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RESEARCH ARTICLE
TAXONOMIC CATALOG OF THE BRAZILIAN FAUNA

Brazilian Scarabaeoidea (Insecta: Coleoptera) in the Taxonomic Catalogue of the Brazilian Fauna, with a key for families and subfamilies

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ABSTRACT. A comprehensive overview of Scarabaeoidea in Brazil is provided based on the Taxonomic Catalogue of the Brazilian Fauna (CTFB). Data in CTFB include 2,532 valid species within 345 genera, belonging to 21 subfamilies and 10 families. Those have been described by 272 authors from 1758 to 2023. Among these authors, Carl Hermann Conrad Burmeister (1807–1892), George Frey (1902–1976), Friedrich Ohaus (1864–1946), Julius Moser (1863–1929), and Edgar von Harold (1830–1886) stand out as the most prolific, collectively accounting for approximately 43% of all known Brazilian species of Scarabaeoidea. For taxa occurring in Brazil, we also provide a dichotomous key for use identifying Scarabaeoidea families and subfamilies, along with diagnosis, remarks, and comments on their natural history.

KEY WORDS. Beetles, checklist, Lamellicornia, taxonomy, CTFB.

INTRODUCTION

Scarabaeoidea Latreille, 1802, historically referred to as "Lamellicornia" (see Kohlmann and Morón 2003), are one of the most diverse superfamilies of Coleoptera, comprising approximately 41,370 extant species into 15 families with a cosmopolitan distribution (sensu Schoolmeesters 2023). According to Krell (2006), the origin of the group dates back to the Upper Jurassic, nearly 180 million years ago, and a recent molecular clock used in a phylogeny of Coleoptera, conducted by Cai et al. (2022), corroborates the fossil evidence.

Beetles belonging to Scarabaeoidea can be diagnosed by the following characters: antennae formed by a scape, a pedicel, a funicle bearing at least one almost radially symmetrical antennomere, and a clava or club bearing three to seven lamellate antennomeres; procoxa conical or cylindrical, with base concealed in coxal cavity, capable of a wide antero-posterior movement; protibia with at least one distal outer tooth; prothorax with sintrocanthin (the small and fused episternun, epimeron, and trochantin) concealed in coxal cavity and articulated to the ventral side of notum; prothorax and pterothorax articulation tough and capable of a strong dorso-ventral movement;

abdominal tergite VIII forming a pygidium; male terminalia bearing a ventral spiculum gastrale (detached and ventrally fused laterals of tergite IX) posterior or fused with the sternite IX, dorso-lateral paraprocts (split tergite IX; also called hemitergite), a dorsal proctiger (tergite IX), and genitalia usually with a cylindrical phallobase bearing a basal apodeme, parameres evident, penis with or without a medial sclerotized piece and with a membranous endophallus (usually retractile but permanently everted in some species) bearing the terminal flagellum; female terminalia bearing a dorsal proctiger and dorso-lateral paraprocts as males, a latero-ventral robust gonocoxite that could be divided in two or three shield-like pieces (proximal, medial and distal pieces of gonocoxite; often called valvifers, hemisternite, gonosubcoxites, or lateral paraproct), and a distal small gonostylus; and larvae are scarabaeiform usually with a "C" shape (Sharp and Muir 1912, Hlavac 1975, Lawrence and Newton 1982, Kohlmann and Morón 2003, Dupuis 2005, Scholtz and Grebennikov 2005).

The scarabaeoids are found in virtually all terrestrial habitats, with a high diversity of food habits, i.e., herbivores, necrophages, fungivores, coprophages, etc (see Marinoni et al. 2003), performing important environmental functions and services, like pollination, nutrient cycling, and bioturbation. Larvae of some species, mainly of Melolonthidae, have been reported as agricultural pests (Morón 1997, Cherman et al. 2011, Oliveira and Frizzas 2021).

While no one disputes the monophyly of the superfamily, evolutionary relationships and classification between families have been the subject of several studies, with differing opinions between authors (e.g., Howden 1982, Browne and Scholtz 1999, Smith et al. 2006, Bouchard et al. 2011, Cherman and Morón 2014, McKenna et al. 2015, Dietz et al. 2023). For the comprehensive history of Scarabaeoidea classifications up to twenty years ago, see Kohlmann and Morón (2003).

As with other groups of insects, the taxonomic studies of South American Scarabaeoidea were initiated by European authors as a result of collecting trips during the 17th to 20th centuries (Papavero 1971, 1973). Several works were published, documenting and describing the New World fauna of scarabaeoids (i.e., Blanchard 1847, Lacordaire 1856, Harold 1868, 1869, Arrow 1912, Blackwelder 1944, 1973) or, more recently, by country (i.e., Mexico: Kohlmann et al. 2023, El Salvador: Pablo-Cea et al. 2023, Panama: Ratcliffe 2002, Chile: Mondaca 2023, Ecuador: Carvajal et al. 2011, Peru: Ratcliffe et al. 2015, Guianas: Hielkema and Hielkema 2019, and part of Colombia: Taboada-Verona et al. 2019). For Brazil, data on some groups of Scarabaeoidea are sparse in the literature, limited to the revisions of taxa, checklists from Brazilian regions, and more recent results of Ecological work (see Cupello et al. 2023 for an overview).

The aim of this study is to introduce the state-of-art of the Brazilian Scarabaeoidea fauna based on information present in the Taxonomic Catalogue of the Brazilian Fauna (CTFB). This compilation of data is an effort of several Brazilian authors who, since 2015, update CTFB based on revisions, checklists or any publication dealing with Scarabaeoidea, to document all Brazilian fauna in a comprehensive online dataset.

MATERIAL AND METHODS

The data analyzed were extracted from the Scarabaeoidea section of the CTFB website (http://fauna.jbrj.gov.br/fauna/listaBrasil/PrincipalUC/PrincipalUC.do?lingua=en). All available data of Scarabaeoidea were exported into an Excel spreadsheet on May 10, 2023. In this study we are following the classification proposed by Bouchard et al. (2011) with modifications proposed by Cherman and Morón (2014), of which recognize 14 families of Scarabaeoidea (Table 1).

These data include published information on each species or subspecies of Scarabaeoidea reported from the Brazilian territory as follows: ID number (given for each species individually), author's name and year of description, whether the species maintains its original combination or not, whether the name is valid or a synonym, and whether the species is endemic to Brazil or not. Data extracted from CTFB were accounted for using the "dplyr" package in the R-Studio software.

Information on the occurrence of the species in Federative Units and/or biomes are not available for some groups. However, all species have their taxonomic history fully completed, for instance, if the name of a species was changed (e.g., new combination) during the taxonomic history, the original combination is also provided. Data on the number of species each author described between 1758 and 2023, as well as the accumulation curve of species description during the same period were also generated.

All photographs presented here were made using a stereomicroscope Leica model m205C (7.8X–160.0X) with image capture system MC190 HD.

RESULTS AND DISCUSSION

A total of 2,532 valid species, 345 genera, 21 subfamilies and 10 families of Scarabaeoidea are reported in the Brazilian territory (Table 2). The number of species represents

Table 1. Family names of Scarabaeoidea proposed by different authors.

MacLeay (1819)	Arrow (1910)	Crowson (1955)	Paulian (1988)	Bouchard et al. (2011)	Cherman and Morón (2014)
Aesalidae	Lucanidae	Acanthoceridae	Aclopidae	Belohinidae	Belohinidae
Anoplognathidae	Passalidae	Geotrupidae	Aegialiidae	Diphyllostomatidae	Cetoniidae
Aphodiidae	Scarabaeidae	Lucanidae	Allidiostomidae	Geotrupidae	Diphyllostomatidae
Cetoniidae		Passalidae	Aphodiidae	Glaphyridae	Geotrupidae
Dynastidae		Scarabaeidae	Aulonocnemidae	Glaresidae	Glaphyridae
Geotrupidae			Belohinidae	Hybosoridae	Glaresidae
Glaphyridae			Ceratocanthidae	Lucanidae	Hybosoridae
Lamprimidae			Cetoniidae	Ochodaeidae	Lucanidae
Lucanidae			Chironidae	Passalidae	Melolonthidae
Melolonthidae			Diphyllostomatidae	Pleocomidae	Ochodaeidae
Passalidae			Dynastidae	Scarabaeidae	Passalidae
Rutelidae			Euchiridae	Trogidae	Pleocomidae
Scarabaeidae			Geotrupidae		Scarabaeidae
Syndesidae			Glaphyridae		Trogidae
Trogidae			Hybosoridae		
			Lichniidae		
			Lucanidae		
			Melolonthidae		
			Ochodaeidae		
			Orphnidae		
			Pachypodidae		
			Passalidae		
			Phaenomeridae		
			Rutelidae		
			Scarabaeidae		
			Systellopodidae		
			Taurocerastidae		
			Trogidae		

Table 2. Total number of valid subfamilies, tribes, subtribes, genera, subgenera, species, and subspecies of the 10 Scarabaeoidea families occurring in Brazil.

Family	Subfamily	Tribe	Subtribe	Genera	Subgenera	Species	Subspecies
Cetoniidae	2	5	4	22	0	84	3
Geotrupidae	1	1	0	7	1	76	0
Glaresidae	1	0	0	1	0	1	0
Hybosoridae	4	2	0	19	4	85	3
Lucanidae	2	5	0	14	3	75	0
Melolonthidae	6	23	7	163	14	1,591	137
Ochodaeidae	1	1	0	1	0	3	0
Passalidae	1	2	0	12	2	110	7
Scarabaeidae	2	13	8	104	45	826	59
Trogidae	1	0	0	2	2	15	0
Total	21	51	19	345	71	2,532	203

Table 3. Total number of valid subfamilies, tribes, subtribes, genera, subgenera, species, and subspecies scrutinized from the Taxonomic Catalog of the Brazilian Fauna (CTFB) for Brazilian fauna and the Catalogue of Life (COL) for the world fauna of Scarabaeoidea.

Category	Brazil (CTFB)	World (COL)
Families	10	15
Subfamilies	21	59
Tribes	51	164
Subtribes	19	105
Genera	345	3,040
Subgenera	71	556
Species	2,532	41,370
Subspecies	203	3,809

approximately 6.12% of all described species of Scarabaeoidea worldwide (Schoolmeesters 2023; Table 3). Among the families reported in Brazil, Melolonthidae (with 1,591 species) and Scarabaeidae (826 species) constitute 82.26% of the entire superfamily. On the other hand, Glaresidae and Ochodaeidae have one and three species reported from Brazil, respectively. Additionally, 272 authors have described species of Scarabaeoidea from Brazil. The top five authors in terms of the number of described species are Carl Hermann Conrad Burmeister (251 species; Fig. 1A), Georg Frey (227 species; Fig. 1B), Friedrich Ohaus (216 species; Fig. 1C), Julius Moser (199 species; Fig. 1D), and Edgar von Harold

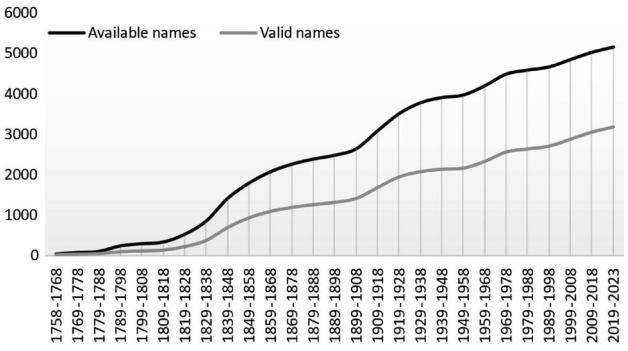
Abb. 7: Dr. h.c. Georg Frey. (Foto Archiv Naturhistorisches Museum Basel).

Figure 1. The four most prolific authors who described a total of 893 valid species of Scarabaeoidea reported from Brazil: (A) Carl Hermann Conrad Burmeister, 1807–1892; (B) Georg Frey, 1902–1976); (C) Julius Moser, 1863–1929; (D) Friedrich Ohaus, 1864–1946. Images A, C, D available at https://sdei.senckenberg.de/biographies/index.php. Image B extracted from Sprecher-Uebersax et al. (2013).

(195 species). Collectively, their contributions account for approximately 30.12% of all available names (Appendix 1).

A total of 5,168 new species (and subspecies) were described between 1758 and May 2023, showing that 48.9% of all described species were synonymized during the taxonomic history of the group (Fig. 2). When analyzing Fig. 3, it is possible to identify three main peaks of species descriptions. The first and largest peak is for 1839–1848, with 562 described species, of which 320 are currently valid. A significant portion of the high number of species described during this time (203) is attributed to Hermann Burmeister (Fig. 1A). Also, Charles Émile Blanchard (in Blanchard and Brullé 1835–1847; see Sherborn and Griffin 1934), described 81 new scarabaeoids that occur in Brazil. The second peak (1909–1918), with an accumulation of 448 newly described species (of which 271 are currently valid), included works by Friedrich Ohaus (123 species), Julius Moser (111 species), and Gilbert Arrow (48 species). After 1938, there was a noticeably abrupt decline that extended until 1958, maybe partially due to the damages caused by the Wars to natural history museums in Europe, and Europe reconstruction efforts, that may have delayed access to specimens deposited in these institutions. The third and last peak is dated between 1969 and 1978, driven by a new generation of authors who focused in the Scarabaeoidea systematics, like Georg Frey (140 species), Rudolf Petrovitz (58 species), and Sebö Endrödi (32 species).

A study recently published by Cupello et al. (2023) summarises and explores the rise of taxonomic studies in Scarabaeinae fauna. While arguments put forth by the authors to elucidate a "taxonomic revolution" are primarily centered around studies of Scarabaeinae in the New World, many of the points discussed can be extended to studies of Scarabaeoidea in Brazil (see Cupello et al. 2023).



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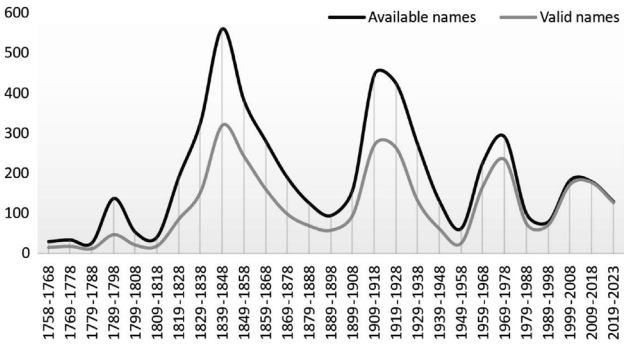

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Figures 2–3. Number of accumulated available and valid species between 1758 and 2023. (3) Number of available and valid names of Scarabaeoidea recorded from Brazil between 1758 and 2023.

Identification key to the Brazilian families and subfamilies of Scarabaeoidea

1. Antennae with 11 antennomeres; and antennal club composed of three antennomeres ..... Geotrupidae: Bolboceratinae (Fig. 4E)
1'. Antennae with 10 or fewer antennomeres; if more, then antennal club with more than three antennomeres 2
2. Mesotibia with the larger spur pectinate (Fig. 6A, black arrow) ..... Ochodaeidae: Ochodaeinae (Fig. 4G)
2.' Mesotibia with both spurs not pectinate 3
3. Antennal lamellae separated, preventing them from moving together into a compact block (Fig. 6C) 4
3'. Antennal lamellae closed at the base, allowing mobility and the ability to come together forming a single compact mass (Fig. 6B) 6
4. Antennae geniculate (Figs 4J, 6C); if not, then body strongly cylindrical ..... Lucanidae 5
4'. Antennae never geniculate (Figs 4M and 6B), body always flattened ..... Passalidae: Passalinae (Fig. 4M)
5. Antennae geniculate (Fig. 6C) ..... Lucanidae: Lucaninae (Fig. 4J)
5'. Antennae not geniculate (Fig. 6B) ..... Lucanidae: Syndesinae (Fig. 4L)
6. Five visible sternites 7
6'. Six visible sternites 9
7. Clypeus as wide as labrum, semicircular; labrum fully exposed anteriorly to clypeus ..... Melolonthidae: Aclopinae (Fig. 5A)
7'. Clypeus much wider than labrum, that is mostly concealed beneath clypeus 8
8. Eyes divided by canthus (Fig. 6D, white arrow). Size smaller than 6 mm ..... Glaresidae (Fig. 4F)

8'. Eyes not divided by canthus (Fig. 6E, white arrow). Size over 7 mm ..... Trogidae: Omorginae (Fig. 5G)
9. Labrum and mandibles not visible anteriorly, dorsally or laterally, base of mandibles sometimes visible laterally. Mandibles with incisor lobe membranous and setose, with brush- or comb-like apex, seldom partially visible. Clypeus and gena dorsoventrally flattened and usually forming a broad anterior surface, being separated from each other by a dorsal suture (sometimes indistinct) ..... Scarabaeidae 10
9'. Either labrum or mandibles, or most commonly both, visible anteriorly, dorsally or laterally, labrum at least visible anteriorly, however in some cases fused to clypeus and barely distinguishable. Mandibles with incisor lobe large and robust or small and blade-like, but not forming a brush-like structure (not to be confused with the prostheca that is usually a large setose membrane between incisivus and mola). Clypeus flat or not, not separated from gena by a dorsal evident suture; gena and clypeus not forming a flat anterior surface; gena dorsally exposed only by the evident canthus (rarely absent) 11
10. Mesocoxae usually separated by a distance smaller than their width. Metatibiae usually with two spurs (Fig. 6F; in some species the spur may be small and inconspicuous amidst the fringe of apical setae); if both spurs are absent, then the posterior margin of elytra will have conspicuous tubercles. Abdomen with propygidium not exposed, pygidium partially covered by elytra ..... Scarabaeidae: Aphodiinae (Fig. 5H)
10'. Mesocoxae usually separated by a distance greater than or equal to their width. Metatibiae always with only one spur (Fig. 6G). Abdomen with propygidium exposed, pygidium not covered by elytra. ..... Scarabaeidae: Scarabaeinae (Fig. 5I)
11. Antennal insertions visible dorsally in front of each canthus (Fig. 6I) ..... Cetoniidae 12
11'. Antennal insertions hidden dorsally by clypeus or canthus (Fig. 6B–C) 13
12. Mesepimeron visible dorsally (Fig. 6I, black arrow) ..... Cetoniidae: Cetoniinae (Fig. 4H)
12'. Mesepimeron not visible dorsally ..... Cetoniidae: Trichiinae (Fig. 4I)
13. Pronotum with a deep transverse groove in the middle of the disc. Size shorter than 6 mm not considering the abdomen, which can be greatly expanded beyond the elytra ..... Hybosoridae: Cerathocanthinae (pars)
13'. Pronotum without a transverse groove in the disc. Size in general longer than 6 mm 14
14. Protothorax shaped in a way that allows it to "close" together with the pterothorax, forming a body resembling a sphere or pill; size smaller than 10 mm..... Hybosoridae: Ceratocanthinae (pars) (Fig. 4B)
14'. Body not shaped like a sphere or pill as the protothorax and pterothorax do not join ventrally 15
15. Antennal club with the first antenomere excavated, accommodating the following antenomere (if first antennal club not excavated, then dorsal surface of elytra completely plane and separated from the pseudoepipleuron by a longitudinal keel – see Fig. 4A)..... Hybosoridae 16
15'. Antennal club with all articles lamellar, not excavated ..... Melolonthidae 18
16. Pronotum with large punctures, keels, and/or tubercles. Mesoventrite not invaginated 17
16'. Pronotum without large punctures (at most simple punctures), keels or tubercles. Mesoventrite invaginated ..... Hybosoridae: Hybosorinae (Fig. 4C)
17. Frontoclypeal suture evident; dorsal surface of elytra convex..... Hybosoridae: Pachyplectrinae (Fig. 4D)
17'. Frontoclypeal suture inconspicuous, if evident, then dorsal surface of elytra plane ..... Hybosoridae: Anaidinae (Fig. 4A)
18. Base of the spurs on the metatibia separated by the insertion of the first article of the metatarsus (Fig. 6H)....19
18'. Base of the spurs on the metatibia adjacent (Fig. 6F–G) 21
19. Labrum and mandibles exposed beyond the clypeal apex, visible in dorsal view..... 20
19'. Labrum and mandibles not exposed beyond the clypeal apex....Melolonthidae: Sericinae (pars) (Fig. 5D)
20. Laterally viewed, clypeus and labrum are at the same level..... Melolonthidae: Sericinae (pars)
20'. Laterally viewed, clypeus and labrum are at different levels ..... Melolonthidae: Orphninae (Fig. 5E)
21. Claws of the mesotarsus of the same shape and/or size (Fig. 6J; rarely with different shape in some Melolonthinae) 22
21'. Claws of the mesotarsus of different shape and/or size (Fig. 6L)..... Melolonthidae: Rutelinae (Fig. 5F)
22. Mesotarsus with bifid (Fig. 6M), appendiculate, or toothed claws (rarely simple); labrum may be visible. ..... Melolonthidae: Melolonthinae (Fig. 5C)
22'. Mesotarsus with simple claws (Fig. 6J); labrum covered by the clypeus ..... Melolonthidae: Dynastinae (Fig. 5B)

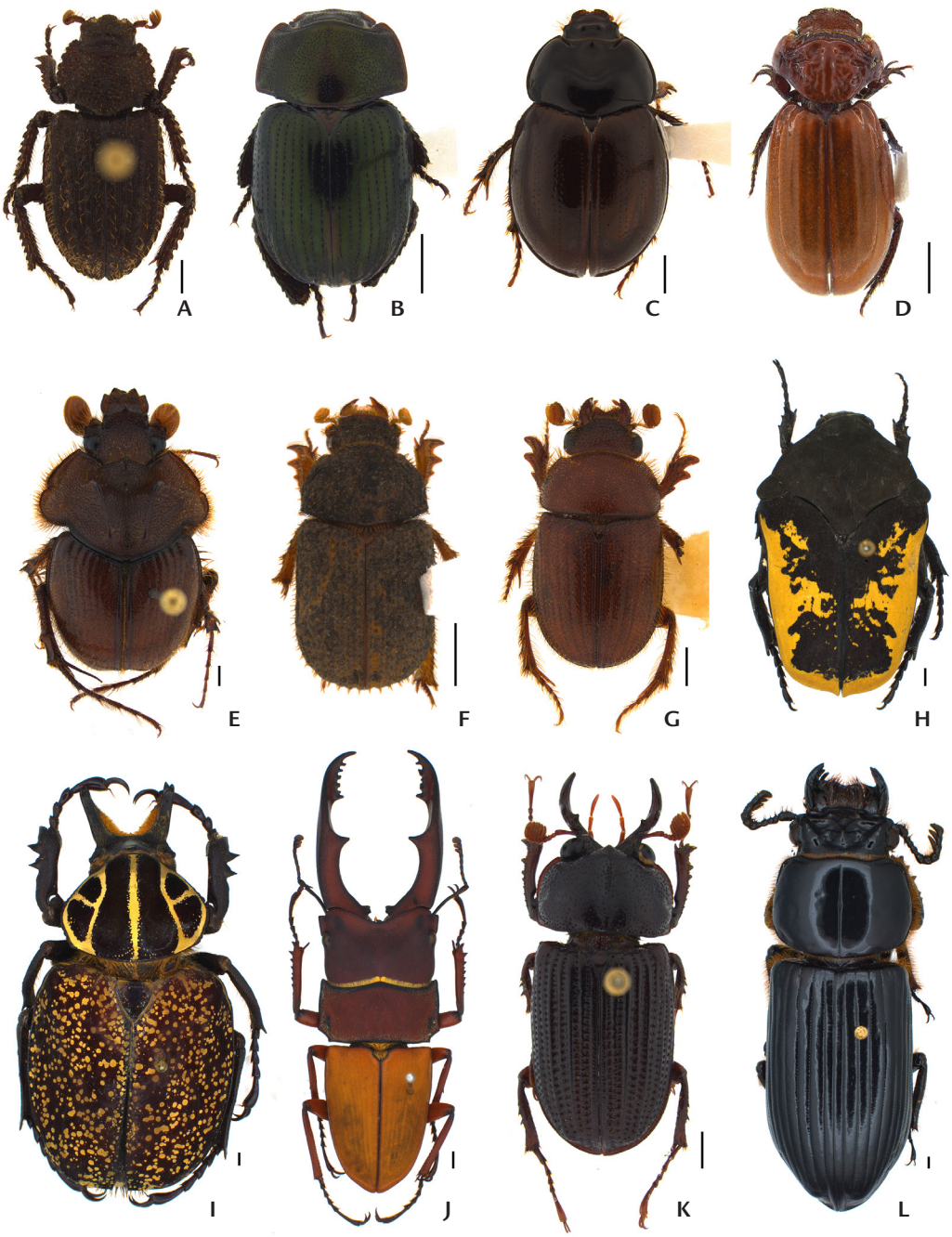

Figure 4. Dorsal habitus of representatives of Scarabaeoidea subfamilies from Brazil: (A) Hybosoridae: Anaidinae [*Cryptogenius miersianus* Westwood, 1842]; (B) Hybosoridae: Ceratocanthinae [*Germarostes aphodioides* (Illiger, 1800)]; (C) Hybosoridae: Hybosorinae [*Coilodes humeralis* (Mannerheim, 1829)]; (D) Hybosoridae: Pachyplectrinae [*Daimothoracodes mirabilis* Petrovitz, 1970]; (E) Geotrupidae: Bolbocerathinae [*Parathyreus rectus* Howden, 1985]; (F) Glaresidae: Glaresinae [*Glaresis pardoalcaidei* Martínez, Pereira and Vulcano, 1961]; (G) Ochodaeidae: Ochodaeinae [*Parochodaeus cornutus* (Ohaus, 1910)]; (H) Cetoniidae: Cetoniinae [*Gymnetis flava* (Weber, 1801)]; (I) Cetoniidae: Trichiinae [*Inca clathratus* (Olivier, 1789)]; (J) Lucanidae: Lucaninae [*Leptinopterus burmeisteri* Arrow, 1943]; (K) Lucanidae: Syndesini [*Psilodon schuberti* Perty, 1830]; (L) Passalidae: Passalinae [*Veturius sinuatus* (Eschscholtz, 1829)]. Scale bars: 1 mm.

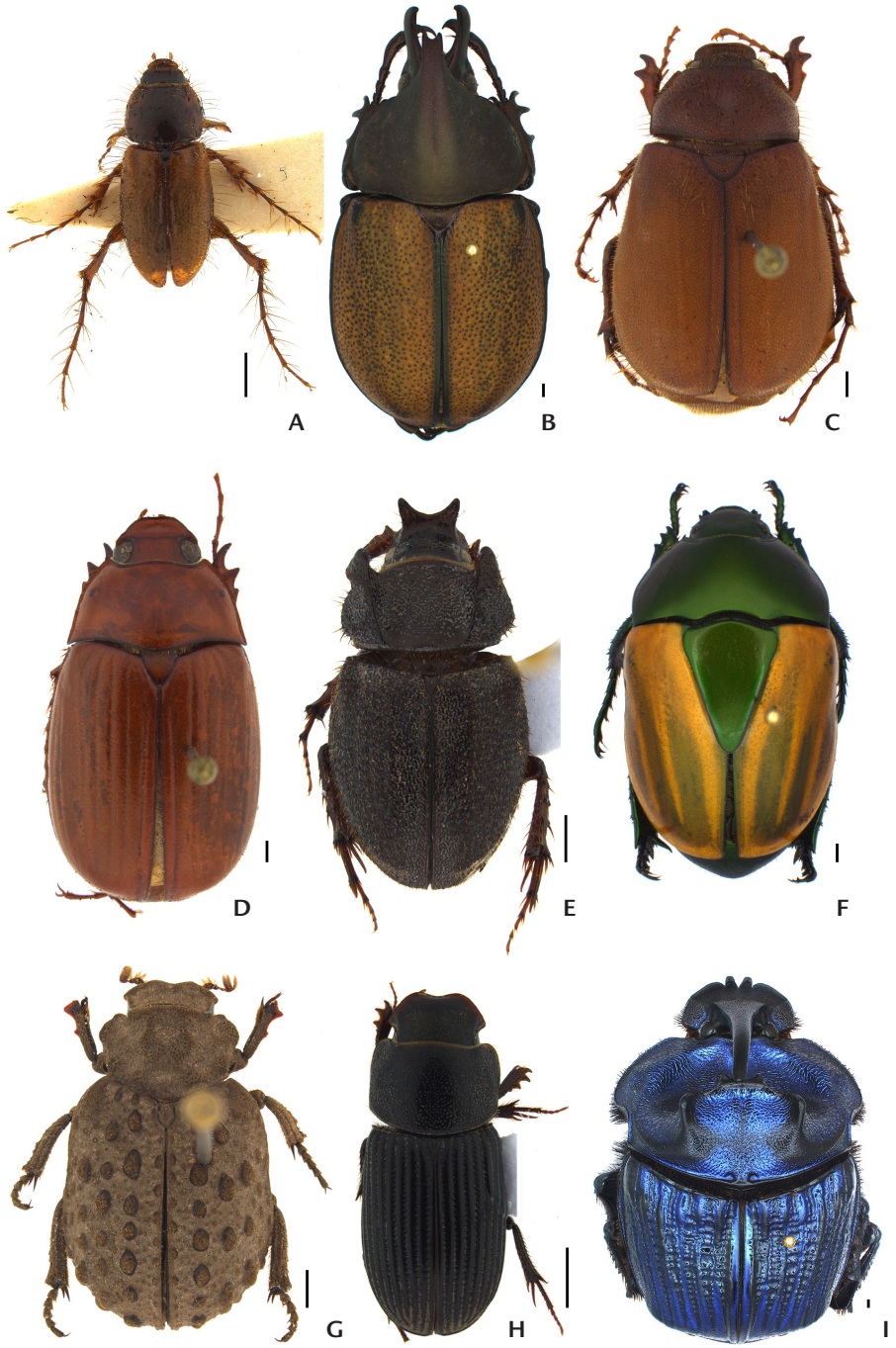

Figure 5. Dorsal habitus of representatives of Scarabaeoidea subfamilies from Brazil: (A) Melolonthidae: Aclopinae [*Aclopus brunneus* Erichson, 1835]; (B) Melolonthidae: Dynastinae [*Agacephala mannerheimi* Castelnau, 1832]; (C) Melolonthidae: Melolonthinae [*Phyllophaga cuyabana* (Moser, 1918)]; (D) Melolonthidae: Sericinae [*Ovomanonychus striatus* Costa, Cherman and Iannuzzi, 2020]; (E) Melolonthidae: Orphninae [*Paraegidium costalimai* Vulcano, Pereira and Martínez, 1966]; (F) Melolonthindae: Rutelinae [*Macraspis festiva* Burmeister, 1844]; (G) Trogidae: Omorginae [*Polynoncus bifurcatus* (Vaurie, 1962)]; (H) Scarabaeidae: Aphodiinae [*Ataenius strigicauda* Bates, 1887]; (I) Scarabaeidae: Scarabaeinae [*Coprophanaeus lancifer* (Linnaeus, 1767)]. Scale bars: 1 mm.

Figure 6. Morphological structures of Scarabaeoidea from Brazil: (A) Mesotibia with the larger spur pectinate (black arrow; *Parochodaeus cornutus* (Ohaus, 1910) – Ochodaeidae); (B) Anntenae not geniculate (*Athyreus tuberculatus* Westwood, 1848 – Geotrupidae); (C) Antennae geniculate (*Casignetus humboldti* (Gyllenhal, 1817) – Lucanidae); (D) Eyes divided by canthus (*Glaresis pardoalcaidei* Martínez, Pereira and Vulcano, 1961 – Glaresidae); (E) Eyes not divided by canthus (*Omorgus triestinae* Pittino, 1987 – Trogidae); (F) Metatibiae with two spurs (*Martineziana excavaticollis* (Blanchard, 1845) – Scarabaeidae, Aphodiinae); (G) Metatibiae with only one spur (*Coprophanaeus cyanescens* (d'Olsoufieff, 1924) – Scarabaeidae, Scarabaeinae); (H) Spurs on the metatibia separated by the insertion of the first article of the metatarsus (*Manonychus* sp. – Melolonthinae, Sericinae); (I) Mesepimeron visible dorsally (black arrow; *Gymnetis margineguttata* Gory and Percheron, 1833 – Cetoniidae); (J) Claws of the mesotarsus with the same shape and/or size (*Strategus surinamensis* Burmeister, 1847 – Melolonthidae, Dynastinae) and schematic drawing of the claws; (K) Claws of the mesotarsus of different shape and/or size (*Pelidnota burmeisteri* Burmeister, 1844 – Melolonthidae, Rutelinae); (L) Mesotarsus with bifid claws (*Euryaspis gaudichaudii* Blanchard, 1851 – Melolonthidae, Melolonthinae) and schematic drawing of the claws. Scale bars: 0.5 mm (A, D, F); 1 mm (B, C, E, G, H, I, J, K, L).

TAXONOMY

Families of Scarabaeoidea from Brazil

Cetoniidae Leach, 1815

Figs 4H–I, 6I

Diagnosis. Mandibles with small incisivus, hidden by the clypeus when observed dorsally. Procoxae conical and project ventrally. Many species have a post-humeral elytral emargination, and the mesepimeron is clearly visible in dorsal view (Krikken 1984, Cherman and Morón 2014; Fig. 6I).

Remarks. Cetoniidae are a very popular group in expositions due to their vibrant colors and significant horn variation. Many species hold ecological importance, as they act as predators of other insects, contribute to organic matter degradation (particularly decaying fallen fruit), and serve as pollinating agents (Krikken 1984). Species of Cetoniidae are typically collected using fruit baits in canopy traps when not found on natural resources.

It is a cosmopolitan group of beetles, with approximately 4,500 species described within about 500 genera (Schoolmeesters 2023). In Brazil, 84 species in 22 genera are known, distributed among five tribes in two subfamilies (Rodrigues et al. 2023). There are foundational works that can be used for identification, providing keys to the genera and species found in Brazil. These keys can also be used to identify species from other regions.

Researching by tribe in Cetoniinae, we can identify only genera of the New World Cremastochelini in the works of Howden (1971), Krikken (1976, 1981), and Martínez (1992). Species of the genus *Euphoria* Burmeister, 1842, the only member of the Cetoniini present in Brazil, can be identified in Orozco (2012). For the Gymnetini, there are works by Shaughney and Ratcliffe (2015), Ratcliffe and Deloya (1992), and Ratcliffe and Micó (2001), as well as numerous studies by Ratcliffe (2005, 2010, 2011, 2013, 2014a, 2014b, 2015a, 2015b, 2018, 2019). In the Trichiinae, *Trigonopeltastes* Burmeister & Schaum, 1840, is the only known genus of Trichiini in Brazil whose species can be identified in Howden and Joly (1998), Ricchiardi (2003), and Smith (2016). Finally, the Incaini (also referred as "Incini", see Sousa and Seidel 2021) are covered in the works of Ricchiardi (2002), Seidel et al. (2018), and Sousa and Seidel (2021).

Geotrupidae Latreille, 1802

Figs 4E, 6B

Diagnosis. Shape oval or round. Antennae with 11-antenomeres with 3-jointed club, with all antennomeres at least partially tomentose. Clypeus often with tubercle or horn. Mandibles produced beyond apex of labrum (Howden 1955, Jameson 2002a).

Remarks. These beetles exhibit a diverse diet, including saprophagous and mycetophagous, with some adults seemingly not feeding (Jameson 2002a, Houston and Bougher 2010). According to Jameson (2002a), adult geotrupids can dig deep burrows in the soil and usually remain there during the day, often being active at night (also see Lawrence and Jin 2019). Geotrupidae are found worldwide, with approximately 1,100 species described within about 83 genera in three subfamilies (Schoolmeesters 2023). In Brazil, there is only the Bolboceratinae, with 76 species in five genera (Vaz-de-Mello 2023a; Table 2). Species of Bolboceratinae are typically collected using flight interception traps or light traps, when not found in their natural habitat (Howden 2006, Boilly and Vaz-de-Mello 2021).

There are foundational works that can be used for identification of the Brazilian genera, like Howden and Martínez (1963) for Athyreini and Martínez (1976) for the non-Athyreyni. To identify the species of *Bolbapium* Boucomont, 1910 a recent revision in Carvalho and Vaz-de-Mello (2022) can be used. Species of *Athyreus* MacLeay, 1819 can be identified in Howden and Martínez (1978) with a new species from Brazil in Howden (2002). *Parathyreus* Howden and Martínez, 1963 can be identified in Howden (1985a). *Neoathyreus* Howden and Martínez, 1963 can be identified in Howden (1985b) and Boilly and Vaz-de-Mello (2021), that provided a key to species-group.

Glaresidae Preudhomme de Borre, 1886

Figs 4F, 6D

Diagnosis. Glaresidae are represented by small species (2.5–6 mm) similar to the genus *Trox* Fabricius, 1775 (Trogidae) (Scholtz et al. 1987). However, Glaresidae can be easily separated from Trogidae by a conspicuous characteristic of the large bulbous eyes divided by a prominent canthus (Fig. 6D; which is absent in species of Trogidae as showing in Fig. 6E).

Remarks. Glaresidae are a monogeneric family with 92 species described worldwide (Zídek 2015, Keller and Skelley 2020, Schoolmeesters 2023). *Glaresis* Erichson, 1848 was originally classified as a genus of the Trogidae, or sometimes as Scarabaeidae, until the phylogenetic study conducted by Scholtz (1986). One year later, the group was elevated to the rank of family by Scholtz et al. (1987). The proposal made by Scholtz et al. (1987) was supported by both morphologi-

cal (Browne and Scholtz 1999) and molecular (Smith 2006, Ahrens et al. 2014) phylogenies, and is followed today.

Regarding the Brazilian territory, only one species, *Glaresis pardoalcaidei* Martínez, Pereira & Vulcano, 1961, has been reported from Paraná state (see Costa-Silva and Vaz-de-Mello 2023a). It is not uncommon to find specimens of Glaresidae in Brazilian collections, indicating that *G. pardoalcaidei* – as well as other related new morphotypes still undescribed – has a wider geographical distribution in the country than previously thought. However, without a formal revision of the group, which needs to be urgently undertaken, this information will remain unknown to the scientific community.

Specimens of Glaresidae are often found in sandy habitats such as riverbanks and dune systems (Paulsen 2016). They can be collected actively, using flight interception traps or light traps.

Hybosoridae Erichson, 1847

Fig. 4A–D

Diagnosis. Hybosoridae are a morphologically heterogeneous family. Most species are commonly recognized by the presence of a prominent mandible and antennal club formed by three antennomeres, with the basal antennomere cupuliform, sheltering the other two (Ocampo 2006a, Basílio et al. 2023). The species of Ceratocanthinae do not present this antennal pattern, but they can be easily identified either by having a body capable of conglobation (Ceratocanthini) or by being very small in size (less than 6 mm) and having a transverse and deep excavation in the pronotum (Ivieolini and Scarabatermitini) (Ballerio and Grebennikov 2016). The only common characteristic to all Hybosoridae is the tarsal insertion before the apex of the protibia (Basílio et al. 2023).

Remarks. Hybosoridae have a worldwide distribution, comprising 96 genera and about 723 species distributed in six subfamilies, one extinct (Mimaphodiinae) and five extant (Anaidinae, Ceratocanthinae, Hybosorinae, Liparochrinae, and Pachyplectrinae) (Basílio et al. 2023). In Brazil, there are currently 19 genera and 85 species recorded in four of the five extant subfamilies – except Liparochrinae (Table 2) (Basílio and Vaz-de-Mello 2023). However, the number of genera and species, both in Brazil and worldwide, has been constantly increasing. Species of Hybosoridae have been recorded in almost all Brazilian states, and it is likely that there are species of this family in the five states that lack records so far (Tocantins, Piauí, Rio Grande do Norte, Alagoas, and Sergipe).

Hybosoridae were historically classified as a subfamily of Scarabaeidae (i.e., Hybosorinae and Ceratocanthinae) (Paulian 1982, Allsopp 1984, Howden and Gill 2000). However, even after Hybosoridae being elevated to the rank of family (with Ceratocanthinae treated as a subfamily of Hybosoridae) and being consensually accepted, these two taxa continued to be treated as separated families (Table 1) (Paulian 1988). In 2004, morphological data from larvae and adults recovered Hybosoridae with the inclusion of Ceratocanthidae, which started to be treated as Ceratocanthinae (Grebennikov et al. 2004). This classification is currently the most accepted, and is supported by morphological (Ocampo 2006b, Ballerio and Grebennikov 2016) and molecular data (Ocampo and Hawks 2006, Grebennikov and Smith 2021).

Regarding their biology, they can be necrophagous, coprophagous, fungivores, or feed on rotting wood. Many species have the habit of burying themselves, and some have stridulatory behavior. Associations with ants and termites have also been recorded (Jameson 2002b, Ocampo 2006b, Basílio et al. 2023). Representatives of Ceratocanthinae and Liparochrinae have the ability to roll their bodies into a ball (Ocampo 2006b, Ballerio and Grebennikov 2016). Dichotomous keys have been proposed to identify genera of Anaidinae (Ocampo 2006b), Ceratocanthinae (Paulian 1982, Ballerio and Grebennikov 2016), and Neotropical Hybosorinae (Basílio et al. 2022).

Lucanidae Latreille, 1804

Figs 4J–L, 6C

Diagnosis. Species of Lucanidae can be easily recognizable by the strong sexual dimorphism, with males presenting extremely elongate mandibles in most cases (as showed in the Figs 4J, 6C), although some taxa could be confused with other Coleoptera families. In Brazil, Lucanidae can be distinguished from other Scarabaeoidea families by the presence of three (Lucaninae) to six (Syndesinae) antennal lamellae, scape as long as funicle, and antennae usually geniculate (Fig. 6C). Tarsal claws always simple; ninth abdominal segment modified in a well-developed genital capsule; aedeagus in most cases with a permanently everted internal sac, except in the genus *Psilodon* Perty, 1830 (Syndesinae).

Remarks. Lucanids are the most diverse family of the first lineages of Scarabaeoidea, with around 1,805 worldwide described species, 147 genera in eight subfamilies, three of which are extinct (Schoolmeesters 2023). In Brazil there are currently 75 species representing two of the five living subfamilies (Grossi 2023). The Brazilian lucanids were first

studied by Luederwaldt (1930, 1931b, 1934c, 1935), and after him, and before the 2000s, four species were described in Brazil (Benesh 1937, Lacroix 1982, Bomans and Arnaud 1996). During the last 20 years, field work and studies on Brazilian stag-beetles have increased, and the family has been subject of new taxon descriptions, immature descriptions, life history approaches and reclassification of some genera (Grossi et al. 2003, Grossi and Vaz-de-Mello 2007, Grossi and Paulsen 2009, Grossi 2009, Grossi et al. 2012, Silva and Grossi 2019, Cáceres et al. 2023). Lucaninae are by far, the most diverse subfamily in Brazil and the World, comprising more than 90% of World Lucanid fauna. While the Syndesinae encompasses only three currently described species for Brazil, there will be at least twice that number described in an ongoing revision of *Psilodon*.

Among the Brazilian lucanid genera, *Altitatiayus* Weinreich, 1960, and probably *Zikanius* Grossi & Paulsen, 2009, and *Montesinus* Grossi, 2016 have underground behavior, with larvae feeding on grass roots. However, most other genera have larvae that feed on dead wood, decayed or not, and pupate in the wood, with only *Psilodon* pupating in the ground (see Grossi and Aguiar 2014). Genera like *Leptinopterus* Hope, 1838, *Macrocrates* Burmeister, 1847, *Metadorcus* Parry, 1870 *Metadorcinus* Kriesche, 1922, *Casignetus* MacLeay 1819, and *Charagmophorus* Waterhouse, 1895 can be collected during daylight, flying at mountain peaks, or feeding on sap flows. Other genera like *Sclerostomus* Burmeister, 1847 and *Psilodon* have nocturnal habits, being attracted to light traps.

Melolonthidae Leach, 1819

Figs 5A–F, 6H, 6J–M

Diagnosis. Melolonthids are difficult to be distinguished from other scarabaeoids because the taxon is highly diversified, usually they have the following features combined: mandibles strongly sclerotized; labrum and mandibles partially exposed or hidden by the clypeus dorsally; antennal club formed by three to seven lamellar articles, club in general as long as the funicle, lamellae with fan-like movement; abdomen with six ventrites, propygidium strongly sclerotized, junction (sometimes fused) with the corresponding sternite next to the last pair of spiracles; pygidium completely exposed or partially covered by the elytra; male genitalia bilobed or fused; body size from 3 to 170 mm (Endrödi 1966, Cherman and Morón 2014).

Remarks. Melolonthidae are probably (if not) the most specious family of Scarabaeoidea, comprising approximately 18,684 described species worldwide (Schoolmeesters 2023). Of these species, 1,591 are known from Brazil (Table 2), corresponding to about 8.5 % of the global diversity of the family and representing approximately 62.8% of the Brazilian fauna of Scarabaeoidea. Brazilian melolonthids are distributed in six subfamilies, where Melolonthinae, Rutelinae and Dynastinae have the most representatives, with 621, 476 and 396 species, respectively; the other three are Sericinae, Orphninae and Aclopinae, which encompass 75, 18 and 5 species, respectively (Vaz-de-Mello and Grossi 2023).

Dynastinae comprise the group of beetles popularly called rhinoceros beetle (Ratcliffe et al. 2020). In some Brazilian regions they are known as “cascudinho” or “besouro-de-chifre” (Lenko and Papavero 1996). The subfamily is currently subdivided in eight accepted tribes (whose definitions are unstable), six of which are known from Neotropical region, all represented in Brazil: Agaocephalini, Cyclocephalini, Dynastini, Oryctini, Pentodontini and Phileurini (Endrödi 1985). The taxonomic knowledge on the Brazilian dynastines is largely fragmented in literature and the synopsis published by Endrödi (1985) remains the main work covering the taxonomy of most tribes, genera and species. An up to date on the taxonomy for most taxa of the Dynastinae from Brazil is needed, mainly for greatly specious genera such as *Cyclocephala* Dejean, 1821 and *Heterogomphus* Burmeister, 1847. However, it’s worth highlighting the importance of recent taxonomic studies that produced new information regarding the Brazilian dynastines [see Sobral et al. (2018) for *Aegopsis* Burmeister, 1847; López-García and Deloya (2019, 2022) for *Tomarus* Erichson, 1847; Sobral et al. (2019) for *Colacus* Ohaus, 1910; Duarte and Grossi (2020a), and Duarte et al. (2022) for *Bothynus* Hope, 1837; Duarte and Grossi (2020b) for *Podischnus* Burmeister, 1847; Prandi et al. (2020) for *Megasoma* Kirby, 1825; Costa et al. (2022) for *Gibboryctes* Endrödi, 1974]. Adults of Dynastinae from Neotropical region are recognized by the body usually without metallic aspect (except some members of Agaocephalini); labrum not apparent, hidden below clypeus; outer margin of mandibles mostly exposed laterally to clypeus; antennae usually with10 antenomeres and club with three lamellae; meso- and metatarsi with both claws simple, equal, not movable, devoid of cleft, tooth or serrations; propygidium with or without stridulatory striae; sexual dimorphism usually pronounced: males of some taxa ornamented with remarkable horns that are absent or reduced in females. They are predominantly nocturnal or crepuscular when adults, being attracted to light at night (Ratcliffe et al. 2020). Some representatives of *Cyclocephala* are the main floral visitor of Annonaceae and Araceae in

Brazil (Maia et al. 2012). The larval stages of Dynastinae usually feed on decaying plant matter, mainly wood (Ritcher 1958, Ratcliffe et al. 2020), while others feed on roots of living plants and, in some situations, they can be considered of economic importance by damaging roots of cultivated plants (Gassen 1989, Lourenção et al. 1999, Oliveira and Frizzas 2021, Oliveira et al. 2008, Cherman and Grossi 2020).

Melolonthinae are the richest subfamily in Brazil, where they are represented by 625 species in 30 genera and five tribes (Cherman and Vaz-de-Mello 2024), but also among the Scarabaeoid subfamilies, with 6,009 species worldwide (Schoolmeesters 2023). This number was even greater (Evans 2002) before the splitting of the sericines and the sericoidines mainly (Ahrens et al. 2011, 2014, Šípek et al. 2016) into new subfamilies (Dietz et al. 2023, Schoolmeesters 2023). Among the five Brazilian tribes: Macrodactylini, Diplotaxini, Melolonthini, Hopliini, and Tanyproctini, the first three are the most representative (530, 51, and 37 species, respectively) and are also called the "true melolonthines", giving their close relationship with Melolonthini (Coca-Abia 2007, Ahrens et al. 2014, Cherman et al. 2016, Costa et al. 2021). Adults of Brazilian melolonthines are characterised (Evans 2002, Cherman and Pereira 2020) by having 5–25 mm in length, dorsal surface often conspicuously setose or scaled; color mostly reddish brown or black; mandibles and labrum well developed and completely hidden from above; antennal club oval to elongate, in general thin; head and pronotum always unarmed; metatibial spurs adjacent (when present), meso- and metatarsal claws in general toothed, cleft, or serrate; abdomen with five or six ventrites fused laterally, suture sometimes visible; and pygidium exposed. Sexual dimorphism weakly developed, most males with abdomen less convex, longer antennal club and tarsi than females. Often called May beetles, June beetles, and chafers, melolonthines are generally phytophagous, with some genera of considerable economic importance (i.e., *Phyllophaga* Harris, 1827, *Liogenys* Guérin-Méneville, 1831, and *Plectris* Le Peletier & Audinet-Serville, 1828) (Cherman et al. 2011, 2014, Valmorbida et al. 2018, Cherman and Pereira 2020, Coutinho et al. 2022), giving the nocturnal defoliation activity of adults and rhizophagous habits of larvae (Ritcher 1966, Morón 1997, Morón et al. 1997, Evans 2002). Identification keys to Brazilian species of Melolonthinae are sparse and fragmented, available for certain tribes (Macrodactylini: Fuhrmann and Vaz-de-Mello 2017; Diplotaxini: Cherman et al. 2019) or genera, such as *Plectris* (Frey 1967), *Liogenys* (Cherman et al. 2019), and *Phyllophaga* (Frey 1975). Additional works including keys to species of Melolonthinae occurring in agricultural environments are Cherman et al. (2013) (species from southern Brazil), Cherman and Pereira (2020) (Brazilian species), and Brumley et al. (2020) (exotic species of Australia).

Rutelinae MacLeay, 1819 are the second largest subfamily of Melolonthidae, with about 4,200 described species in the World (Jameson 1998, Hardy 1991, Jameson 2002c, Jameson and Hawkins 2005, Krajcik 2007, Jameson and Ratcliffe 2011, Morón and Ramírez-Ponce 2012, Moore et al. 2017), and the highest species richness recorded for tropical regions (Jameson 1998). Seven tribes are currently allocated to the Rutelinae: Adoretini, Alvarengini, Anatistini, Anomalini, Anoplognathini, Geniatini and Rutelini (Bouchard et al. 2011). Anomalini and Rutelini are recorded for the Nearctic, Neotropical, Palearctic and Afrotropical regions, while the Adoretini are recorded for the Palearctic and Afrotropical regions (Ohaus 1918). As for the Alvarengiini, records in Brazil are restricted to Bahia and Paraná states (Bento 2019). Anatistini is recorded in the Neotropical region; Anoplognathini is recorded for Australia and the Neotropical region; and Geniatini has records only in the Neotropical region (Ohaus 1918). In the Neotropical region, about 1,352 species of Rutelinae are recorded (Morón et al. 1997, Moron 2004, Villatoro and Jameson 2001, Villatoro 2002, Jameson and Hawkins 2005, Jameson 2008, Soula 2011, Filippini et al. 2016, Ferreira et al. 2017, Hawks 2017, Moore et al. 2017, Seidel et al. 2017, Sierra 2017, Ferreira et al. 2019, Ferreira and Grossi 2022, Ferreira et al. 2022), of which 476 species and 103 subspecies allocated in 58 genera are recorded for Brazil (Ferreira and Grossi 2023). Adults of Brazilian rutelines are for the most part very shiny, metallic blue, green, brown or reddish gold, and can vary from intense and shiny black to metallic gold, with a series of contrasting and iridescent combinations (Morón et al. 1997). Rutelinae are characterized by elongated and robust oval body, convex back, 3–30 mm in length; labrum weakly produced beyond apex of clypeus, except in *Anomalacra* Casey, 1915 (Anomalini); antennae with 8–10 antennomeres; scutellum exposed; transverse procoxa; mesotibia with two spurs at apex, adjacent; tarsal claws independently movable, unequal in length and often weakly divided at apex; and exposed pygidium (Ohaus 1934, Machatschke 1965, Morón et al. 1997, Jameson 2002c). Adults are strictly phytophagous and some play an important ecological role in the pollination of some plant species; the larvae are saprophytic and contribute directly to the decomposition process of dead organic matter deposited inside the forests, as well as to nutrient cycling (Hardy 1991, Morón et al. 1997, Paucar-Cabrera 2003). Some species

feed on the roots of plants of economic importance (i.e., *Leucothyreus* MacLeay, 1819 and *Paranomala* Casey, 1915) (Ritcher 1958, Jameson et al. 2003, Jameson and Howkins 2005). Despite the biological, ecological and diversity importance of rutelines, there are still gaps in the taxonomic knowledge of the group (Morón et al. 1997). In some of the tribes, most of the genera do not have identification keys for the species (i.e., Geniatini). However, important studies have been conducted on the group in recent years, especially in Brazil, including: (i) Systematic reviews in Alvarengiini (Bento 2019), in Geniatini to *Eunanus* Ohaus, 1909 (Ferreira et al. 2024), *Evanos* Castelnau, 1840 (Grossi and Vaz-de-Mello 2018), *Lobogeniates* Ohaus, 1917 (Ferreira unpublished data) and *Rhizogeniates* Ohaus, 1909 (Ferreira et al. unpublished data), and in Rutelini to *Byrsopolis* Burmeister, 1844 (Medeiros et al. 2022) and *Oplognathus* MacLeay, 1819 (Carvalho et al. 2021); (ii) Species descriptions with identification keys in Rutelini to *Chlorota* Burmeister, 1844 (Medeiros and Grossi 2020), *Homonyx* Guérin-Méneville, 1839 (Ferreira et al. unpublished data), *Macraspis* MacLeay, 1819 (Medeiros et al. 2019, Bento and Grossi 2021), *Moronius* Grossi & Vaz-de-Mello, 2015 (Carvalho and Grossi 2018), *Pelidnota* MacLeay, 1819 (Ferreira et al. 2017, 2018, 2021, 2022, Ferreira and Grossi 2022) and in Geniatini to *Trizogeniates* Ohaus, 1917 (Ferreira et al. 2019); and (iii) proposition of phylogenetic hypotheses in Geniatini, *Lobogeniates* (Ferreira unpublished data), *Rhizogeniates* (Ferreira et al. unpublished data) and *Geniates* Kirby, 1818 (Bento et al. unpublished data).

Sericinae are being considered a subfamily since phylogenetics hypotheses show a series of tribes (i.e., Sericini, Sericoidini, and Athliini (Ahrens 2006, Smith et al. 2006, Smith and Evans 2018)) clustered together, which were traditionally recovered within Melolonthinae (Ahrens et al. 2011, 2014, Gunter et al. 2016, Dietz et al. 2023). This subfamily comprises 5,322 species (Schoolmeesters 2023): the "true sericines", 4,000 species worldwide (Eberle et al. 2017), and the other 1,322 called the "Southern World" Melolonthinae, giving their distribution over the Southern Hemisphere (Ahrens et al. 2014, Eberle et al. 2014). Some authors also consider the latter group as another subfamily, Sericoidinae (Dietz et al. 2023, Schoolmeesters 2023). American Sericini have recently been assessed thoroughly (Pacheco et al. 2020, 2021, 2022a, 2022b, 2022c, 2023, Pacheco and Ahrens 2023), as well as the sericoidines (Costa et al. 2020, 2021). In Brazil, Sericinae are represented by 75 species in three tribes: Sericini, with 50 species; Sericoidini, with 23 species; and Athliini with two species. The species richness of this subfamily in the Neotropical region and especially in Brazil is still quite underestimated, and numerous species await description (FC Costa and TL Pacheco, personal communication). Available keys to American Sericinae are still scattered and out-of-date in most cases. For Brazilian Sericini, there are up-to-date identification keys to *Symmela* Erichson, 1835 (Pacheco et al. 2022c) and to *Raysymmela* Saylor, 1947 species (Pacheco et al. 2022b); Frey (1973) to *Astaena* Erichson, 1847 species. For the Brazilian Sericoidini, Frey (1973) is used for some *Blepharotoma* Blanchard, 1850 species, and there is a key to *Ovomanonychus* Costa, Cherman & Iannuzzi, 2020; while a key to *Manonychus* Moser, 1919 is being currently elaborated (FC Costa, personal communication). A key to Athliini is available in Smith and Evans (2018).

Aclopinae are a poorly known group of scarab beetles distributed in Australia and South America (Neita-Moreno et al. 2019). *Aclopus* Erichson, 1835 is the only genus of the subfamily recorded in Brazil, where five species are known, all distributed in central and southern regions (Ocampo and Mondaca 2012, Neita-Moreno et al. 2019). Apparently, there are no keys to identify species of *Aclopus*. Allsopp (1981, 1983), Ocampo and Mondaca (2012) and more recently Neita-Moreno et al. (2019) provided identification keys to genera and species of South American and Australian Aclopinae, but *Aclopus* was not included. Immature stages and natural history of the Aclopinae members are also unknown.

Orphninae are widely distributed throughout tropical and subtropical regions of the southern continents (Frolov 2012). Four genera are known from Brazil: *Aegidiellus* Paulian, 1984; *Aegidinus* Arrow, 1904; *Aegidium* Westwood, 1845; and *Paraegidium* Vulcano, Pereira & Martínez, 1966. All Brazilian Orphninae genera were studied in recent taxonomic revisions and contributions: see Colby (2009) and Frolov et al. (2019) for *Aegidinus*; Frolov et al. (2017a) for *Aegidium*; Frolov et al. (2017b) for *Paraegidium*, and Frolov et al. (2017c) for *Aegidiellus*. Regarding the immature stages of the Brazilian orphnines, only those of *Paraegidium costalimai* Volcano, Pereira and Martinez, 1966 are known (Sousa and Fuhrmann 2020).

Ochodaeidae Streubel, 1846

Figs 4G, 6A

Diagnosis. The most conspicuous and useful characteristic to separate Ochodaeidae from other Scarabaeoidea family is the presence of a pectinate spur on the mesotibia (Fig. 6A). No other family of Scarabaeoidea has this characteristic (see Paulsen and Ocampo 2012).

Remarks. The Ochodaeidae are a widespread family with 159 described species in 22 genera and two extant

subfamilies (one extinct; Schoolmeesters 2023). The dichotomous key provide by Paulsen and Ocampo (2012) is the unique tool to identify the South American species. For the Brazilian territory, just three species in one genus (*Parochodaeus* Nikolajev, 1995) are reported: *Parochodaeus jatahyensis* (Benderitter, 1912) from Goiás (GO), *P. campsognathus* (Arrow, 1904) from Mato Grosso (MT) and Rio Grande do Sul (RS), and *P. cornutus* (Ohaus, 1910) also from RS (Vaz-de-Mello and Costa-Silva 2023). With the exception of the study by Paulsen and Ocampo (2012), no other study has addressed the South American fauna of Ochodaeidae.

Available data on the natural history of Ochodaeidae are limited (Carlson 1975). Recent studies have mentioned species of Ochodaeidae as agricultural pests of the summer truffle (Asmomycota: Tuberaceae: *Tuber aestivum* Vittadini, 1831) in the Galilee region, Israel (Huchet et al. 2022). In the Brazilian context, despite the economic growth in the production and trade of hypogeous fungi (e.g., truffles and/or plants with mycorrhizal associations; see Sulzbacher et al. 2012, 2019, Grupe et al. 2018), the ecological relationships between Ochodaeidae and truffle cultivation remain unknown. Based on the material we examined in South American entomological collections, species of Ochodaeidae can be collected using flight interception traps and light traps.

Passalidae Leach, 1815

Fig. 4M

Diagnosis. One of the greatest peculiarities of the family is the undoubtedly remarkable morphological homogeneity. Most of species share the same basic morphological plan, which is further accentuated by a very rare visible sexual dimorphism (Boucher 2006). Passalidae are represented by individuals with medium to large size (13–80 mm), morphologically similar to some Lucanidae. However, this group can be easily distinguished from other families of Scarabaeoidea by having the following set of characters: strongly sclerotized body, with shiny black color, dorsoventrally flattened, elytra completely covering the abdomen and distinctly striated with evident punctations; prothorax separated from the elytra by a long pedunculated mesonotum, where the visible scutellum is located anteriorly and below the frontal edge of the elytra. Prognathous head with robust and strongly sclerotized mandibles having a complex dentition system; labrum large and rigid, spatulate, prominent and retractable that slides almost entirely into the oral cavity; ligula exposed, fully sclerotized, relatively large and located in front of the mentum; hypostomal process always developed, taller and longer than in other Scarabaeoidea. Dorsal region of head provided with several integumentary structures more or less concave or convex, unique in Passalidae.

Remarks. Passalidae, with about 1,000 valid species, are a relatively small group when compared to the other families of Scarabaeoidea. These wood-degrading beetles occur essentially in the Pantropical area, with a few species present in the Nearctic (Reyes-Castillo 1970, Boucher 2006).

Passalidae are subdivided into two subfamilies: Aulacocyclinae (Indo-Malo-Australian) and Passalinae (Pantropical) (Boucher 2006). With regard to the American Passalinae, the group is represented by two American endemic tribes: Proculini with 20 genera and Passalini with 14 genera, together comprising about 50% of global passalid diversity (Boucher 2006, Beza-Beza et al. 2020, Jiménez-Ferbans et al. 2022). In the Brazilian territory, Passalidae are the third most diverse family with about 110 species (Table 2) belonging to 12 genera, three from Proculini and nine from Passalini (Bevilaqua and Vaz-de-Mello 2023).

The most specious and contentious genus within the family is *Passalus* Fabricius, 1792, which is undeniably polyphyletic (Boucher 2015, Bevilaqua and Fonseca 2020). The lack of clear delimitation further exacerbates the disparity in species numbers within this genus compared to other genera in the family. Although a more recent proposal for the classification of Passalini and *Passalus*, based on a phylogenetic analysis incorporating morphological and molecular characters has been put forth (Jiménez-Ferbans et al. 2022), we adhere to the hypotheses proposed by Boucher (2015). These hypotheses validate some genera previously treated as synonyms or as a subgenus of *Passalus*, which remains a polyphyletic genus awaiting further division. *Veturius* Kaup, 1871, the second most diverse genus in the family, is indeed the largest monophyletic group at the genus level (Boucher 2006, Boucher and Salazar 2018).

In Brazil, the composition of the family is as follows: within Passalini, there are nine genera present in the country. *Passalus*, the most prominent genus, boasts 36 species and four subspecies. *Pertinax* Kaup, 1869, follows with 17 species and one subspecies; while *Paxillus* MacLeay, 1819, contributes nine species. *Spasalus* Kaup, 1869, is represented by seven species, *Rhagonocerus* Kaup, 1871, by five species, and *Passipassalus* Fonseca & Reyes-Castillo, 1993, includes three species. *Neleuops* Kuwert, 1891, *Ptichopus* Kaup, 1869, and *Toxeutotaenius* Kuwert, 1896, each encompass two species.

For Proculini, the largest genus is *Veturius* with 22 species, follow by *Popilius* Kaup, 1871, with seven species, and *Verres* Kaup, 1871 with a single species.

Taxonomic knowledge about the Brazilian Passalidae fauna is dispersed in several works. However, it is possible to highlight as the main ones, the works of Luederwaldt (1931a, 1934a, 1934b, 1941) which is still considered the most complete work on Brazilian Passalids, the description of *Passipassalus* by Fonseca and Reyes-Castillo (1993), the review of the Brazilian species of *Paxillus* by Mattos and Mermudes (2013), and Boucher et al. (2016) for *Veturius*. For summaries of local fauna and/or descriptions of new taxa there are the works of Fonseca (1988), Bevilaqua and Fonseca (2019, 2020) for Amazonian fauna and Mattos and Mermudes (2014, 2015, 2016, 2018) for the fauna of the south and southeast regions of the Atlantic Forest. With advances in research, the number of species and the level of understanding of Brazilian species will increase in the coming years.

Scarabaeidae Latreille, 1802

Figs 5H–I, 6F–G

Diagnosis. Antennae with 8 or 9 antenomeres, with lamellae mobile and compactable club formed by the last three antennomeres. Clypeus and gena dorsoventrally flattened and usually forming a broad anterior surface, being separated from each other by a dorsal suture (sometimes indistinct). Mandibles in Brazilian species with incisive area membranous. Labrum and mandibles not visible, base of mandibles sometimes visible laterally. Abdomen with six ventrites.

Remarks. Scarabaeidae are a cosmopolitan family with 36,009 described species (Schoolmeesters 2023). In Brazil, it is represented with 826 species and 104 genera distributed into two subfamilies (Table 2): Scarabaeinae (Fig. 5I) and Aphodiinae (Fig. 5H). This family is, in its majority, composed of coprophagous beetles which feed and nest directly on the faecal matter of mammals, giving them the popular name of dung beetles (Halffter and Edmonds 1982).

The subfamilies can be determined by the following combination of characters: Scarabaeinae mesocoxae are usually separated by a distance greater than or equal to their width and the metatibiae generally presents only one apical spur; on the other hand, Aphodiinae mesocoxae are usually separated by a distance smaller than their width and the metatibiae generally presents two apical spurs. Scarabaeinae usually have the propygidium and pygidium exposed, while in Aphodiinae the propygidium is completely covered by the elytra and the pygidium is partially covered. Other differences can be found in the reproductive system: females of Scarabaeinae have only one ovary with one ovariole, while females of Aphodiinae have two ovaries each with six ovarioles.

Aphodiinae comprises more than 3,500 species of generally small (1.5–8.0 mm) and saprophagous beetles (Stebnicka 2001a, Schoolmeesters 2023). Their biology is extremely diverse with some groups being found associated with mammal dung, under wood-bark, or fungi, while some species have been reported feeding on the dung of beetles such as Passalidae and few genera can even be found associated with social insects (Chapin 1940, Stebnicka 2001a, 2007a, 2007b).

In Brazil, Aphodiinae is represented by 145 species, 40 genera, and five tribes: Aphodiini, Eupariini, Odontolochini, Psammodiini, and Rhyparini (Vaz-de-Mello 2023b). A key for New World genera of Aphodiinae has been written by Skelley (2008), and an identification guide with an updated key for genera in Brazil is under development by one of the authors (E. Gama unpublished data)

The knowledge on the Aphodiinae has improved considerably in recent years with many groups being reviewed. The Italians, Marco and Giovanni Dellacasa, have reviewed many groups in Aphodiini, thus, it is recommended to consult these authors when studying this tribe (see Dellacasa et al. 2001, 2011, 2012). Many groups of Eupariini have also been reviewed (see Stebnicka 2009), including *Ataenius* Harold, 1867, the most specious genus in the New World with at least 190 described species (Stebnicka 2007b). In Brazil, 55 species of *Ataenius* are recognized, representing approximately 37% of the Aphodiinae known in Brazil (Vaz-de-Mello 2023b). Ten of the 11 species groups of *Ataenius* are present in Brazil and keys for these groups or for species within each species group can be found in Stebnicka's works (2001b, 2003, 2004, 2005, 2006, 2007c, Stebnicka and Lago 2005). Psammodiini in Brazil have no recent taxonomic revisions; the last study was conducted by Gordon and Pittino (1992). For the identification of genera and species of Neotropical Odontolochini, Skelley (2007b) is recommended. For the Rhyparini, only two genera are present in Brazil: *Aschnarhyparus* Makhan, 2006 and *Termitodius* Wasmann, 1894; both genera have been briefly reviewed by Skelley (2007a) and Skelley et al. 2022).

Whereas, the subfamily Scarabaeinae is a highly diverse group, comprising approximately 6,840 species distributed worldwide (Schoolmeesters 2023). They are primarily coprophagous, with some exhibiting secondary necrophagy or saprophagy (Halffter and Edmonds 1982). These beetles typically have an oval-shaped body, with species ranging from 1.9 mm (e.g., *Degallieridium lilliputanum* Vaz-de-Mello, 2008) to more than 50 mm in length – e.g., *Coprophanaeus*

ensifer (Germar in Wiedemann and Germar, 1821). The genera and subgenera of Neotropical Scarabaeinae can be identified using the multilingual dichotomous key available in Vaz-de-Mello et al. (2011).

In Brazil, there are 784 described species of Scarabaeinae in 68 genera (Vaz-de-Mello 2023b). However, this number is subject to change as ongoing taxonomic research on scarab beetles progresses. Despite numerous taxonomic studies conducted in recent years on various groups, such as *Sylvicanthon* Halffter & Martínez, 1977 (Cupello and Vaz-de-Mello 2018), *Scybalocanthon* Martínez, 1948 (Silva and Valois 2019), *Canthon* (*Pseudepilissus*) Martínez, 1954 (Vieira et al. 2020), *Canthon* (*Peltecanthon*) Pereira, 1953 (Nunes et al. 2020a); *Canthon* (*Goniocanthon*) Pereira & Martínez, 1956 (Nunes et al. 2019); *Dichotomius* (*Homocanthonides*) Luederwaldt, 1929 (Maldaner et al. 2018), *Deltochilum* (*Deltohyboma*) Lane, 1946 (González-Alvarado and Vaz-de-Mello 2021), *Agamopus* Bates, 1887 (Costa-Silva et al. 2022), and *Dichotomius* (*Cephagonus*) Luederwaldt, 1929 (Nunes and Vaz-de-Mello 2020b) – see Cupello et al. 2023 for a comprehensive list. Many highly specious and problematics groups such as *Uroxys* Westwood, 1842, *Canthidium* Erichson, 1847 and *Ateuchus* Weber, 1801 are still considered taxonomical gaps and are in need of revisions (Cupello et al. 2023). As a result of this growing effort in understanding the New World diversity of Scarabaeinae, the number of revisions and the discovery of new species has grown steadily over the last three decades (Cupello et al 2023).

One of the key factors promoting these taxonomic advances is the interest in using the group as bioindicators by ecologists focused on conservation biology (see Cupello et al 2023 for more information). This new interest not only pushed taxonomists to provide reliable identifications and identification tools for researchers from other fields (e.g., ecologists) but also the growing number of specimens collected by these professionals provide taxonomists with the means for resolving some major taxonomic gaps (Cupello et al 2023).

Typically, Scarabaeinae are collected using pitfall traps baited with mammalian dung (i.e., cattle, human and pig), mushroom, decaying fruits as well as decaying carrion (Halffter and Matthews 1966, Costa-Silva et al. 2018, Raine and Slade 2019). Recent studies have shown that flight interception is an efficient method for dung beetles, given their strong flying abilities, and some species are only sampled through pitfall or flight interception traps, with these two collection methods being complementary (Puker et al. 2020, Ong et al. 2021, Bach et al. 2023).

Trogidae MacLeay, 1819

Figs 5G, 6E

Diagnosis. Adults of Trogidae differ from other Scarabaeoidea families by presenting an abdomen with five ventrites and the dorsal surface of elytra with tubercles. Only few exceptions exist within trogids, such as *Omorgus* (*Haroldomorgus*) *batesi* (Harold, 1872), where the tubercles are absent; for further details, refer to Costa-Silva et al. (2021). Trogidae species share a morphological resemblance with Glaresidae species. Nevertheless, these two families can be distinguished by the absence of eyes divided by a canthus in Trogidae (Fig. 6E), a feature that is present in Glaresidae (see Scholtz 1986 and Strümpher et al. 2016 for more detailed information; Fig. 6D).

Remarks. Trogidae are a cosmopolitan family with approximately 340 described species in five genera and two extant subfamilies (Zídek 2017, also see Strümpher et al. 2016 for an overview of the family). For Brazil, the trogids are a well-documented group consisting of 17 species belonging to two genera: *Polynoncus* Burmeister, 1876, and *Omorgus* Erichson, 1847 (Costa-Silva and Vaz-de-Mello 2023b). The Brazilian fauna of *Omorgus* was recently reviewed by Costa-Silva et al. (2021), who reported seven species in two subgenera (the widespread *Omorgus* and the monotypic *Haroldomorgus* Scholtz, 1986). The genus *Polynoncus*, endemic from South America, was recently reviewed by Costa-Silva et al. (2024), where 38 described species were recognized (Scholtz 1990, Costa-Silva and Diéguez 2020, Costa-Silva et al. 2024), with 10 reported from Brazil (Vaurie 1962, Scholtz 1990, Zídek 2017, Costa-Silva and Vaz-de-Mello 2023b). A dichotomous key and high-resolution photographs of types of Polynoncus and Brazilian *Omorgus* can be found in Costa-Silva et al. (2024) and Costa-Silva et a. (2021), respectively.

The morphological description of trogid larvae is a poorly explored field of study. According to Zídek (2017), only four larvae description are known to South America, being only two from Brazil: *Omorgus suberosus* (Fabricius, 1775) and *O. persuberosus* (Vaurie, 1962) – see Scholtz (1993).

Species of Trogidae are typically collected throughout the year using various methods such as pitfall traps baited with decaying organic matter, light traps, flight interception traps (FIT), or by actively searching under animal carcasses (the former for larvae and adults).

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Appendix 1. Name of authors as signed on the original publication, and number of Brazilian valid species of Scarabaeoidea. Authors who have signed authorship with different forms: [1]Castelnau = Laporte, [2]Carvalho-de-Santana = Carvalho, [3]Vulcano = d'Andretta.

Author's name	Species described
Carl H.C. Burmeister	251
Georg Frey	227
Friedrich Ohaus	216
Julius Moser	199
Edgar von Harold	195
Charles E. Blanchard	173
Fernando Z. Vaz-de-Mello	140
Antônio Martínez	79
Marc Soula	77
Hermann Luederwaldt	65
Vladimir Balthasar	59
Adolf Schmidt	50
François Génier	50
Paschoal C. Grossi	49
Sebö Endrödi	49
Gilbert J. Arrow	48
Antoine G. Olivier	43
Brett C. Ratcliffe	41
François-Louis de Castelnau*[1]	41
Ernst F. Germar	40
Joseph A.M. Perty	37
Rudolf Petrovitz	37
Wilhelm F. Erichson	36
Carl G. Mannerheim	32
Fernando A.B. Silva	32
Achille R. Percheron	31
Patrick Arnaud	31
Rafael V. Nunes	31
Renaud M.A. Paulian	31
Henry W. Bates	30
Francisco Silvério Pereira	30
Jean-Baptiste A.L.C. Boucomont	29
Roger-Paul Dechambre	28
Johann C. Fabricius	27
Mariana A. Cherman	25
Carl Felsche	25
John O. Westwood	25
Hippolyte L. Gory	24
Henry F. Howden	24
Charles O. Waterhouse	24
Heinrich Prell	23
Zdzislawa T. Stebnicka	23
Virgínia L. Canhedo	22
Matthias Seidel	19
Johann F.G. von Eschscholtz	19
Thaynara Pacheco	18
Walter Höhne	18
August F. Kuwert	16
Carolus Linnaeus	16
Cláudio R.V. da Fonseca	15
François-Louis de Laporte*[1]	15
M. H. Lucas	15
William S. MacLeay	15
Marcely Valois	14
Jean-Guillaume Audinet-Serville	13
Charles F.P.A. Preudhomme de Borre	13
André da S. Ferreira	13
Andrey V. Frolov	12
Hermann J. Kolbe	12
Júlio Louzada	12
G. d'Olsoufieff	12
Freddy Bravo	11
Lilia A. Akhmetova	11
Federico C. Ocampo	11
Johann C.F. Klug	11
Amédée L.M. Le Peletier (= "Saint-Fargeau")	11
Stéphane Boucher	10
Edrielly Carvalho*[2]	10
Johan W. van Lansberge	10
Lorenzo Camerano	9
Félix É. Guérin-Méneville	9
William Kirby	9
Oscar L. Cartwright	8
Fabien Dupuis	8
Gonzalo Halffter	8
Lúcia M. Almeida	7
Paulo R.M. Duarte	7
Pedro Reyes-Castillo	7

Continues

Author's name	Species described
Roni A.F. Medeiros	7
Ludwig Redtenbacher	7
Lawrence W. Saylor	7
Frederick Bates	6
Mary E. Jameson	6
Louis A.A. Chevrolat	6
Joyce Cook	6
Mario J. Cupello	6
Dru Drury	6
Arthur V. Evans	6
Anton F. Nonfried	6
Andrew B.T. Smith	6
Nikolas A. Vigors	6
Mateus Bento	5
Henri Boileau	5
Johann J. Kaup	5
Maria Aparecida Vulcano*[3]	5
José R.M. Mermudes	5
Ingrid Mattos	5
Luís G. Nunes	5
Michele Rossini	5
James Thomson	5
Friderico Weber	5
Esteban I. Abadie	4
Gustaf J. Billberg	4
Vinícius da Costa-Silva	4
Johann W. Dalman	4
Pierre A.J. Drapiez	4
Joseph J.E. Gillet	4
Frederic H. Gravely	4
Leonhard Gyllenhal	4
Johann F.W. Herbst	4
Olivier E. Janson	4
Gustav Kraatz	4
Frederick E. Melsheimer	4
Frederic J.S. Parry	4
Patricia Vaurie	4
Karla Villatoro	4
Philippe Antoine	3
Marcus Bevilaqua	3
Carl H. Boheman	3
Olivier Boilly	3
Edrielly Carvalho-de-Santana*[2]	3
John H. Curtis	3
Robert D. Gordon	3
Everardo J. Grossi	3
Léon M.H. Fairmaire	3
Johannes N.F.X. Gistel	3
Johann K.W. Illiger	3
Mary L. Jameson	3
Th. Kirsch	3

Continues

Author's name	Species described
Maria E. Maldaner	3
Santiago Montoya-Molina	3
W. Möllemkamp	3
Basil G. Nevinson	3
Massimo Prandi	3
Paul N. Schürhoff	3
Rafael Sobral	3
Massimiliano Spinola	3
Chrysantus Sternberg	3
Carl P. Thunberg	3
Erich Wasmann	3
Ricardo M. Koike	2
Moacir Alvarenga	2
Eugène Benderitter	2
Hugues E. Bomans	2
Carlos Bruch	2
Thomas L. Casey	2
Luciana Iannuzzi	2
Fabio C. Costa	2
Marco Dellacasa	2
Achille Deyrolle	2
Takaaki Fujii	2
Arturo González-Alvarado	2
Francisco Racca-Filho	2
Mariana D. Santos	2
Bert Kohlmann	2
Violeta Halffter	2
Howard E. Hinton	2
Frederic W. Hope	2
Sérgio Ide	2
Carl G. Jablonsky	2
Hermes E. Escalona	2
Luis J. Joly	2
Rudolf Kriesche	2
Jean-Pierre Lacroix	2
Margarita M. López-García	2
Cuauhtémoc Deloya	2
Shinji Nagai	2
Marcela S.G. Carvalho	2
Dirk Ahrens	2
Marcela Monné	2
Juarez S. Pinto-Junior	2
Riccardo Pittino	2
Yannig Ponchel	2
Louis J. Reiche	2
Mario Zunino	2
Hermann R. Schaum	2
David Sharp	2
Paul Skelley	2
Rafael C.J. Sousa	2
Eduard W. Steinheil	2

Continues

Author's name	Species described
Jacob Stürm	2
Ernst L. Taschenberg	2
Virgínia L. Canhedo	2
Marcelli K. Vieira	2
Erich Weinreich	2
Carlos Aguilar-Julio	1
Celso Godinho	1
Daniel S. Basílio	1
Ambroise F.J. Beauvois	1
Bernard Benesh	1
Richard E. Blackwelder	1
Heinrich Blut	1
Patrice Bouchard	1
Nair O. Aguiar	1
Auguste Bourgoin	1
Juan Brèthes	1
Hermann R. Schaum	1
Paulo F. Bührnheim	1
Ernest C.A. Candèze	1
Tamara G. Carvalho	1
Fortuné Chalumeau	1
Julia Colby	1
James D.G. Darling	1
Carl DeGeer	1
Martin Hardy	1
Jean-Pierre Lumaret	1
Giovanni Dellacasa	1
Robert Didier	1
Carl A. Dohrn	1
Maria O.A. Ribeiro	1
Maria F.S. Fernandez	1
Fernando B.P. Gouveia	1
Juares Fuhrmann	1
Paolo Gandini	1
Bruce D. Gill	1
George R. Gray	1
Karl B.M.J. Heller	1
Ernst O.W. Taschenberg	1
Alexander Heyne	1
Walter D. Hincks	1
Jean-Bernard Huchet	1
B.E. Jakowleff	1
André Janssens	1
Edward A. Klages	1
W.D. Kozhantshikov	1
Jan Krikken	1
Jean T. Lacordaire	1
Bengt-Olof Landin	1
Rudolf B. Lange	1
Pierre A. Latreille	1
John L. LeConte	1
Nathanael G. Leske	1
Sven I. Ljungh	1
Felix Lynch-Arribálzaga	1
Johann W. Machatschke	1
Adrian Martínez	1
Maria Aparecida V. d'Andretta*[3]	1
Leonello Milani	1
Łukasz Minkina	1
Matthew R. Moore	1
Carlos Moreira	1
Miguel A. Morón	1
José R. Salvadori	1
Paul Nagel	1
John C. Neita-Moreno	1
Palisot de Beauvois	1
Giorgina Pangella	1
Samuel B. Pessôa	1
Ronald D. Cave	1
Jefson M. Ribeiro	1
Enrico Ricchiardi	1
John Sahlberg	1
Antonio Santos-Silva	1
Lucas Sawaris	1
Gustav Schoch	1
Jennifer M. Shaughney	1
John W. Shipp	1
Ana B.G. Moura	1
Josival F. Araújo	1
Rita C. de Moura	1
Guy Silvestre	1
Filippo Silvestri	1
José W. de Morais	1
Antoine J.J. Solier	1
Nils S. Swederus	1
Layse Harada	1
Tom Schouteet	1
Jaak Van Meenen	1
Marcio Gavino	1
Johann(es) E. Voet	1
Gotthelf Fischer von Waldheim	1

Continues