New taxa of Afrotropical Toktokkies (Coleoptera: Tenebrionidae: Molurina) from the Natural History Museum of Basel

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Abstract

Investigation of the darkling beetle (Tenebrionidae) specimens from the Natural History Museum Basel (Switzerland) resulted in the discovery of two new species of Afrotropical toktokkies (tribe Sepidiini). Both taxa provided novel morphological data which, in the light of previously acquired molecular evidence, challenged the taxonomic coherence of the genus Dichtha. To accommodate this information a new genus Bouchardium gen. nov. is hereby proposed. The three following species were assigned to this new genus: Bouchardium chillygonzalesi sp. nov. (type species), B. cubicum (Guérin-Méneville, 1845) comb. nov. (transferred from Dichtha), B. mariae sp. nov. The placement of Bouchardium within the subtribe Molurina is briefly discussed. Additionally, a new species of the genus Toktokkus (T. zofiae sp. nov.) is described from South Africa.

Key words: darkling beetles, Sepidiini, Natural History Museum Basel, species discovery

Introduction

Due to its worldwide coverage and taxonomic diversity, the Frey Beetle Collection—housed in the Natural History Museum Basel, Switzerland (NHMB)—constitutes one of the most important holdings of darkling beetle (Coleoptera: Tenebrionidae) specimens in the World (Sprecher-Uebersax et al. 2013). It contains entomological exemplars collected by prominent specialists such as Hans Gebien (1874–1947) and Carl Koch (1904–1970) (Schawaller 2018, 2020). It is also home to countless name-bearing type specimens concerning the family (e.g., Iwan 2002, Kamiński 2011, Kamiński et al. 2019). Furthermore, despite being relatively well studied, the collection still holds a vast amount of undescribed taxa. The specimens of the afrotropical tribe Sepidiini, informally referred to as toktokkies (Kamiński et al. 2019), constitute an especially good example. Namely, several undescribed taxa representing this group were labeled in the collection by Koch as new species but never officially introduced within the framework of zoological nomenclature.

Despite recent phylogenetic efforts (Kamiński et al. 2019, 2021, 2022, Gearner et al. 2022), the taxonomy of Sepidiini remains unsatisfactorily studied. This is reflected in the unstable nature of some of the most iconic genera representing this group, such as Psammodes Kirby, 1819, which was drastically revised due to recent verification of the type materials (see Kamiński et al. 2022). Several problems are linked to this state of things; however, the following two seem to contribute most importantly. Primarily, many of the over 1,000 species representing Sepidiini were described without consulting the type materials of the taxa introduced before. This created a chain of events, in which initial misidentifications became a foundation for subsequently introduced taxonomic decisions. At the species level, this contributed to the introduction of countless synonyms (Kamiński et al. 2019), while at the generic level, it led to the incoherence of the currently designated genera. Secondly, as revealed by Kamiński et al. (2021) for the genus Toktokkus Kamiński & Gearner, 2021, the observable morphological diversity of some lineages representing toktokkies is extremely hard to grasp within the species-level categories. This often leads to the taxonomic over-splitting of some populations and description of narrowly defined species/subspecies known from single collecting events.

As the type materials concerning toktokkies are dispersed throughout at least 59 institutions worldwide (Kamiński...
et al. 2019), a comprehensive treatment of all the species at once is currently challenging. Nevertheless, in light of the presently available molecular and morphological data (Kamiński et al. 2021, 2022, Gearner et al. 2021), partial generic revisions seem to be an efficient way of improving the overall taxonomy of Sepidiini. The primary long-term goal of the author is to propose well-distinguishable genera that will be the foundation for subsequent alpha taxonomic studies. The main driver for the present paper was the discovery of two new species tentatively assigned to the genus Dichtha Haag-Rutenberg, 1871. This newly identified material was used to test the coherence of the generic concept Dichtha. Additionally, a new species of Toktokkus has been identified and described below.

Material and methods

The specimens of the newly described species were identified within the Frey Beetle Collection in NHMB. However, a few additional specimens were found in the entomological collection of the Museum and Institute of Zoology Polish Academy of Sciences, Warsaw, Poland (MIZ PAN), and the private collection of Martin Lillig, Saarbrücken, Germany (MLPC). Additional reference material for the investigation presented below originated from several entomological collections of the world, such as the Ditsong Museum in Pretoria, South Africa, the Natural History Museum in London, United Kingdom, and the Muséum National d’Histoire Naturelle in Paris, France. A full list of investigated collections can be seen in Appendix S2 in Kamiński et al. (2021). Description style and morphological terminology follow that of Kamiński et al. (2022). Original label data for specimens are given in quotation marks and separated by a comma. Images were taken using a Canon 77D body with a Canon EF 100 mm macro lens. The distribution of species was illustrated using QGIS version 2.4. Distributional records for previously recognized species were taken from Kamiński et al. (2019, 2021) and https://www.inaturalist.org/ via GBIF. In the latter case only records with voucher photographs were selected (GBIF.org 2023). Country-level records were not mapped.

Taxonomy

Bouchardium gen. nov.

Type species. Bouchardium chillygonzalesi sp. nov.; here designated.

Diagnosis. The specific structure of the prosternum (elongate and projecting tip of prosternum, in lateral view, Figs 1A, 3F, K), elytra (presence of sharp lateral costae, Figs 1–3), and scutellum (apex with deep transverse grooves, Fig. 3A–C) place Bouchardium close to the following genera (Kamiński et al. 2021, Gearner et al. 2022): Amiantus Fåhraeus, 1870, Arturium Koch, 1951, Brachyphrynus Fairmaire, 1882, Dichtha, Distretus Haag-Rutenberg, 1871, Euphrynus Fairmaire, 1897, Glyptophrynus Fairmaire, 1899, Melanolophus Fairmaire, 1882, Phrynocolus Lacordaire, 1859, Phrynophanes Koch, 1951, and Physophrynus Fairmaire, 1882. Among these, Bouchardium displays the greatest affinity towards Distretus and Dichtha as all share a similar structure of elytra (sharply carinate humeral edge and flattened surface of elytra). Nevertheless, Bouchardium can be differentiated from all of the abovementioned genera, including Dichtha and Distretus, by a unique arrangement of pronotal punctures (sides of the pronotal disc with large, confluent punctures; center of the disc with small punctures, 4–5 diameters apart vs pronotal disc evenly covered with large sometimes confluent punctures—Figs 2A, F, 3D, F, G, I) and subquadrate shape of the body (frontal/posterior views) (Fig. 1C, 2C, D, 3E).

Notes. According to Kamiński et al. (2022), the morphology of female terminalia is relatively invariable within the ‘Dichtha clade’. All analyzed members of this grouping, including Bouchardium chillygonzalesi sp. nov., B. cubicum (Guérin-Méneville, 1845) comb. nov. and B. mariae sp. nov. possess 3-lobed ovipositors, where the merged lobes 1 (valvifer) and 2 are strongly emarginate basally. Proctigers were reported to be widely indented medially, while bursae were simple (no sclerites were detected) and accompanied by multibranched spermatheca. Finally, spicula ventrali were reported to be Y-shaped (Fig. 4C). Nevertheless, some variability of the apical coxites (c4 plates) has been recovered for different Bouchardium species. In particular, the c4 plates of the newly described B. chillygonzalesi sp. nov. are relatively short and only slightly projected above the outline of the c3 plate (Fig. 4A, B). In the case of B. cubicum and B. mariae sp. nov. the c4 plates are elongated (Fig. 4D).

The aedeagal morphology is relatively invariable within the subtribe Molurina (Kamiński et al. 2021). Up
to now, the shape of male terminalia has not been used for diagnostic purposes at the species or generic levels. Morphology of aedeagal tegmen and spiculum gastrale of Bouchardium mariae sp nov. is illustrated in Fig. 2I, J. Present investigation did not reveal any substantial differences in male terminalia morphology between that species and its other congeners.

**Distribution.** Botswana (Eastern part of the Country), Mozambique, South Africa (Provinces: Gauteng, Limpopo, Mpumalanga, North West), Zimbabwe (Southern part of the Country) (Fig. 5).

**Etymology.** This genus is named in honor of Dr. Patrice Bouchard (Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, Ottawa, Ontario, Canada), a specialist in Tenebrionidae and zoological nomenclature in gratitude for his professional support during the first years of my career.

**Species included** (3). B. chillygonzalesi sp. nov., B. cubicum (Guérin-Méneville, 1845) comb. nov., B. mariae sp. nov.

**Key to the species of Bouchardium**

1. Prosternal process with elongate appendages (Fig. 1E). Elytral disc relatively narrow leaving sides of the epipleura exposed in dorsal view (Fig. 1B). Ovipositor with short c4 plates (not extending beyond the tip of c3) (Fig. 4A, B) .................................................. B. chillygonzalesi sp. nov.
2. Prosternal process rounded (in lateral view) (Fig. 2G). Elytral disc relatively wide covering sides of epipleura in dorsal view (Fig. 1B). Ovipositor with elongate c4 plates (extending beyond the tip of c3) (Fig. 4D)  .................................................. B. cubicum comb. nov.
3. Elytra entirely black. Elytral disc relatively flat (Fig. 3E) .................................................. B. mariae sp. nov.

**Bouchardium chillygonzalesi** sp. nov. (Figs 1, 4A, B, 5)


**Diagnosis.** Due to the similar color pattern of elytra (presence of two red stripes along the sides of the disc) this new species superficially resembles Bouchardium mariae sp. nov. (see diagnosis below). Nevertheless, Bouchardium chillygonzalesi sp. nov. can be distinguished from all its congeners by the presence of posteriorly projecting appendages on the prosternal process (Fig. 1E) and by having short c4 plates of ovipositor, which do not extend beyond the tip of c3 (Fig. 4A, B).

**Description.** Length 20.0–24.0 mm, width of pronotum 5.0 mm, and elytra 10.0–13.0 mm.

Head: Hypognathous. Frorns finely punctate (~6 diameters apart); frontoclypeal suture coarse, presenting as deep groove in middle; apical clypeal margin not emarginate; labrum coarsely punctate laterally with shallow groove along apical margin bearing yellow, acuminat setae. Eyes comma-shaped, with ventral portion reduced, strongly emarginate around epistomal base. Antennae slender, relatively short (only slightly reaching beyond base of pronotum), bearing acuminat yellow setae; length of antennomere 2 equal to ~0.2 of antennomere 3; length of antennomere 4 about 0.6 of length of antennomere 3. **Prothorax:** Pronotum laterally with coarse, confluent punctures; widest in anterior half. Disc dull, finely punctate (4–5 diameters apart); anterior angles slightly produced. Hypomeron convex, dull, and impunctate. Prosternal process with pair of appendages, with wide bordering (ventral view). **Pterothorax:** Scutellum apically covered with dense setation. Elytra widest in half, disc relatively flat, sharply angled below margin; disc brown, impunctate, without tubercles; edges of disc red, with corrugated borders. Elytral slope steep, impunctate, elytral apex rounded. Epipleura impunctate and without tubercles, clearly differentiated from neighbouring portion of elytra and encircling ventrite 5. Lateral regions of metaventrite (between coxae) extremely short. Metaepisternal suture abbreviated posteriorly. **Legs:** Densely covered in golden setae, slender. Tarsi narrow, covered with golden setation. **Abdomen:** Ventrites 1–4 extremely finely and sparsely punctate laterally (>5 diameters apart); ventrite 5 with denser and coarser punctuation (3–4 diameters apart).
**Etymology.** This species is named in honor of Jason Charles Beck (20 March 1972)—professionally known as Chilly Gonzales—Grammy-winning pianist and composer from Canada.

**Distribution.** South Africa (Provinces: Gauteng), Zimbabwe (Fig. 5).

*Bouchardium mariae* sp. nov.
(Figs 2, 4C, 5)


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**FIGURE 1.** Morphology of *Bouchardium chillygonzalesi* sp. nov. (holotype). Lateral (A), dorsal (B), posterior (C), and ventral (D) views of the body; prosternal process (E); epipleuron (F); label (G). Arrow indicates edge of epipleuron.

**FIGURE 2.** Morphology of *Bouchardium mariae* sp. nov. (holotype and paratype). Lateral (A), dorsal (B), frontal (C), posterior (D), and ventral (E) views of the body; pronotum (F); prosternal process (G); label (H); aedeagal tegmen (I); spiculum gastrale (J).

**Diagnosis.** Due to the similar color pattern of elytra (presence of two red stripes along the sides of the disc) this new species resembles *Bouchardium chillygonzalesi* sp. nov. These two species can be easily distinguished by the different structure of prosternal process (rounded in lateral view in *B. mariae*; with appendages in *B. chillygonzalesi*—Figs. 1E, 2G). Furthermore, both species differ in the elytral shape and structure (elytra wide with almost smooth borders of the disc in *B. mariae*, elytra narrow with corrugated disc borders in *B. chillygonzalesi*—
Besides the different coloration of elytra, *B. mariae* differs from *B. cubicum* by having a more prominently convex elytral disc (Figs 2, 3E–F).

**FIGURE 3.** Morphology of selected species representing ‘Dichtha clade’: *Bouchardium cubicum* (A, D–F), *Amiantus gibbosus* Fåhraeus, 1870 (B), *Bouchardium mariae* (C), *Dichtha inflata* (Gerstaecker, 1854) (G, H), *Dichtha quedenfeldti* Kolbe, 1886 (I, J), *Distretus* (*Perdistretus*) *mormolyce* Koch, 1953, holotype (K). Pronotum (D, G, I); posterior (E, H, J), lateral (F), and ventral (K) views of the body.

**Description.** Length 19.0–25.0 mm, width of pronotum 7.0 mm, and elytra 12.0–14.0 mm. **Head:** Hypognathous. Frons finely punctate (~6 diameters apart); frontoclypeal suture coarse, presenting as deep groove in middle; apical clypeal margin not emarginate; labrum coarsely punctate laterally with shallow groove along apical margin bearing yellow, acuminate setae. Eyes comma-shaped, with ventral portion reduced, strongly emarginate around epistomal base. Antennae slender, elongate (reaching beyond base of pronotum), bearing acuminate yellow setae; length of antennomere 2 equal to ~0.2 of antennomere 3; length of antennomere 4 about half antennomere 3. **Prothorax:** Pronotum laterally with coarse, confluent punctures; widest in anterior half. Hypomeron convex, dull, and impunctate. Prosternal process rounded in lateral view, with wide bordering (ventral view). **Pterothorax:** Scutellum apically covered with dense setation. Elytra widest in basal third, disc convex, sharply angled below margin; disc black, impunctate, without tubercles; edges of disc red. Elytral slope steep, impunctate, elytral apex rounded. Epipleura impunctate and without tubercles, clearly differentiated from neighbouring portion of elytra and encircling ventrite 5. Lateral regions of metaventrite.
(between coxae) extremely short. Metaepisternal suture abbreviated posteriorly. Legs: Densely covered in golden setae, slender. Tarsi narrow, covered with golden setation. Abdomen: Ventrites 1–4 extremely finely and sparsely punctate laterally (>5 diameters apart); ventrite 5 with denser and coarser punctuation (3–4 diameters apart).

**Etymology.** This species is named in honor of my daughter, Maria Antonina Kamińska, born on June 9, 2016 (Warsaw, Poland).

**Distribution.** Botswana, South Africa (Provinces: Gauteng), Mozambique, Zimbabwe (Fig. 5).

**FIGURE 4.** Morphology of female terminalia within the genus *Bouchardium* gen. nov. *Bouchardium chillygonzalesi* sp. nov. (A, B), *B. mariae* sp. nov. (C), *B. cubicum* (D). Ovipositor (A, B, D), spiculum ventrale (C). **Abbreviations:** c- coxities, c2-c4- subsequent lobes of coxities, v- valvifer, ip- inner plate of paraprocts, op- outer plate of paraprocts, pa - paraprocts.

*Toktokkus* Kamiński & Gearner, 2021

**Notes.** The most recent taxonomic contributions concerning *Toktokkus* were published by Kamiński et al. (2021), Gearner et al. (2022), and Kamiński (2022).

Toktokkus zofiae sp. nov.
(Fig. 6A–F)


Diagnosis. The species is most similar to T. herero Gearner, 2021 by having prominent punctures on the pronotal disc and a golden setation of the elytral disc (Kaminski et al. 2021). Both species can be distinguished by different body size (T. zofiae: 18.5 mm, T. herero: 23.0–25.0 mm), basal margination of pronotal disc (T. zofiae: complete, T. herero: interrupted in the middle) (Fig. 6D), structure of prosternal process (T. zofiae: rounded in lateral view, T. herero: angular in lateral view) (Fig. 6H, E), and tuberculation of elytral disc (T. zofiae: microtubercles present, T. herero: microtubercles absent) (Fig. 6A, G).

Description (based on holotype). Length 18.5 mm, width of pronotum 7.0 mm, and elytra 11.0 mm.

Head: Hypognathous. Frons finely and irregularly punctate; frontoclypeal suture coarse, with deep groove in middle; apical clypeal margin broadly shallowly emarginate; clypeus projected toward front of body. Eye comma-shaped, with reduced ventral part, strongly emarginate around epistomal base; with deep groove on temporal side. Mentum and submentum missing due to dermestid damage. Antennae broken off at level of 4th segments; slender, moderately covered in recumbent acuminate goldish setae; antennomere 2 short, equal to 0.2 of antennomere 3 length; antennomere 4 about half of antennomere 3 length.
FIGURE 6. Morphology of *Toktokkus zofiae* sp. nov. (holotype) (A–F) and *T. herero* (G, H). Lateral (A), dorsal (B), and ventral (C) views of the body; pronotal disc (D), prosternal process (E, H); label (F); and elytral disc (G).

**Prothorax**: Pronotal lateral margin rounded, well visible. Pronotum widest above middle. Disc dull, finely punctate (4–5 diameters apart); anterior and basal margins complete, anterior apices slightly produced. Hypomeron convex, without submarginal groove, impunctate. Prosternal process rounded in lateral view, longitudinally depressed in middle (ventral view). Anterior margin of prosternum straight, with gold setae.

**Pterothorax**: Scutellum densely covered with microtubercles. Elytra widest in half, slightly rounded, covered in scattered gold setae; covered with dense tubercles (1–3 diameters apart) and microtubercles (2–4 diameters apart). Laterally situated tubercles very pronounced. Elytral slope relatively steep, elytral apex flattened. Epipleura impunctate, not tuberculated, clearly distinguishable from neighbouring portion of elytra, widely enfolding fifth ventrite. Mesoventrite with deep median groove and elevated sides. Metaventrite impunctate, densely setose. Lateral regions of metaventrite (between coxae) extremely short. Metaepisternal suture abbreviated posteriorly.

**Legs**: Covered with dense gold setae. Procoxa exposed basally. Apex of protibia with denticle on outer margin, lateral carina terminating in basal third. Spurs on meso- and metatibiae of equal length. Tarsi narrowed laterally.

**Abdomen**: Ventrites 1–3 medially covered with goldish setae, moderately punctate (2–3 diameters apart) and weakly rugulose; ventrites 4–5 finely punctate (1–3 diameters apart); ventrite 5 without submarginal sulcus.

**Terminalia**: Due to scarcity of materials, terminalia were not dissected. Nevertheless, the tip of the ovipositor was visible on the analyzed specimen. The morphology of coxites is consistent with the bauplan reported for the genus (Kamiński et al. 2021).

**Etymology**: This species is named in honor of my daughter, Zofia Irena Kamińska, born on November 3, 2018 (Flagstaff, USA).

**Distribution**: South Africa—only known from the type locality (Gemsbok Pan).
Discussion

While introducing the classification of the tribe Sepidiini, Koch (1955) designed an informal grouping of genera among the subtribe Molurina, which he referred to as ‘Phrynocoloid Molurina’. According to his definition, the members of this lineage were united by a specific structure of the prosternum (collar-like covering postgenal to mental portions of the head) and elytra (primary costae sharp to dentate). Although taxonomically limited, the recent studies of Kamiński et al. (2021) and Gearner et al. (2022) provided molecular support for the existence of this phylogenetic lineage within Molurina. The authors revised Koch’s morphological definition by noticing that all of the members of the grouping share a unique structure of scutellum (apex with deep transverse grooves—Fig. 3A–C). On the other hand, the presence of sharp/dentate costae has been excluded from diagnostic features as it was proven to be variable among the genera. The lineage has been renamed and referred to as the ‘Dichtha clade’. According to Kamiński et al. (2021), the following genera constitute this grouping: Amiantus, Arturium, Brachyphrynus, Dichtha, Distretus, Euphrynus, Glyptophrynus, Melanolophus, Phrynocolus, Phrynophanes, and Physophrynus. The total diversity is estimated to exceed 125 species and subspecies (Kamiński et al. 2019).

Contrary to the morphological definition of the ‘Dichtha clade’ itself, the diagnostic features of many of the genera representing this grouping remain blurry (Wilke 1921, Koch 1951, 1955, 1956, 1962, Mal 2005), potentially indicating the non-monophyletic nature of some of them. Such assumptions were also preliminarily supported by the already published molecular data. Namely, the analysis conducted by Kamiński et al. (2021) revealed the polyphyly of the genus Dichtha. In particular, Amiantus octocostatus Péringuey, 1886 and Dichtha inflata (Gerstaecker, 1854) (type species of the genus) were clustered together, while the morphologically distinct Dichtha cubica was recovered as a separate lineage. Up to now, Dichtha was defined by having parallel sides of elytra (Fig. 3B, E, G), flat elytral disc (not covered with costae), and smooth scutellum of a particular shape (Fig. 3A–C) (Haag-Ruthenberg 1871, Robiche 2013). Nevertheless, previous authors noticed the morphological distinctiveness of Dichtha cubica, which was the only species of the genus having the subquadrate shape of elytra (Robiche 2013) (Fig. 3E).

The discovery of two new species (i.e., B. mariae sp. nov., B. chillygonzalesi sp. nov.), which in many aspects closely resemble Dichtha cubica, revealed that some of the previously observed apomorphies (subquadrate body shape—Figs 1–2, laterally punctured pronotal disc—Fig. 2A, 3F) for this species are present in a wider group of taxa. Taking into consideration the molecular (Kamiński et al. 2021) and morphological distinctiveness of this grouping, it is hereby designated as a new genus Bouchardium. Although this taxonomic decision clarifies only a small portion of the total species diversity of ‘Dichtha clade’, it constitutes the first step towards larger revisionary work. The generic affiliation of the remaining species of Dichtha (D. inflata (Gerstaecker, 1854), D. modesta Robiche, 2013, D. transvalica Brancsik, 1914, and D. quedenfeldti Kolbe, 1886) is temporarily sustained. However, it is possible that such grouping remains paraphyletic in regards to Amiantus and/or Distretus.

The discovery of the new species of the genus Toktokkus (i.e., T. zofiae sp. nov.) within the Frey Beetle Collection, might indicate that, regardless of the recent revisionary efforts, the taxonomy of this genus is still insufficiently studied (Kamiński et al. 2021, Gearner et al. 2022, Kamiński 2022). The newly described species represents a well-diagnosable entity that, together with T. herero, represents a previously unrecognized lineage of the genus.

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References
