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Research article

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Taxonomic revision of the *Canthidium* Erichson, 1847 species of the *gigas* group (Coleoptera, Scarabaeidae, Scarabaeinae)

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Abstract. The *gigas* species group of the subgenus *Canthidium* (*Neocanthidium*) is defined and described. This species group is composed of three described species [*C. gigas* Balthasar, 1939, Brazilian Atlantic Forest, including intrusions into Cerrado, *C. bokermanni* (Martínez *et al.*, 1964), Chaco and western Cerrado in Brazil, Bolivia, Paraguay, and Argentina, and *C. kelleri* (Martínez *et al.*, 1964), Brazilian Cerrado and neighbouring open areas] and three new species: *Canthidium stofeli* sp. nov. from the western and southern regions of the Brazilian Amazon, *Canthidium feeri* sp. nov. from French Guiana, and *Canthidium ayri* sp. nov. from the Brazilian Atlantic Forest. We present descriptions and redescriptions, illustrations, an identification key and comments on the distributions of the species of the *gigas* group.

Keywords. Dung beetles, taxonomy, new species, South America, Neotropical region.

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Introduction

The genus *Canthidium* Erichson, 1847 is diagnosed by the presence of nine-articulated antennae with a pubescent club; cylindrical labial palpi; ventral clypeal process usually absent, if present in the form of one longitudinal carina; mesoventrite very short; metaventrite usually simply convex; and dilation of meso and metatibia with a curved inner margin and an more or less straight outer margin in ventral view (Vaz-de-Mello *et al.* 2011). *Canthidium* is currently subdivided into two subgenera, *Canthidium* s. str. and *Neocanthidium* Martínez & Halffter, 1986, with some species not presently assigned to any subgenus (see Cupello 2018).

Since its original description (Erichson 1847), many species have been described in general revisions (e.g., Harold 1867a, 1867b), synopses (Boucomont 1928; Balthasar 1939; Martínez *et al.* 1964) and regional studies (Howden & Young 1981; Solís & Kohlmann 2004; Kohlmann & Solís 2006). Currently, the genus includes 170 valid species-group names (Cupello 2018; Génier & Cupello 2018).

Due to the large number of species included in many New World dung beetle genera, efforts towards delimiting species groups that facilitate taxonomic revisions are highly desirable. So far, formal species groups have been delimited in several Scarabaeinae genera such as *Dichotomius* Hope, 1838 (Luederwaldt 1929; Nunes & Vaz-de-Mello 2013), *Onthophagus* Latreille, 1802 (Zunino & Halffter 1997), *Eurysternus* Dalman, 1824 (Génier 2009), *Ontherus* Erichson, 1847 (Génier 1996), and *Canthon* Hoffmannsegg, 1817 (Halffter & Martínez 1977). In a preliminary attempt to discriminate some species group within *Canthidium*, we propose a readily distinguishable species group around *Canthidium gigas* Balthasar, 1939. Characters defining this group include the large size of its species in relation to the other species of the genus, strongly convex body and uniform black colour. The *gigas* group includes three previously described species – namely, *Canthidium (N.) gigas* Balthasar, 1939, *C. (N.) bokermanni* (Martínez *et al.*, 1964) and *C. (N.) kelleri* (Martínez *et al.*, 1964), – and three new species described below.

Material and methods

Institutional abbreviations

A total of 129 specimens were examined from the following collections:

- AMBC = Ayr de Moura Bello personal collection, Rio de Janeiro, Brazil
- BMNH = British Museum of Natural History, London, United Kingdom
- CEMT = Setor de Entomologia da Coleção Zoológica da Universidade Federal de Mato Grosso, Cuiabá, Brazil
- CMNC = Canadian Museum of Nature, Ottawa, Canada
- MACN = Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”, Buenos Aires, Argentina
- MZSP = Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil
- NMPC = Národní muzeum (National Museum), Prague, Czech Republic
- OUMNH = Oxford University Museum of Natural History, Oxford, United Kingdom
- SEMC = Snow Entomological Museum, Lawrence, Kansas, United States of America
- TLC = Trond Larsen personal collection, Conservation International, Washington, D.C., United States of America

Other abbreviations

- EECFA = Estação Experimental de Ciências Florestais Anhembi
- Esalq/USP = Escola Superior de Agricultura Luiz de Queiroz/Universidade de São Paulo

FIT	=	flight interception trap
PNB	=	Parque Nacional de Brasilia
R.F. IBGE	=	Instituto Brasileiro de Geografia e Estatística
UNESP	=	Universidade Estadual Paulista
UNILAVRAS	=	Centro Universitario de Lavras

Pictures were taken using a Leica M205C stereo microscope and the images were stacked with the manufacturer's software. Maps were generated with Diva-Gis (ver. 7.5.0), using the shapefile of Löwenberg-Neto (2014) of the biogeographical regionalization of Morrone (2014). Holotype label data were transcribed verbatim in quotation marks; text lines are separated by a slash mark. The nomenclature used for the geographical distributions is based on the biogeographical regionalization scheme of Morrone (2014). The nomenclature used for the microsculpture is based on Harris (1979).

Specimen lengths were measured from the mid-anterior part of the pronotum to the elytral apex to eliminate potential errors caused by various inclinations of the head; therefore, the length provided here is just a 'partial length', not the total length of the specimens.

Results

Class Hexapoda Blainville, 1816
Order Coleoptera Linnaeus, 1758
Family Scarabaeidae Latreille, 1802
Subfamily Scarabaeinae Latreille, 1802
Genus *Canthidium* Erichson, 1847

Subgenus *Neocanthidium* Martínez *et al.*, 1964

The *gigas* species group

Diagnosis

Species of the *gigas* group are readily recognizable from other members of the genus by their large (8 to 15 mm), globose black body, which contrasts with the light-coloured antennae. In addition, the group shows coarse punctation on head and anterior surface of the pronotum; dorsal surface of the eyes posteriorly narrowed; interocular distance approximately seven times wider than the maximum dorsal eye width, and clypeus with two well-defined rounded teeth separated by an acute angle.

Description

Clypeal margin well defined internally, with two more or less rounded teeth medially, separated by an acute angle. Clypeogenal suture distinct. Hypomeron with coarse longitudinal microsculpture between punctuation and obliquely-oriented setae. Prosternum with few long setae, with greater concentration at central region, the apex of each setae reaches mesoventrite. Profemora with ventral surface with a longitudinal carina along posterior margin and with a distinct row of punctures along anterior margin, each puncture with a golden seta; surface with microstriae; tibiofemoral joint with a tuft of golden setae. Protibiae widening towards apex, external edge with three teeth, external edge serrate between proximal tooth and base, dorsal surface with punctation along the central axis, anteriorly with long setae; venter with longitudinal carina and a single row of punctures parallel to lateral edge. Protibial spur tapering towards apex and more or less angulate at apical third in females or wider apically and bent ventrally at median half in males. Tarsi with five tarsomeres; claws simple, strongly curved. Mesofemora with a carina along posterior edge, ventral surface with some setae anteroapically, centre and apex with minute punctation. Mesotibiae with narrow basal half, apical half abruptly dilated, with carina and

punctuation along anterior margin, near the carina with punctation; external edge with small teeth, internal edge smooth. First mesotarsomere as long as next two mesotarsomeres combined; second to fourth mesotarsomeres decreasing gradually in length and fifth mesotarsomere longer than the fourth; claws simple and strongly curved; two apical spurs, one as long as the first mesotarsomere and the other as long as the first and second mesotarsomeres combined. Elytral striae wide and distinct, with circular punctures slightly wider than the striae. Interstriae with small, scattered punctures. Pseudepipleuron narrowing gradually towards the apex, where it dilates slightly at the end of the fifth striae; surface with sparse fine punctation. Abdomen glabrous, finely punctate. Pygidium convex, margined along posterior edge, distinctly punctate.

Sexual dimorphism

Males and females can be differentiated by the protibial spur, which has a narrow apex in females and is flattened in males.

Key to the species of the gigas group

1. Head without transverse carina, horn or tubercle along frontoclypeal suture. Cerrado-Atlantic Forest transition in São Paulo state (Brazil) *Canthidium (Neocanthidium) ayri* sp. nov.
– Head with a transverse carina, conical horn or tubercle along the frontoclypeal suture 2

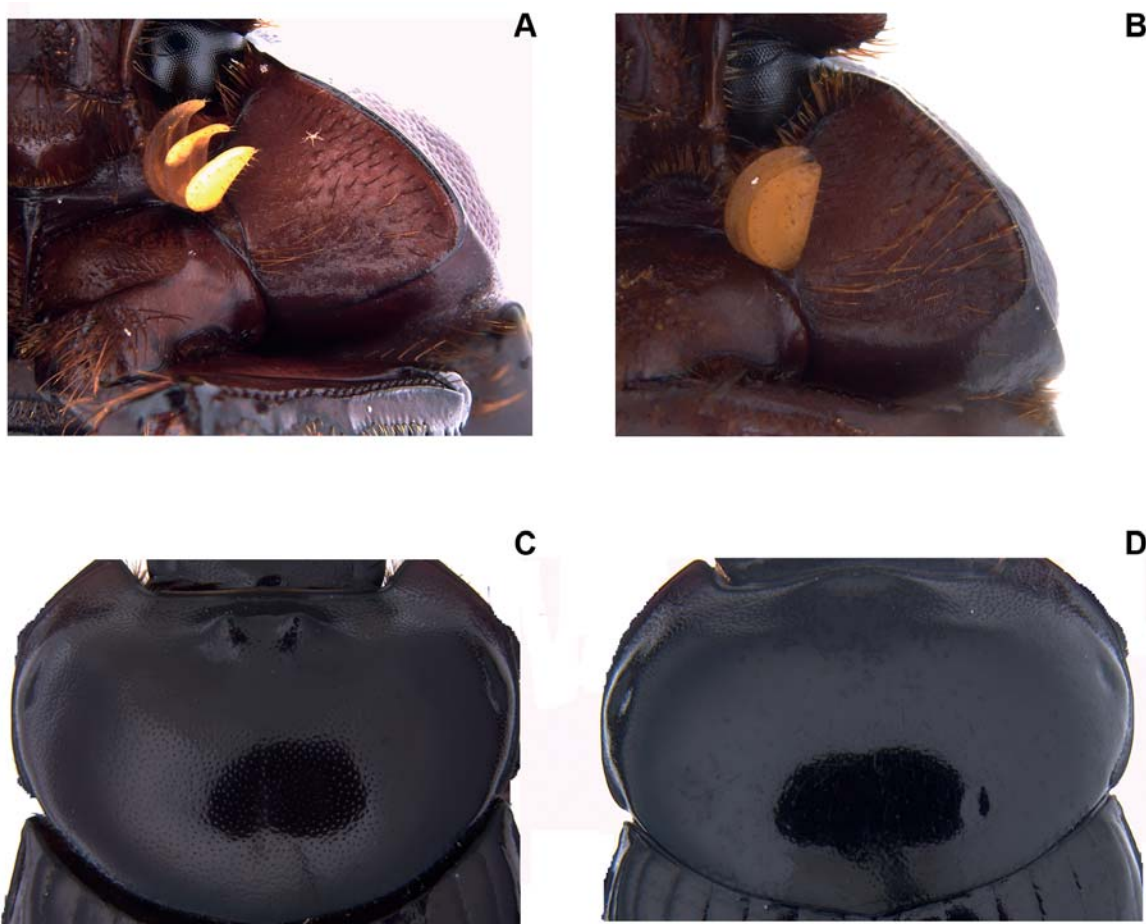


Fig. 1. **A.** *Canthidium gigas* Balthasar, 1939, hypomerum with complete hypomerical carina. **B.** *Canthidium kelleri* (Martínez *et al.*, 1964), hypomerum with incomplete hypomerical carina. **C.** Disc of pronotum completely punctated. **D.** Disc of pronotum with indefinite punctation. Not to scale.

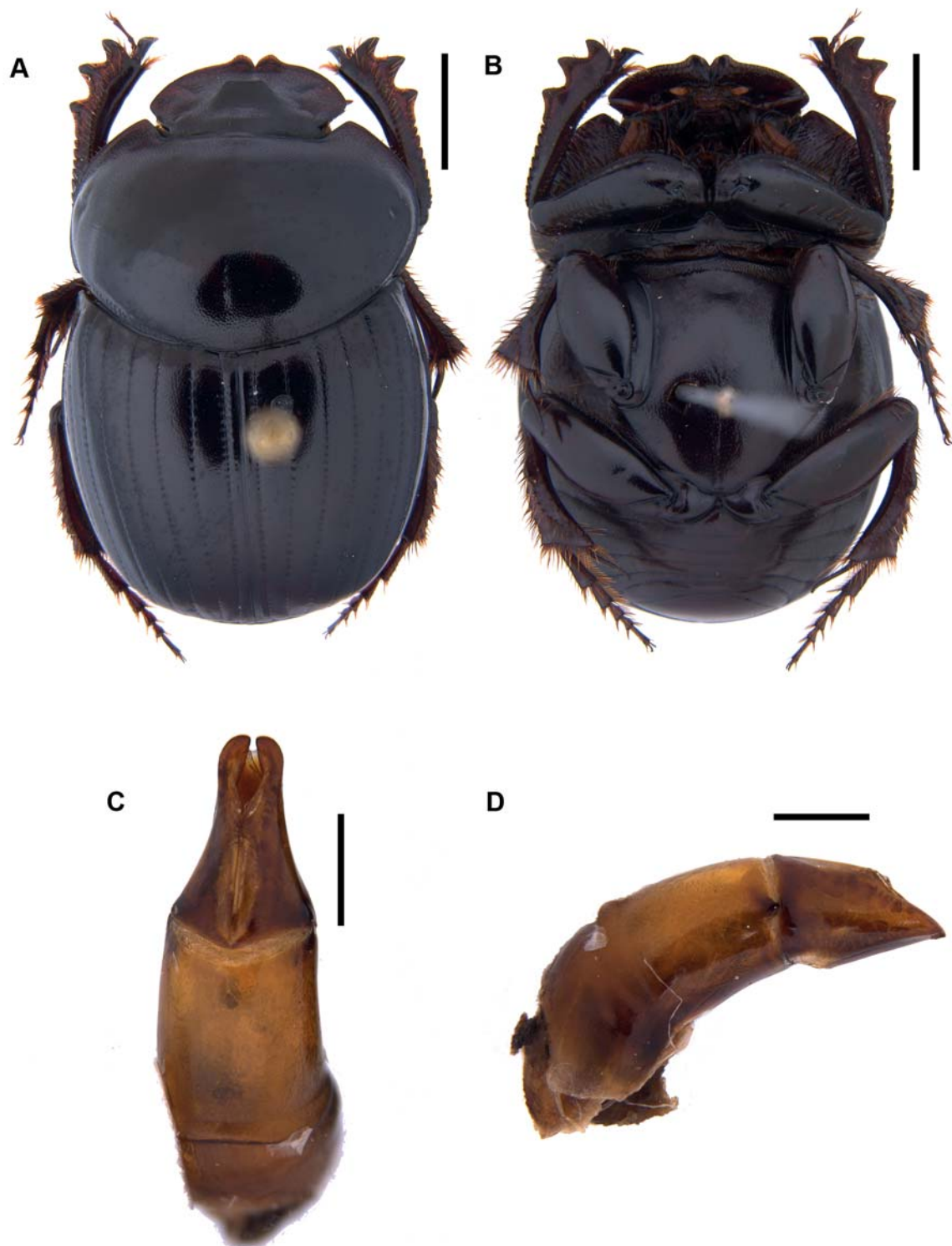


Fig. 2. *Canthidium gigas* Balthasar, 1939. **A.** Dorsal view. **B.** Ventral view. **C.** Dorsal view of aedeagus. **D.** Lateral view of aedeagus. Scale bars: 1 mm.

2. Head with conical horn. Hypomeron with incomplete hypomeral carina (Fig. 1B). Brazilian Cerrado and neighbouring open area *Canthidium (Neocanthidium) kelleri* (Martínez *et al.*, 1964)
 - Head with either short or long transverse carina, lacking a horn. Hypomeron with complete hypomeral carina (Fig. 1A). Known from forested/shaded habitats 3
3. Head with a long transverse frontoclypeal carina, length greater than one half interocular width. Pronotum anteriorly with a shallow excavation near centre (absent in small specimens and smaller in females than in males); bordered anteriorly by a transverse bilobed carina (reduced to a pair of lobes in smaller individuals). Amazonia 4
 - Head with a short transverse frontoclypeal carina, length less than one-third of interocular width. Pronotum convex anteriorly, without evident lobes or excavations. Chaco, Cerrado and Atlantic Forest 5
4. Frontoclypeal carina with length less than three-fourths of interocular width. Pronotum with anterior carina and lobes not evident, positioned just behind anterior border and separated from border by distance less than the border width; anterior region of disc punctate, posterior region with indefinite punctation (Fig. 1D). French Guiana *Canthidium (Neocanthidium) feeri* sp. nov.

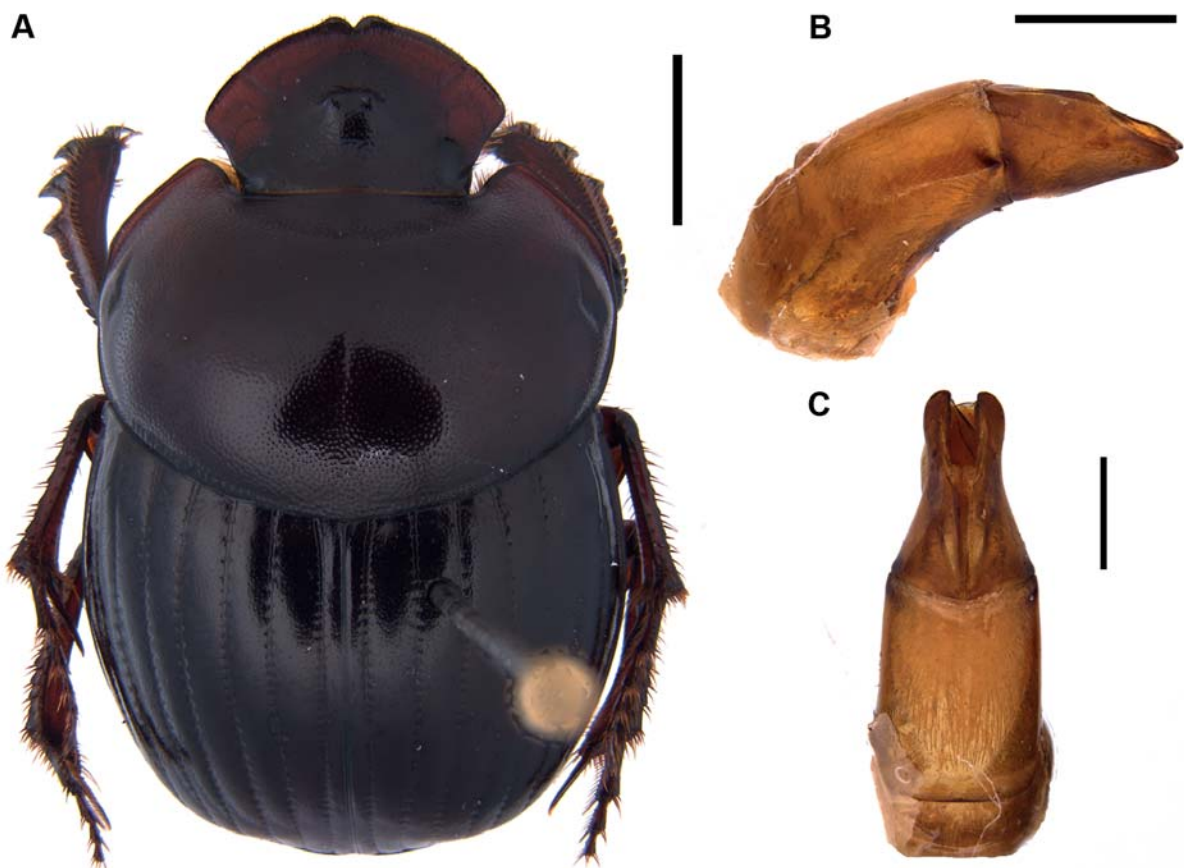


Fig. 3. *Canthidium bokermanni* (Martínez *et al.*, 1964). **A.** Dorsal view. **B.** Lateral view of aedeagus. **C.** Dorsal view of aedeagus. Scale bars: 1 mm.

- Frontoclypeal carina with length greater than four-fifths of interocular width. Pronotum with both anterior carina and two lobes sharply evident, separated from border by a distance equal or greater than the latter's width; disc with surface completely punctate (Fig. 1C). Amazon rainforest south of the Amazon River in Brazil and Peru *Canthidium (Neocanthidium) stofeli* sp. nov.
- 5. Parameres, in dorsal view, with strong median angulation and concave apical excavation (Fig. 2C); in lateral view, with dorsomedial angulation of 120° (Fig. 2D). Brazilian Atlantic Forest, including intrusions into Cerrado *Canthidium (Neocanthidium) gigas* Balthasar, 1939
- Parameres, in dorsal view, with feeble median angulation and shallow apical excavation (Fig. 3C); in lateral view, with dorsomedial angulation of 160° (Fig. 3B). Chaco and western Cerrado in Brazil, Bolivia, Paraguay and Argentina
..... *Canthidium (Neocanthidium) bokermanni* (Martínez *et al.*, 1964)

Species accounts

Canthidium (Neocanthidium) ayri sp. nov.

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Figs 4, 8

Diagnosis

Canthidium ayri sp. nov. is differentiated from the other species in the group by the unarmed head and pronotum, lacking projections.

Etymology

Named for Ayr de Moura Bello, great collector and enthusiast of Brazilian beetles, directly or indirectly responsible for the present increase of studies on Brazilian Coleoptera.

Type material

Holotype

BRAZIL • ♂; “Cerqueira César/ SP-Brasil/ II-1995/ COL. J. Carlos”; CEMT, ex AMBC.

Paratypes

BRAZIL – **São Paulo** • 1 ♀; Anhembi; EECFA, Esalq/USP; light trap, *Eucalyptus urophylla*; 22°40' S, 48°10' W; E.N.L. Ferreira leg.; CEMT. – **Paraná** • 1 ♀; Icaraima, Estância Felipe; same collection data as for preceding; 23 Dec. 2018–5 Jan. 2019; D.F. Rodrigues leg.; CEMT. – **Minas Gerais** • 1 ♂; Monjolinho; 19°33'10" S, 49°15'25" E; Nov. 1989; CEMT • 3 ♂♂; 6 ♀♀; same locality as for preceding; Dec. 1988; CEMT • 1 ♂; 1 ♀; same locality as for preceding; Dec. 1988; BMNH • 1 ♀; Três Marias; 18°12'23" S, 45°13'53" E; Nov. 1989; CEMT • 1 ♀; same locality as for preceding; Nov. 1991; J.C. Zanúncio leg.; CEMT.

Description (holotype)

MEASUREMENTS. Length: 8 mm.

HEAD. Surface with microsculpture obscurely variolate. Without frontoclypeal carina.

PRONOTUM. Regularly convex, strongly and completely punctate, without projections along anterior margin.

HYPOMERON. Hypomerical carina complete.

METAVENTRITE. With simple and shallow punctation, laterobasal region with stronger punctation, lateral region with microsculpture obscurely variolate, almost semicircular.

MESEPIMERON AND MESEPISTERNUM. With shallow punctation, stronger microsculpture obscurely variolate, almost semicircular.

HIND LEG. Metafemora with a carina along posterior edge, anterior edge with setal fringe, surface with fine punctation. Metatibiae elongated and gradually dilated towards the apex; external margin serrated.

AEDEAGUS. In dorsal view, parameres with median angulation nearly absent and with a shallow apical cavity; in lateral view, with dorsal angulation at the basal one-third.

Variation and sexual dimorphism

Length ranging from 8.00 to 8.31 mm. Males with ventrite VI wider medially, female ventrite VI with the same length throughout. Males also have protibial spur flattened, while in females the protibial spur is narrowed and pointed.

Geographical distribution

The specimens examined were collected in the Brazilian state of São Paulo in the Paraná and Chacoan dominion.

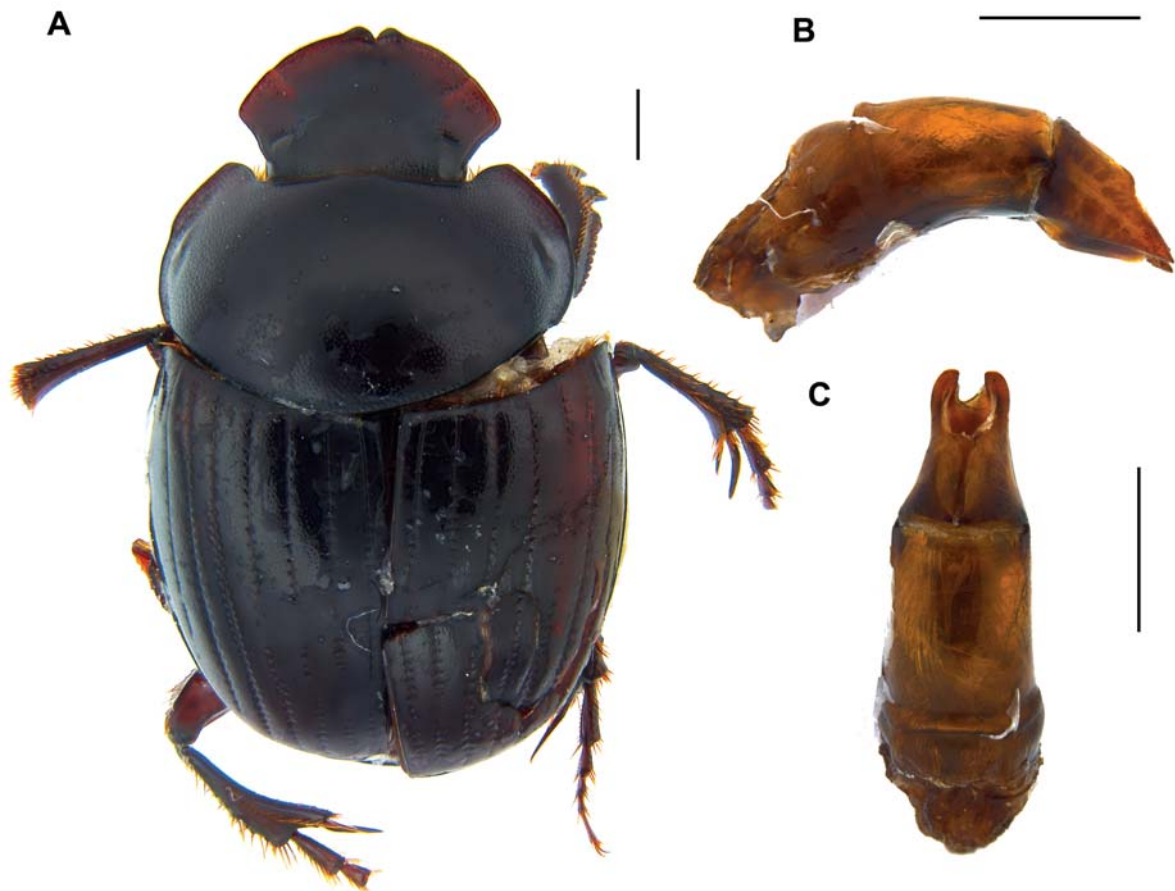


Fig. 4. *Canthidium ayri* sp. nov., holotype (CEMT) **A.** Dorsal view. **B.** Lateral view of aedeagus. **C.** Dorsal view of aedeagus. Scale bars: 1 mm.

Canthidium (Neocanthidium) kelleri (Martínez *et al.*, 1964)

Figs 1B, 5, 8

Neocanthidium kelleri Martínez *et al.*, 1964: 172–177 (original description).

Dichotomius (Luederwaldtinia) paraguayanus Gandini & Aguilar, 2009: 139, figs 1–8 (original description) (synonymized by Nunes & Vaz-de-Mello 2013: 416).

Canthidium (Canthidium) kelleri – Martínez & Halffter 1986: 28 (new combination). — Vaz-de-Mello 2000: 191 (checklist). — Nunes & Vaz-de-Mello 2013: 416 (senior synonymy).

Canthidium (Neocanthidium) kelleri – Cupello 2018: 470 (new subgeneric assignment).

Diagnosis

Canthidium kelleri differs from other species of the *gigas* group by the presence of a conical projection on the head which varies in development according to the size of the specimen.

Type specimens examined

Neocanthidium kelleri

Holotype

ARGENTINA • ♂; handwritten label; “ARGENTINA/ MISSIONES/ LORETO/ En mongas him./ Coll. Martínez// Enc: 958”; “HOLOTYPUS”; “*Neocanthidium/ kelleri* sp. n. ♂/ M., H y P./ A. MARTÍNEZ DET.1963”; “MACN-En 1223”; MACN.

Dichotomius paraguayanus

Holotype

PARAGUAY • ♂; “PARAGUAY: Concepcion, Zanja Moroti. 2.xi.2004”; originally in Gandini’s collection, now deposited in CEMT; CEMT.

Paratypes

PARAGUAY • 1 ♀; Cordillera, Cerro Naranjo; 25°30' S, 57°04'59" W; 15 May 2005; J. Rivas leg.; CEMT.

Other specimens examined

BRAZIL • 1 ♀; Distrito Federal, Brasília; 15°47'39.22" S, 47°52'55.81" W; R.F. IBGE; Dec.1997; I. Diniz leg.; CEMT • 1 ♀; Brasília, Fazenda Água Limpa; 15°57'11.05" S, 47°58'23.76" W; 16 Sep. 1979; Amadur leg.; CEMT • 1 ♂ [paratype of *N. kelleri*]; Goiás, Rio Verde; 17°47'33.79" S, 50°55'10.77" E; Dr. Nick leg.; CEMT • 1 ♀; Mato Grosso, Cuiabá, Fazenda [“Faz.”] Mutuca, Eucalipto-5; 15°18'51" S, 55°58'18" W; 6 Mar. 2009; CEMT • 1 ♀; same locality as preceding, Cerrado-1; 3 Feb. 2009; CEMT • 1 ♂; Chapada dos Guimarães, Cachoeira da Geladeira; FIT; 15°25'25" S, 55°42'58" W; 6,200 m a.s.l.; 9–30 Jan. 2013; D. Gimo leg.; CEMT • 1 ♀; same locality as for preceding, Comunidade João Carro; 15°02'01" S, 55°43'00" W; 300 m a.s.l., 3 May 2016; M. Serrano leg.; CEMT • 1 ♂; Mato Grosso do Sul; Selvíria, UNESP farm, *Brachiaria decumbens* pasture; black light trap; 20°25'6.82" S, 51°20'51.87" W; 21 Sep. 2000; C.A.H. Flechtmann leg.; CEMT • 1 ♀; Minas Gerais, Cordisburgo, Fazenda [“Faz”] Pontinha; 19°5'42.30" S, 44°17'3.58" W; Jan. 1994; F.Z. Vaz-de-Mello leg.; CEMT • 1 ♂; same locality as for preceding; Jan. 1999; Falqueto and Vaz-de-Mello leg.; BMNH • 1 ♀; same data as for preceding; CEMT • 1 ♀; Uberaba; 19°44'50.52" S, 47°56'20.95" W; CEMT • 1 ♀; Lavras; 21°18'50.15" S, 44°59'36.95" W; 20 Jan. 2008; M.R. Rocha and D.H.T. Takahashi leg.; CEMT • 1 ♀; Arinos, Rio Urucuaia; 16°14'34.15" S, 45°32'44.46" W; 20 Apr. 1994; N. Degallier leg.; BMNH • 1 ♂; Buritis, Fazenda [“Faz”] Querência; FIT; 15°10'23,5" S, 46°32'43,1" W; 978 m a.s.l.; 10 Jul. 2013–4 Feb. 2014; C.M. Oliveira leg.; CEMT.

Redescription

HEAD. Surface densely and distinctly punctated, especially on the clypeus. Frontoclypeal suture with conical projection.

PRONOTUM. Regularly convex, without projections, sometimes excavated anteriorly. Anterior edge slightly curved, sides arched.

HYPOMERON. Hypomerical carina incomplete.

METAVENTRITE. With simple and shallow punctation, laterobasal region with stronger punctation, lateral region with microsculpture obscurely variolate, almost semicircular.

MESEPIMERON AND MESEPISTERNUM. With shallow punctation, stronger microsculpture obscurely variolate, almost semicircular.

HIND LEG. Metafemora with a carina along posterior edge, anterior edge with setal fringe, surface with fine punctuation. Metatibiae elongated and gradually dilated towards the apex; external margin serrated.

AEDEAGUS. Parameres, in lateral view, with dorsal angulation at basal two-fifths.

Variation and sexual dimorphism

Length ranging from 8.95 to 11.54 mm. Smaller specimens have the frontal horn reduced in size, appearing as a transverse gibbosity. Pronotum with the anteromedial depression less visible and shallower in some

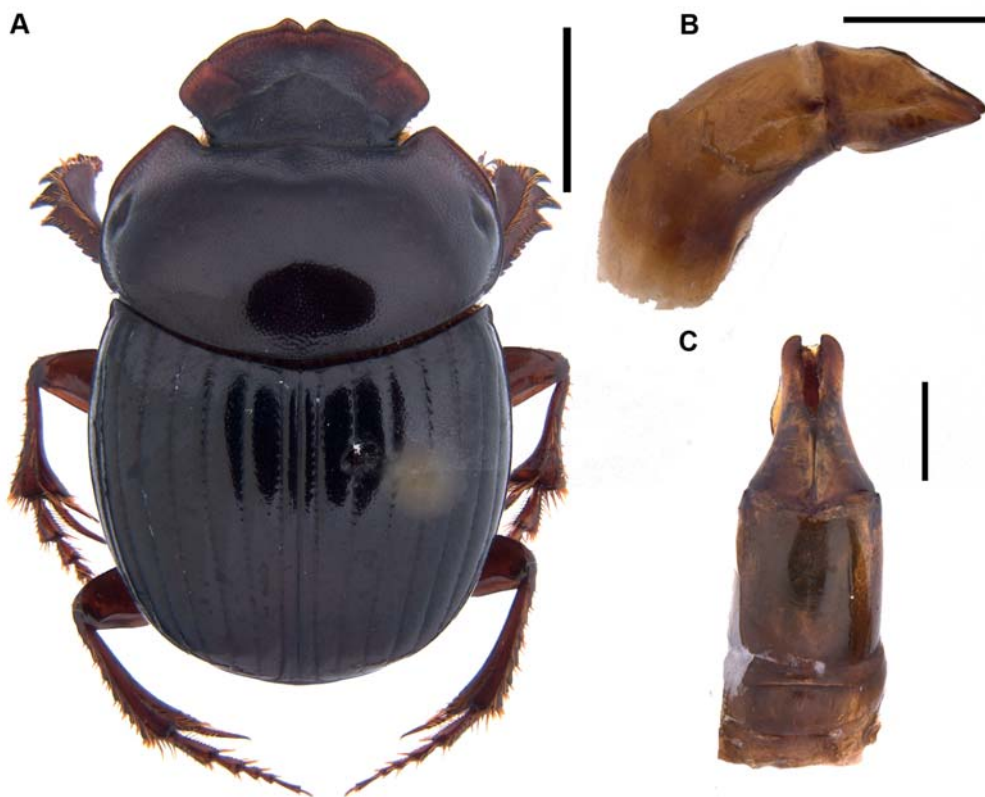


Fig. 5. *Canthidium kelleri* (Martínez *et al.*, 1964). **A.** Dorsal view. **B.** Lateral view of aedeagus. **C.** Dorsal view of aedeagus. Scale bars: 1 mm.

specimens. Pygidium slightly less convex if compared with *C. bokermanni*. Males present a small tooth in the upper ventral part of their metatibiae. Males with ventrite VI wider medially, female ventrite VI with the same length throughout. Males also have protibial spur flattened, while in females the protibial spur is narrowed and pointed.

Geographical distribution

The specimens examined were collected in Paraguay (Cordillera) and Brazil (Mato Grosso, Mato Grosso do Sul, Goiás, Distrito Federal and Minas Gerais). It is present in the Cerrado and the Chaco biomes, which lie in the Chacoan dominion.

Comments

The holotype and one paratype originally identified as male of *D. paraguayanus* were examined by us and were shown to be *C. kelleri*, thus confirming the name's synonymy with *C. kelleri* as firstly proposed by Nunes & Vaz-de-Mello (2013). However, two paratypes originally said to be females by Gandini & Aguilar (2009) are actually males, and belong to *C. bokermanni*. See comments below.

Canthidium (Neocanthidium) feeri sp. nov.

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Figs 1D, 6, 9

Diagnosis

Canthidium feeri sp. nov. differs from other species of the group by the distinct anterior pronotal punctation, apparently lacking punctures on the centre of the disc.

Etymology

Named for François Feer, French scarabaeidologist, working at the Muséum national d'Histoire naturelle (Paris, France) who collected half of the type series.

Type material

Holotype

FRENCH GUIANA • ♂; "GUYANE FRANÇAISE: St/ Laurent du Maroni, Bélvédère/ de Saul, 03°37'22" S/ 53°12'57" W, 17.i.2011"; "22363"; CEMT.

Paratypes

FRENCH GUIANA • 1 ♂; same data as for holotype; CEMT • 1 ♂, 1 ♀; Cayenne, Nouragues Nature Reserve, primary forest, flight interception trap ["FIT"]; 4°5' N, 52°41' W; 28 Mar. 2002; F. Feer leg.; CEMT • 1 ♂; same location as for preceding; Apr. 2003; F. Feer leg.; CEMT • 1 ♂; Saül, Mt. Galbao; ex. flight int. trap; 3°37'18" N 53°16'42" N; 740 m a.s.l.; 5–7 Jun. 1997; J. Ashe and R. Brooks leg.; FG1AB97; #154; CMNC.

Type locality

Bélvédère de Saül, Saint-Laurent-du-Maroni, French Guiana, France.

Description (holotype)

MEASUREMENTS. Length: 9 mm.

HEAD. Surface dense and distinctly punctated. Frontoclypeal carina rectangular and with length less than three-fourths of interocular distance.

PRONOTUM. With anterior carina and lobes not evident, positioned just behind anterior border and separated from border by distance less than the border width; anterior region of disc punctated, posterior region with indefinite punctation.

HYPOMERON. Hypomerical carina complete.

METAVENTRITE. With simple and shallow punctation, laterobasal and lateral region with microsculpture finely strigulate.

MESEPIMERON AND MESEPISTERNUM. With shallow punctation and microsculpture finely strigulate.

HIND LEG. Metafemora with a carina along posterior edge, anterior edge with setal fringe, surface with fine punctation. Metatibiae elongated and gradually dilated towards the apex; external margin serrated.

AEDEAGUS. Parameres, in lateral view, dorsally with angulation on basal third.

Variation and sexual dimorphism

Total length ranging from 9.00 to 10.67 mm. Some males present a small tooth in the upper ventral part of their metatibiae and some have a protuberance on their basal half. Males with ventrite VI wider

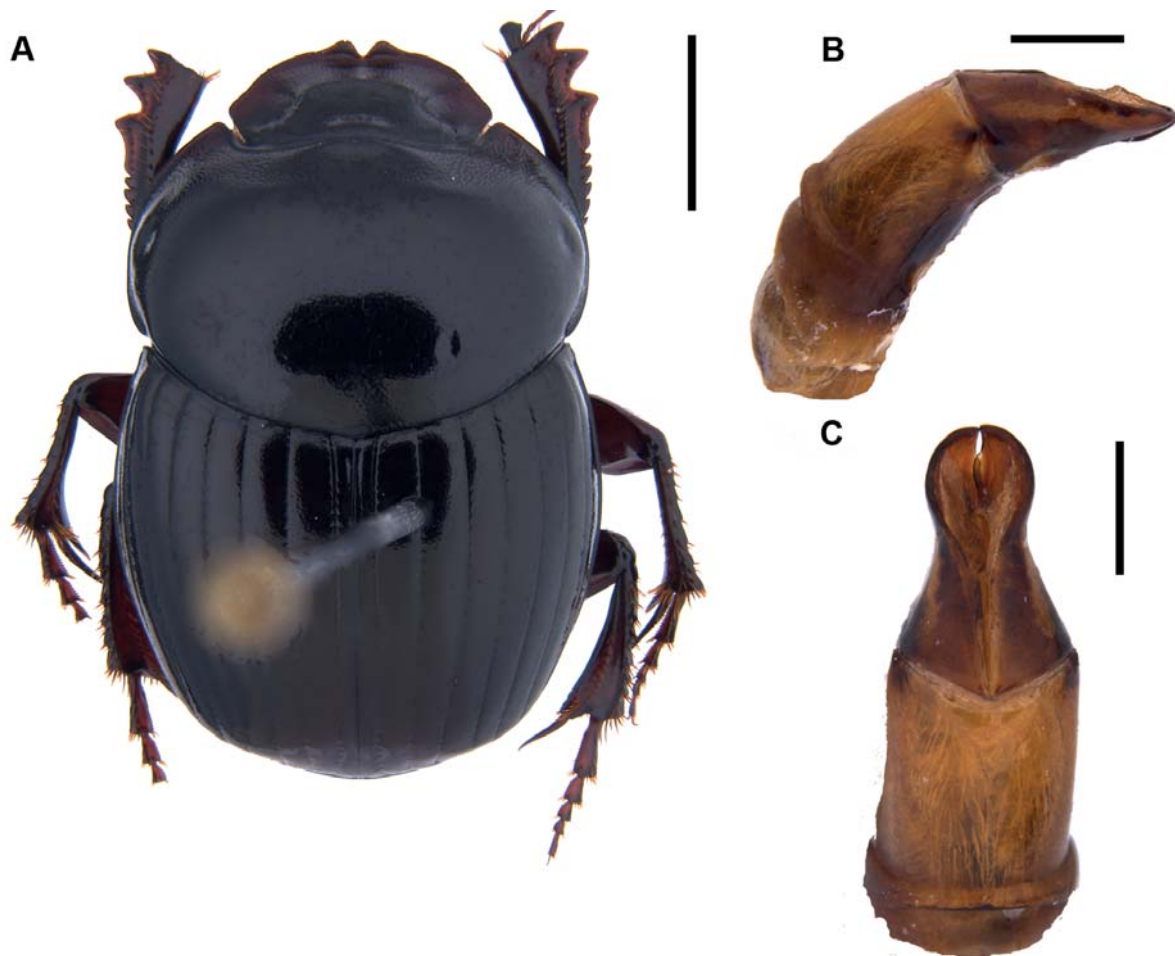


Fig. 6. *Canthidium feeri* sp. nov., holotype (CEMT) **A.** Dorsal view. **B.** Lateral view of aedeagus. **C.** Dorsal view of aedeagus. Scale bars: 1 mm.

medially, female ventrite VI with the same length throughout. Males also have protibial spur flattened, while in females the protibial spur is narrowed and pointed.

Geographical distribution

All the specimens examined for this work were collected in French Guiana, which is located in the Boreal Brazilian dominion.

Canthidium (Neocanthidium) stofeli sp. nov.

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Figs 7, 9

Diagnosis

Canthidium stofeli sp. nov. differs from the other species in the group by having two anterior medial projections, one on each side of the pronotum.

Etymology

Named after Roberto Stofel, for the field support during collections in Cotriguaçu.

Type material

Holotype

BRAZIL • ♂; “BRASIL: Rondônia: Guajará/ Mirim: Proprietário: Fandinho/ 10°44'57.62" S, 65°19'0.32" W/ 138m. flor. Amaz. Isca: baço bov/ 24.II.2010 F.Coletti”; “22366”; CEMT.

Paratypes

BRAZIL • 1 ♂; Acre, Rio Branco, Fazenda [“Faz”] Catuaba; 9°57'19.77" S, 65°51'55.72" W; Feb. 1997; F. Vaz-de-Mello leg.; CEMT • 1 ♀; Rondônia, Guajará-Mirim, Sítio Coletti; flight interception trap [“FIT”]; 10°19'47.11" S, 4°45'12.5" W; 170 m a.s.l.; 28 Jan. 2010; F. Coletti leg.; CEMT • 1 ♀; Pará, Tailândia, Empresa Agropalma; 9–16 Jul. 2016; P. Silva leg.; CEMT • 1 ♀; Belterra, forest; hum/pig trap; 3°17'47" S, 54°57'48" W; 132 m a.s.l.; 24 Mar. 2017; F. França leg.; T2P3; CEMT • 1 ♀; same locality as for preceding; T15P20; CEMT • 1 ♀; Mato Grosso, Querência, Fazenda São Luiz, Amazon Forest; flight interception trap [“FIT”]; 12°39'3.21" S, 52°21'9.37" W; Feb. 2009; R. Andrade leg.; CEMT • 2 ♂♂; Cláudia, Fazenda [“Faz”] Continental; fungus; 11°34'54" S, 55°17'15" W; 20 Feb. 2010; M.F. Souza leg.; CEMT • 1 ♂; Cotriguaçu, Matinha; pitfall baited with fungus; 9°50'19" S, 58°15'3" W; 11–13 Jul. 2009; F.Z. Vaz-de-Mello leg.; BMNH • 1 ♂; same data as for preceding; CEMT • 2 ♀♀; Cotriguaçu, Fazenda [“Faz”] São Nicolau; flight interception trap [“FIT”]; 9°49'9" S, 58°15'47" W; 12–14 Jul. 2009; F.Z. Vaz-de-Mello leg.; CEMT • 1 ♀; same data as for preceding; BMNH • 1 ♂; Cotriguaçu, Fazenda [“Faz”] São Nicolau; pitfall baited with fungus; 9°49'8" S, 58°15'40" W; 17–21 May 2012; F.Z. Vaz-de-Mello leg.; CEMT • 1 ♂; Cotriguaçu, Fazenda [“Faz”] São Nicolau, primary forest; flight interception trap [“FIT”]; 9°50'24" S, 58°15'10" W; 250 m a.s.l.; 6 May 2009; Vaz-de-Mello leg.; CEMT • 1 ♂, 1 ♀; Fazenda São Nicolau (site 6), primary forest; flight int. trap; 9°49'16" S, 58°15'33" W; 220 m a.s.l.; 1 Dec. 2013; F. Génier leg.; CMNC 2013-118 • 1 ♀; Fazenda São Nicolau (site 5), riparian primary forest; flight int. trap; 9°51'56" S 58°13'09" W; 220 m a.s.l.; 3 Dec. 2013; F. Génier leg.; CMNC 2013-129 • 1 ♀; Fazenda São Nicolau (site 6), primary forest; flight int. trap; 9°49'16" S, 58°15'33" W; 220 m a.s.l.; 3 Dec. 2013; F. Génier leg.; CMNC 2013-131.

PERU • 1 ♀; Madre de Dios, CICRA Los Amigos B.S; 12°34'1" S, 70°06'0" W; 250 m a.s.l.; 2005; T. Larsen leg.; TLC • 1 ♀; CICRA Field Station, trail 6, research plot; blue pan trap; 12.55207° S, 70.10962° W; 295 m a.s.l.; 7–9 Jun. 2011; Chaboo team leg.; SEMC PER-11-PTB-009 • 1 ♀; Rio Tambopata, Jorge Chavez; flight intercept trap; 12°38'59" S, 69°06'24" W, 230 m a.s.l.; 28–29 Sep. 1999;

T. Larsen leg.; CMNC • 1 ♀; Rio Palma Real Grande, Limon Camp; flight intercept trap; 12°32'20" S, 68°51'40" W; 220 m a.s.l.; 9–10 Oct. 1999; T. Larsen leg.; CMNC • 1 ♀; Rio Palma Real Grande, Limon Camp; flight intercept trap; 12°32'20" S, 68°51'40" W; 220 m a.s.l.; 13–14 Oct. 1999; T. Larsen leg.; CMNC.

Type locality

Guajará-Mirim, Rondônia, Brazil.

Description (holotype)

MEASUREMENTS. Length: 10 mm.

HEAD. Surface densely and distinctly punctated; with rectangular frontoclypeal carina, length greater than four-fifths of the interocular distance.

PRONOTUM. Completely punctate, with dense and distinct punctation, becoming more accentuated towards the centre of the disc, regularly convex with two medial projections anteriorly, one on each side.

HYPOMERON. Hypomerical carina slightly curved toward edge.

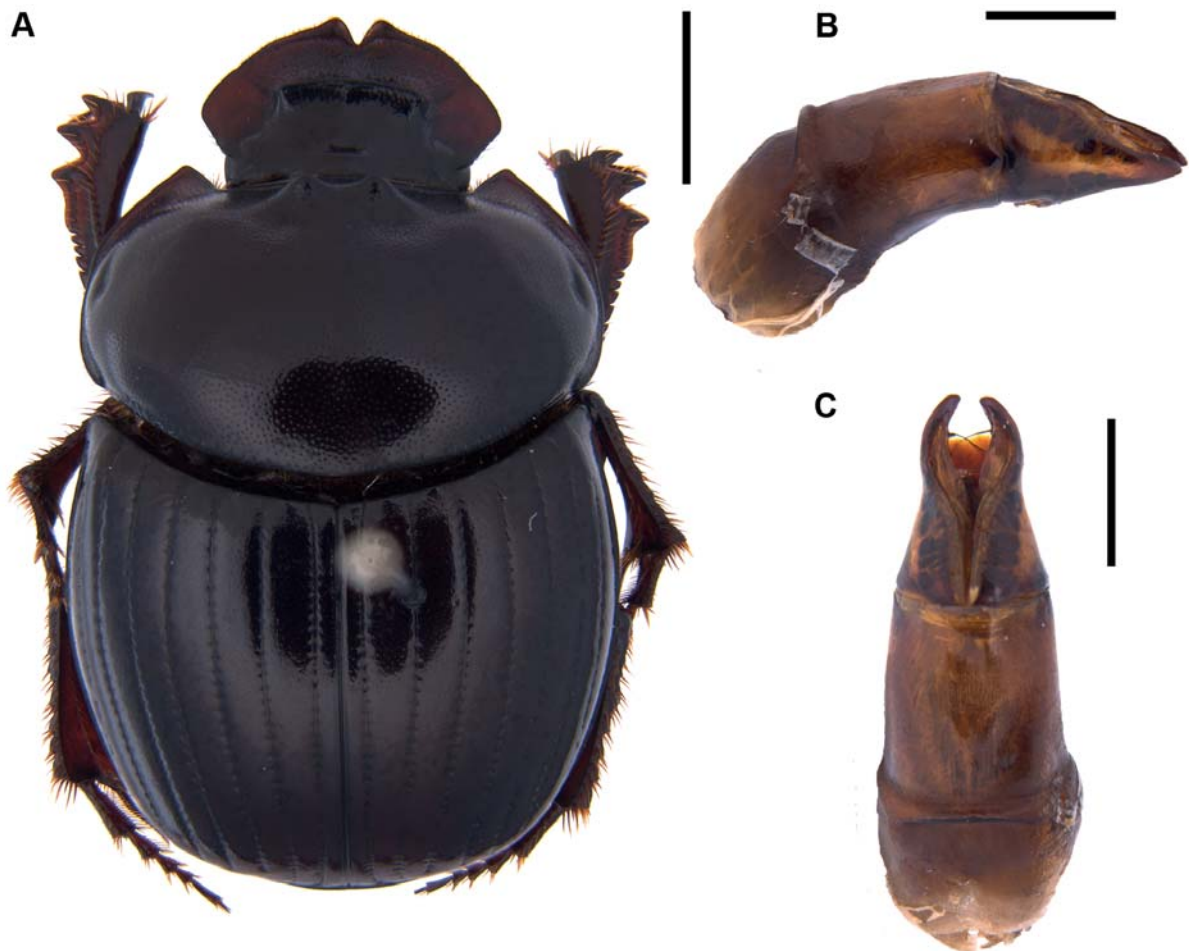


Fig. 7. *Canthidium stofeli* sp. nov., holotype (CEMT) **A.** Dorsal view. **B.** Lateral view of aedeagus. **C.** Dorsal view of aedeagus. Scale bars: 1 mm.

METAVENTRITE. With simple and shallow punctation, laterobasal region with stronger punctation, lateral region with microsculpture obscurely variolate, almost semicircular.

MESEPIMERON AND MESEPISTERNUM. With shallow punctation, stronger microsculpture obscurely variolate, almost semicircular.

HIND LEG. Metafemora with a carina along posterior edge, anterior edge with setal fringe, surface with fine punctation. Metatibiae elongated and gradually dilated towards the apex; external margin serrated.

AEDEAGUS. In dorsal view, parameres with a strong concave angulation and abruptly curved apex.

Variation and sexual dimorphism

Length ranging from 8.87 to 11.11 mm. The projections on the pronotal disc vary according to the size of the specimen, being allometrically developed as the size of the body increases. Males with ventrite VI wider medially, female ventrite VI with the same length throughout. Males also have protibial spur flattened, while in females the protibial spur is narrowed and pointed.

Geographic distribution

The specimens examined came from Brazil (Mato Grosso, Rondônia, Pará) and Peru (Madre de Dios). The species occurs in the southern region of the Amazon biome, corresponding to the Southeastern Amazonian dominion and Boreal Brazilian dominion.

Canthidium (Neocanthidium) gigas Balthasar, 1939

Figs 1.A, C, 2, 10

Canthidium gigas Balthasar, 1939: 127, 128 (original description)

Canthidium gigas – Martínez 1947: 111 (checklist).

Canthidium (Canthidium) gigas – Martínez & Halffter 1986: 27 (checklist).

Canthidium (Neocanthidium) gigas – Cupello 2018: 469 (new subgeneric assignment).

Neocanthidium gigas – Vulcano & Pereira 1964: 592 (identification key).

Type material

Holotype

BRAZIL • ♀; handwritten label; “Cayenne”; “Coll C Felsche/ Kauf 20, 1918”; “*C. gigas*/ sp. m./ Dr. V. Balthasar det.”; “*gigas*/ m.”; “TYPUS”; “HOLOTYPE ♀”; NMPC.

Other specimens examined

BRAZIL • 1 ♀; Espírito Santo, Domingos Martins, Parque Estadual [“P.E.”] Pedra Azul; 20°23'19.93" S, 41°0'55.49" W; Jan. 2000; Lopes-Andrade and F. Vaz-de-Mello leg.; CEMT • 1 ♀; Venda Nova do Imigrante; 20°19'39.02" S, 41°8'9.36" W; Feb. 1998; Falqueto and Vaz-de-Mello leg.; CEMT • 1 ♀; Rio de Janeiro, Itatiaia [“Itatiaya”]; 22°29'29" S, 44°33'33" W; 12 Dec. 1933; J.F. Zikán leg.; CEMT • 1 ♂; Nova Friburgo; 22°16'55" S, 42°31'5" W; Dec. 1995; P. Grossi and E. Grossi leg.; CEMT • 2 ♀♀, 1 ♂; Nova Friburgo; Nov. 2001; E. Grossi leg.; AMBC • 1 ♀; Nova Friburgo, Macaé de Cima; 22°24'8.45" S, 42°30'48.39" W; Jan. 1999; P. Grossi leg.; CEMT • 1 ♀; same locality as for preceding; Mar. 2000; Vaz-de-Mello leg.; CEMT • 1 ♀; same locality as for preceding; Dec. 2001; E. and P. Grossi leg.; CEMT • 1 ♂; same locality as for preceding; Jan. 2000; Grossi leg.; CEMT • 1 ♂; same data as for preceding; BMNH • 1 ♂; Rio de Janeiro, Corcovado; Dec. 1959; M. Alvarenga leg.; MZSP • 1 ♀; São Paulo, São Luiz do Paraitinga, Parque Estadual da [“Pq. Est.”] Serra do Mar, Núcleo Santa Virgínia; Nov. 2004; M. Uehara leg.; AMBC • 1 ♀; Minas Gerais, Ingaí, Reserva do Boqueirão, UNILAVRAS, gallery forest;

flight interception trap [“FIT”]; 21°31′08.05″ S, 44°55′39.81″ E; 13 Nov. 2002; Silva and Frieiro-Costa leg.; CEMT • 1 ♀, 1 ♂; Viçosa, FIT; 20°45′17.52″ S, 42°52′42.88″ W; Nov. 1999; Andrade and Vaz-de-Mello leg.; CEMT • 1 ♀; same data as for preceding; BMNH • 1 ♀; same locality as for preceding; Jan. 1999; Vaz-de-Mello leg.; CEMT • 3 ♀♀, 1 ♂; same locality as for preceding; Nov. 1998; Vaz-de-Mello leg.; CEMT • 1 ♂; same locality as for preceding; Universidade Federal de Viçosa; FIT; 20°45′51.99″ S, 42°52′5.68″ W; Mar. 1998; Vaz-de-Mello leg.; CEMT • 1 ♂; Viçosa, Mata da Biologia; 20°45′ S, 42°51′ W; Nov. 2000; F.Z. Vaz-de-Mello leg.; CEMT • 2 ♀♀; same locality as for preceding; Mata do Paraíso; Dec. 2000; Vaz-de-Mello leg.; CEMT • 1 ♂; same locality as preceding; Dec. 1998; Falqueto and Vaz-de-Mello leg.; CEMT • 1 ♂; same locality as preceding; Dec. 1999, Vaz-de-Mello CEMT • 1 ♀; same locality as for preceding, FIT; 13 Feb. 2015; S. Aloquio, A. Orsetti, C. Lopes-Andrade and M. Bento leg.; CEMT • 1 ♂; Berizal, fazenda [“Faz”] Veredão; 15°39′18″ S, 41°39′16″ W, 13–18 Dec. 2012; P. Grossi leg.; CEMT • 1 ♀; Distrito Federal, Brasília, FAL-UNB [“Faz Água Limpa”], gallery forest; FIT; 15°56′25.1″ S, 47°56′22.2″ W; 4 Dec. 2013; T. Bernardes leg.; CEMT • 1 ♂; same locality as for preceding; PNB, gallery forest, FIT; 14°44′49,5″ S, 48°00′32,3″ W; 11 Nov. 2015; N.H.D.Silva leg.; CEMT • 1 ♂; same locality as for preceding; 21 Dec. 2015; N.H.D. Silva leg.; CEMT • 1 ♀; same locality as for preceding; 27 Nov. 2015; N.H.D. Silva leg.; CEMT • 1 ♀; same locality as for preceding; 12 Jan. 2016; N.H.D.Silva leg.; CEMT • 1 ♀; Paraná, Campina Grande do Sul, Estrada da mandaçaiá; FIT; 25°17′54″ S, 49°02′30″ W; 7–10 Apr. 2014; F.W.T. Leivas leg.; CEMT.

Diagnosis

Canthidium gigas resembles *C. bokermanni* in the presence of a transverse carina on the head and distinct punctation on the pronotal disc. They differ only in the dorsal curvature of the parameres. In *C. gigas*, in dorsal view, the parameres have a strong angulation on their apical half and bear a concave medial excavation from the middle to the apex; in lateral view, the parameres have a dorsal angulation

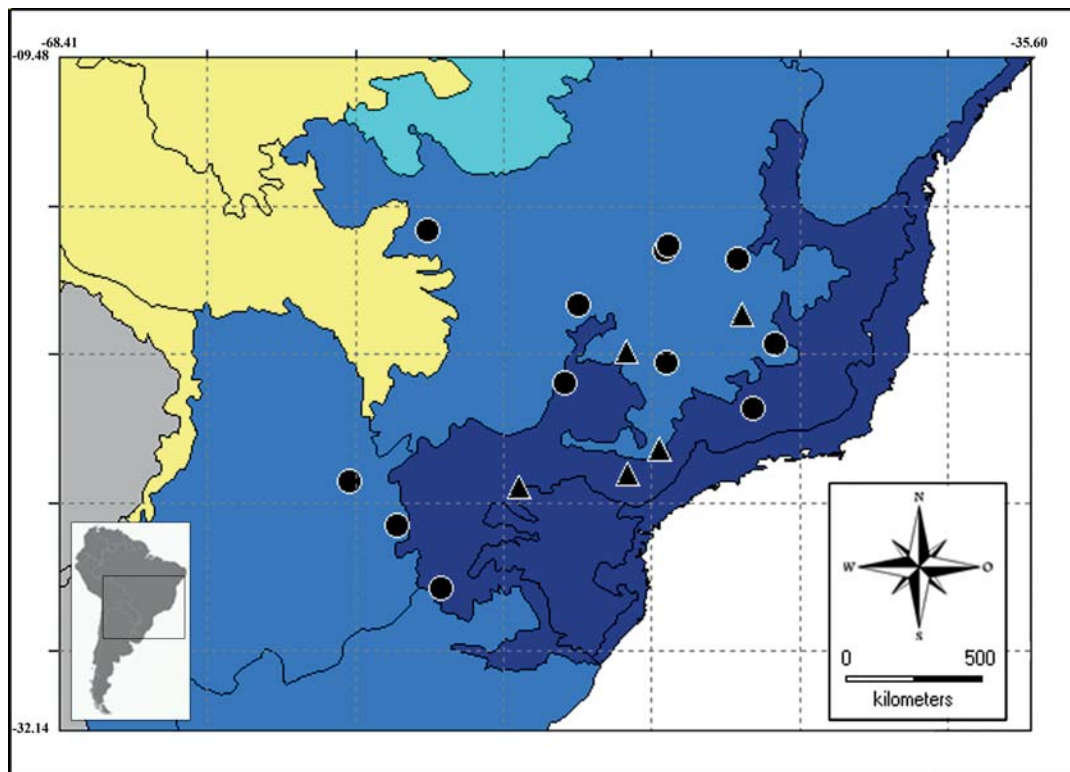


Fig. 8. Geographical distribution of *Canthidium kelleri* (Martínez *et al.*, 1964) (circles) and *Canthidium ayri* sp. nov. (triangles).

of 120°. In *C. bokermanni*, in dorsal view, the apical angulation is almost absent and there is a shallow medial excavation at the apex; in lateral view, the parameres have a dorsal internal angulation of 160°.

Type locality

Brazilian Atlantic Forest. Originally said to be Cayenne, French Guiana, but this is an error. See geographic distribution below.

Redescription

HEAD. Surface with dense and distinct punctation, particularly on clypeus. With a transverse raised projection in the front.

PRONOTUM. Without anteromedial depression, disc anteriorly convex, sometimes with an anterior sinuosity forming two broad and shallow depressions (both surrounding the medial line). Surface with dense and distinct punctation, attenuating towards the centre of disc, where punctation is fine and sparse.

HYPOMERON. With microstriae and setae in the basal part. Hypomerical carina complete curved throughout its length.

METAVENTRITE. With simple and shallow punctation, laterobasal region with stronger punctation, lateral region with microsculpture obscurely variolate, almost semicircular.

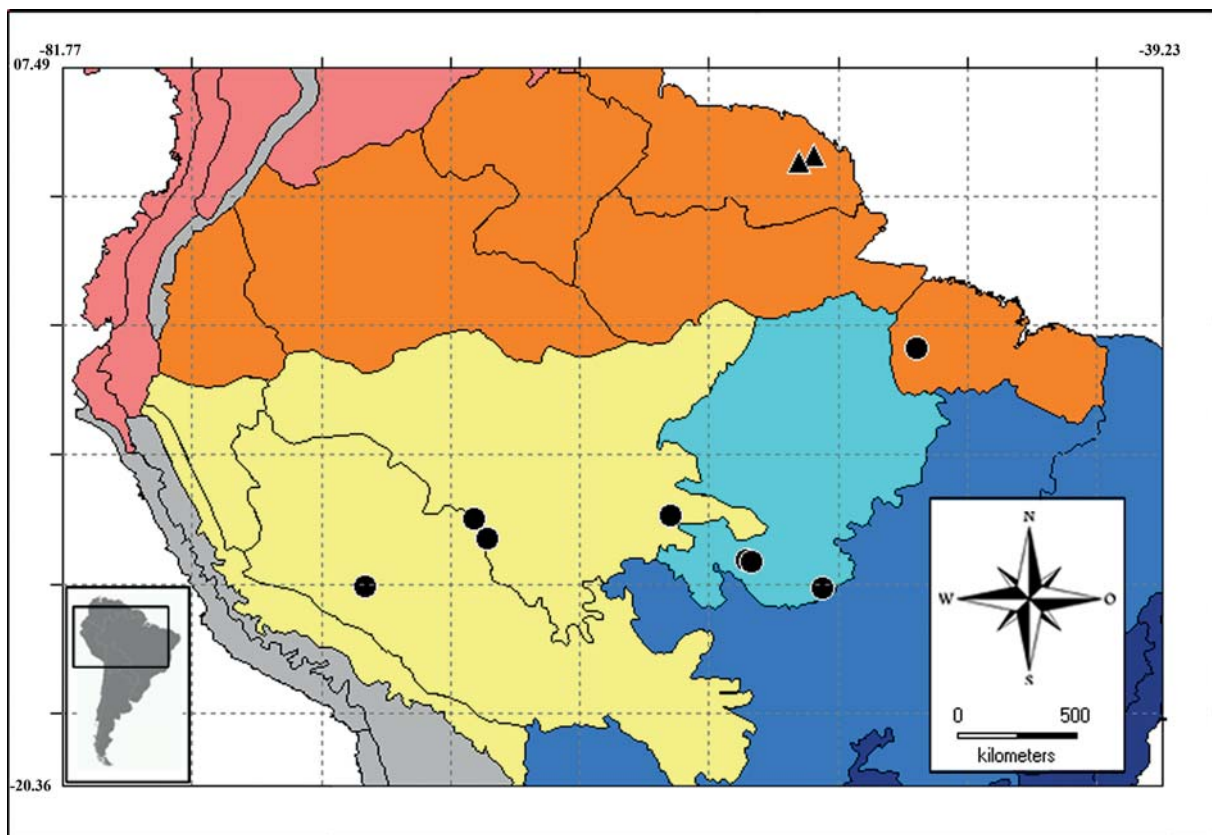


Fig. 9. Geographical distribution of *Canthidium stofeli* sp. nov. (circles) and *Canthidium feeri* sp. nov. (triangles)..

MESEPIMERON AND MESEPISTERNUM. With shallow punctation, stronger microsculpture obscurely variolate, almost semicircular.

HIND LEG. Metafemora with a carina along posterior edge, anterior edge with setal fringe, surface with fine punctation. Metatibiae elongated and gradually dilated towards the apex presenting a sinuosity; external margin serrated.

AEDEAGUS. In dorsal view, parameres with a strong angulation in apical half and with a concave excavation from the middle to the apex; in lateral view, with internal medial angulation of 120° dorsally.

Variations and sexual dimorphism

Length ranging from 9.40 to 12.65 mm. Transverse projection of head sometimes not well defined. The males have a tooth in the upper ventral part, more developed in some specimens than in others. Males with ventrite VI wider medially, female ventrite VI of the same length throughout. Males also have protibial spur flattened, while in females the protibial spur is narrowed and pointed.

Geographical distribution

The specimens examined were mostly collected in the Brazilian states of Minas Gerais, São Paulo, Espírito Santo and Paraná in the Atlantic rainforest biome, located in the Paraná dominion. The record from Distrito Federal is surprising for the species. Judging from the rest of the known distribution, its presence there may be due to gallery forest connecting it to the Atlantic Forest on the coast. Although the holotype is labelled as coming from French Guiana, we believe this represents a mislabelling, since

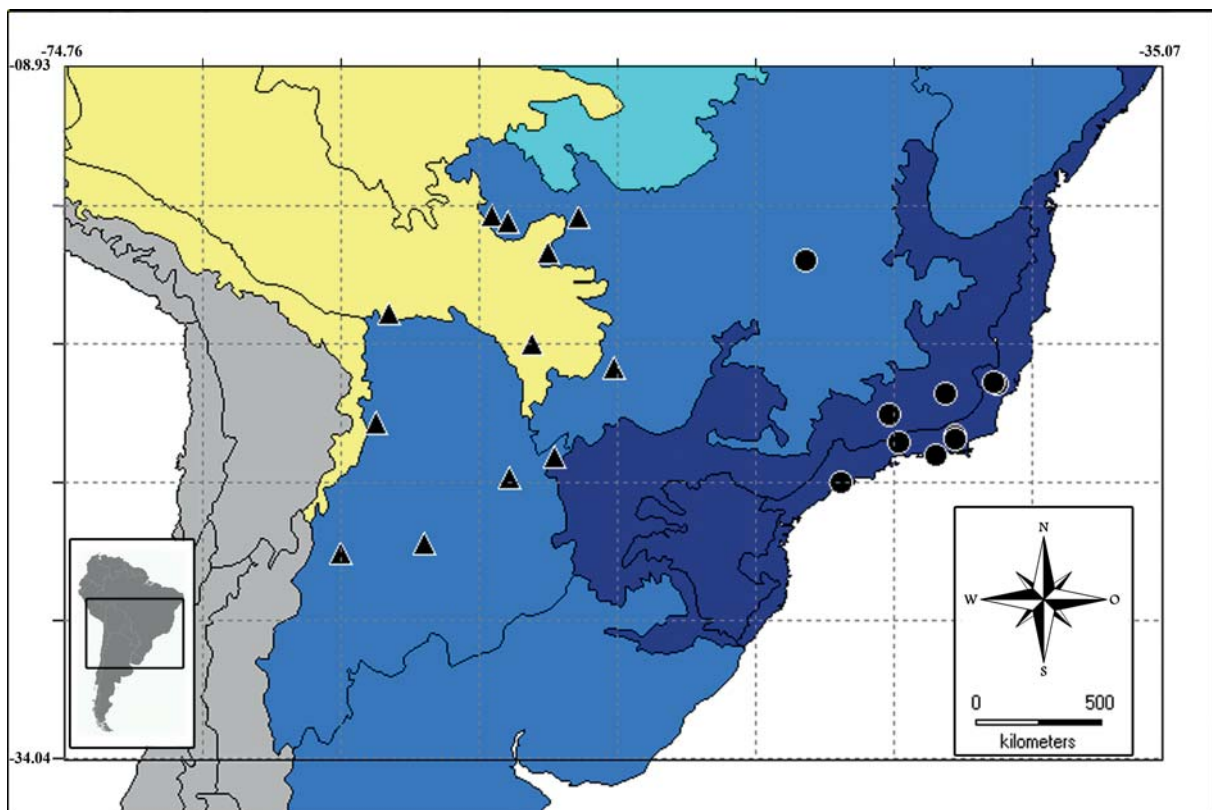


Fig. 10. Geographical distribution of *Canthidium gigas* Balthasar, 1939 (circles) and *Canthidium bokermanni* (Martínez et al., 1964) (triangles)..

no other specimens have been reported from that region. Furthermore, the German entomologist Carl Felsche (who acquired the specimen) was known for buying insects, and this kind of mislabelling has been seen before with his specimens (FZVM, personal observation).

Canthidium (Neocanthidium) bokermanni (Martínez *et al.*, 1964)

Figs 3, 10

Neocanthidium bokermanni Martínez *et al.*, 1964: 168–172 (original description).

Neocanthidium bokermanni – Solís & Kohlmann 2004: 5 (checklist). — Kohlmann & Solís 2006: 236 (checklist). — Cupello 2018: 453, 465, 467 (checklist).

Canthidium (Canthidium) bokermanni – Martínez & Halffter 1986: 21 (checklist).

Canthidium bokermanni – Nunes & Vaz-de-Mello 2013: 416 (mention).

Canthidium (Neocanthidium) bokermanni – Cupello 2018: 467 (new subgeneric assignment).

Dichotomius (Luederwaldtinia) paraguayanus Gandini & Aguilar, 2009 (parts): 139, figs 1–8 (2 paratypes).

Type material examined

Holotype

ARGENTINA • ♂; handwritten label; “ARGENTINA, TUCUMAN, Dto BURRUYAÇÚ/ Km. 5 Burruyaçu/ a San Ramón/ Coll. Martínez// 28-III-946”; “HOLOTYPUS”; “*Neocanthidium/ bokermanni/* M., H. y P sp. n. ♂/ A. MARTÍNEZ DET.1963”; “MACN-En 903”; MACN.

Paratypes

BOLIVIA • 1 ♀; Santa Cruz, Santa Cruz de la Sierra; 17°52'00.00" S, 63°00'00.00" E; 10 Nov. 1955; R. Zischa leg.; CEMT.

Dichotomius paraguayanus

Paratypes

PARAGUAY • 1 ♂; Concepción, Zanja Morotí; 17 Nov. 2001; Martínez leg.; CEMT • 1 ♂; Boquerón, Loma Plata; 24 Sep. 1995; Drechsel leg.; CEMT.

Other specimens examined

ARGENTINA • 1 ♀; Chaco, Potrero; 26°08'35.8" S, 61°41'49.5" W; 31 Oct. 2016; Guerra Alonso leg.; CEMT.

BOLIVIA • 1 ♂; Santa Cruz, Germán Busch, Puerto Suárez, Cerro de Mutum; 18°58'00" S, 57°47'53.00" E; Dec. 2012; P. Wagner leg.; CEMT • 1 ♀; Tarija, between Caiza and Crevaux; blue light; 21°48'53" S, 63°26'53" W; 536 m a.s.l.; 5 Jan. 2005; Mann, Hamel and Herzog leg.; OUMNH.

BRAZIL • 1 ♀; Mato Grosso, Cuiabá; 8 Mar. 2016; L.P. Melo leg.; CEMT • 1 ♀; Chapada dos Parecis, 30 km N Uirapuru; FIT; 14°17' S, 59°15' W; 1–15 Dec. 2001; A. Foucart leg.; CEMT • 1 ♀; Diamantino, Vale da Solidão, riparian Forest; 14°21'50" S, 56°7'23" W; 18 Feb. 2009; D.T.C. Oliveira leg.; CEMT • 1 ♂; same locality as for preceding; 26 Jan. 2009; D.T.C. Oliveira leg.; CEMT • 1 ♀; same locality as for preceding; 14°21'52" S, 56°7'23" W; 23 Dec. 2008–26 Jan. 2009; D.T.C. Oliveira leg.; CEMT • 1 ♀; same locality as for preceding; 14°22'23" S, 56°7'25" W; 31 Jan.–14 Feb. 2009; D.T.C. Oliveira leg.; CEMT • 1 ♀; Porto Estrela, Estação Ecológica [“Est. Eco”] Serra das Araras; light trap; 15°39'14" S, 57°13'1" W; Nov. 2003; L. Kaminski leg.; CEMT • 1 ♀; same locality as for preceding, Boca do José; FIT; 15°39'14" S, 57°13'1" W; Nov. 2003; R. Nunes leg.; CEMT • 1 ♂; Tangará da Serra; 27 Mar.

2016; G.A.A. Arenhart leg.; BMNH • 2 ♀♀; Tangará da Serra, Chácara Asa Branca; manual collection; 14°32'42" S, 58°40'28" W; Nov. 2011; E. Meurer leg.; CEMT • 1 ♀; Tangará da Serra, Campus UNEMAT; light trap; 14°38'58" S, 57°25'24" W; 439 m a.s.l.; R.J. Silva leg.; CEMT • 1 ♀; Chácara Paraíso, semi-deciduous forest; FIT; 14°39'4" S, 57°24'55" W; 460 m a.s.l.; 26 Jan. 2011; CEMT • 1 ♀; same data as for preceding; BMNH • 2 ♂♂; Campos de Júlio, Chapada dos Parecis, 30 km N of Uirapuru; FIT; 14°17' S, 59°15' W; Dec. 2002; A. Foucart leg.; CEMT • 1 ♀; Cuiabá; 8 Mar. 2016; P.L. Mello leg.; CEMT • 1 ♀; Cláudia, Fazenda ["Faz."] Iracema; 11°37'44" S, 55°05'54" W; 20 Feb. 2011; M.F. Souza leg.; CEMT • 2 ♀♀; Mato Grosso do Sul, Corguinho, Quinta do Sol; FIT; 19°49'57" S, 54°49'45" W; Feb. 2011; L.O. Bavutti leg.; CEMT.

Diagnosis

Canthidium bokermanni resembles *C. gigas* in the presence of a transverse carina on the head and distinct punctuation of the pronotal disc; it differs only in the dorsal angles of the parameres. See comments under *C. gigas* for more details.

Redescription

HEAD. Surface with dense and distinctly punctuation, especially on clypeus. With a transverse raised projection in the front.

PRONOTUM. Without anteromedial depression, disc anteriorly convex, sometimes with an anterior sinuosity forming two broad and shallow depressions (both surrounding the medial line).

HYPOMERON. With microstriae and setae in the basal part. Hypomerical carina complete, curved throughout its length.

METAVENTRITE. With simple and shallow punctuation, laterobasal region with stronger punctuation, lateral region with microsculpture obscurely variolate, almost semicircular.

MESEPIMERON AND MESEPISTERNUM. With shallow punctuation, stronger microsculpture obscurely variolate, semicircular.

HIND LEG. Metafemora with a carina along posterior edge, anterior edge with setal fringe, surface with fine punctuation. Metatibiae elongated and gradually dilated towards the apex; external margin serrated.

AEDEAGUS. In dorsal view, parameres lacking angulation apically and with a shallow excavation at apex; in lateral view, dorsally with internal median angulation of 160°.

Variation and sexual dimorphism

Total length ranges from 9 to 13 mm. The transverse carina of the head varies from rectangular to oval, regardless of the size and sex of the specimen. The males have a tooth in the upper ventral part, more developed in some specimens than in others. Males have ventrite VI wider medially, female ventrite VI is of the same length throughout. Males also have protibial spur flattened, while in females the protibial spur is narrowed and pointed.

Geographical distribution

The specimens examined were collected in Argentina (Chaco), Brazil (Mato Grosso and Mato Grosso do Sul), Bolivia (Santa Cruz), and Paraguay (Concepción and Boquerón). The species occurs in two different biogeographic dominions: the Chacoan dominion and the South Brazilian dominion.

Comments

Two paratypes of *Dichotomius paraguayanus*, which were incorrectly interpreted as females by Gandini & Aguilar (2009), proved to be males and to belong to *C. bokermanni*.

Discussion

As previously stated, species groups have so far been delimited, for practical purposes, in several Scarabaeinae genera including *Dichotomius* Hope, 1838 (Luederwaldt 1929; Nunes & Vaz-de-Mello 2013), *Onthophagus* Latreille, 1802 (Zunino & Halffter 1997), *Eurysternus* Dalman, 1824 (Génier 2009), *Ontherus* Erichson, 1847 (Génier 1996) and *Canthon* Hoffmannsegg, 1817 (Halffter & Martínez 1977). We note that the members of the *gigas* group exhibit unique characters that distinguish them from their congeners. In fact, some authors have identified specimens of the *gigas* group in other genera [such as *Dichotomius* (Nunes & Vaz-de-Mello 2013)], which shows how much they differ from other species of *Canthidium*.

In addition to the above described morphological characteristics that separate the species, the group is well established based on its geographical distribution. Endemic to South America, the species occurs in different ecoregions. *Canthidium gigas* and *C. ayri* sp. nov. are endemic to the Atlantic Forest, their occurrence being restricted respectively to the north and south of this biome. *Canthidium bokermanni* and *C. kelleri* are found in Cerrado vegetation; *C. bokermanni* in the west region of the biome, and *C. kelleri* in the east. Finally, *C. feeri* sp. nov. is restricted to French Guiana, north of the Amazon biome, and *C. stofeli* sp. nov. occurs in the southern region of this biome.

The group also has unique characteristics regarding feeding. Most species of Scarabaeinae are coprophagous, but there may be variations, such as *C. kelleri* and *C. bokermanni* feeding on the mycelia of fungi (Halffter & Matthews 1966). Most recently, Falqueto *et al.* (2005) reported *C. gigas* from fungus-baited pitfall traps. The two paratypes of *C. ayri* sp. nov. were collected with light traps and the other species often appear in flight interception traps, in addition to traps baited with fungi. More studies and field observations are needed to confirm if fungi are indeed a fundamental part of these species' diet.

Conclusions

This work dealt with the taxonomic revision of the *Canthidium* species of the *gigas* group. We described three new species for the group, but we firmly believe that in order to broaden the distribution data more studies are required, including field collecting and museum studies.

Acknowledgments

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