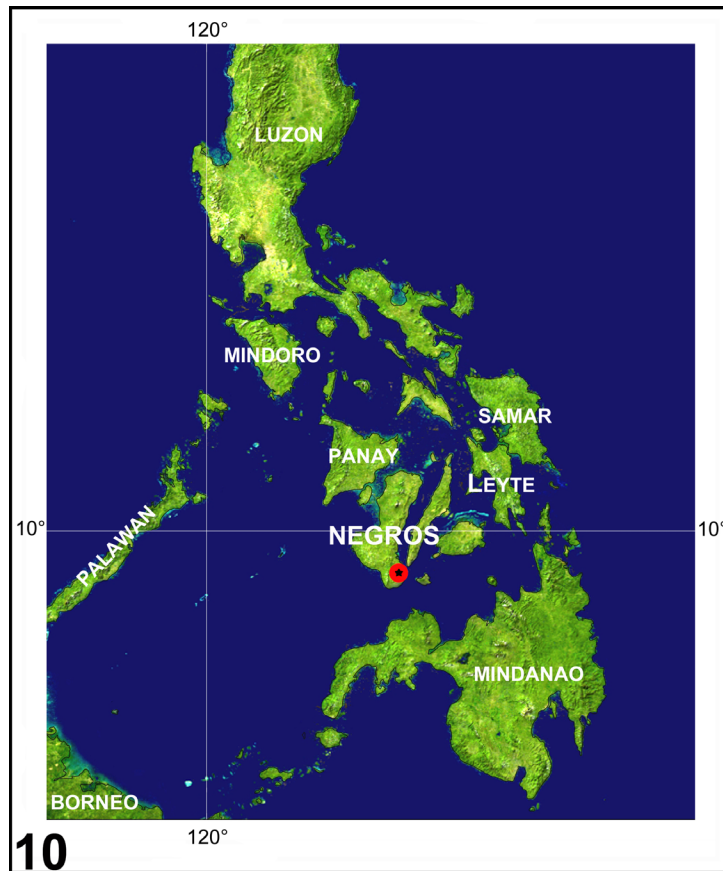


Figure 10. Location map showing the type locality of *Ceratochodaeus darlingi* Huchet, new species, on Negros island.



Figure 11. Type locality of *Ceratochodaeus darlingi* Huchet, new species, on Negros island. **a)** Malaise trap used for collecting the specimens. **b)** Malaise trap in front view, a local collector nearby (photos courtesy: C. Darling, ROM).



Figure 12. *Ceratochodaeus eliotti* (Huchet, 2014), male specimen from Leyte Island.



Figure 13. Collecting site of *C. eliotti* (Huchet, 2014) in Leyte (photo courtesy: C. Darling, ROM).