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Article

Dung beetles in South American pasturelands

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Abstract: Pasturelands are characterized as grasslands utilized for cattle raising and consist of natural or exotic vegetation, predominantly grasses. In the context of sustainable production, the biodiversity of insects within grazing environments holds significant value. Dung beetles play a crucial role in sustaining pasturelands as the burial of feces by these beetles fosters ecological services indispensable for maintaining a robust and healthy environment. Given that different dung beetle species contribute to distinct environmental benefits, a comprehensive understanding of the species present in pasturelands, their origins, and the ecological services they provide is imperative. This study endeavors to compile comprehensive information on dung beetle species native to South America, emphasizing taxonomic precision and a confirmed affinity for cattle dung. Our findings are derived from a synthesis of literature and observational data, incorporating location information obtained from taxonomic revisions and specimen labels of specimens housed at CEMT. In South America, a total of 57 dung beetle species are documented that inhabit grazing areas and actively feed on cattle manure. These areas span diverse biomes encompassing native and/or introduced grasslands, which may include deforested sections within forest biomes such as Chaco, Pantanal, Cerrado, Caatinga, Pampa, Atlantic Forest, Amazon Forest, Paramo, Puna, Llanos, and Patagonia. The preponderance of species identified fall within the paracoprid category, recognized as particularly vital for the sustainability of pasturelands. Despite their acknowledged importance, a noticeable knowledge gap impedes the effective conservation of these species. This gap is a focal point of discussion in this study, addressing the challenges and opportunities for enhancing conservation efforts. The species documented in this research exhibit notable economic and environmental relevance in the context of sustainable livestock production, emphasizing the urgency and significance of initiatives that prioritize their conservation.
Keywords*: Scarabaeinae; livestock; grasslands; conservation.*

Besouros rola-bostas em pastagens sul-americanas

Resumo: Pastagens são áreas formadas por vegetação nativa ou exótica, principalmente gramíneas, e são utilizadas na pecuária. A diversidade de insetos em áreas de pastagens é muito valiosa, especialmente quando consideramos os métodos de produção sustentável. Besouros rola-bostas são importantes para a sustentabilidade em pastagens porque o enterrio de esterco promove benefícios essenciais para a manutenção do ambiente pastoril. Espécies diferentes exercem diferentes serviços ecossistêmicos, logo é necessário saber quais espécies estão presentes em áreas de pastoreio para saber quais são os benefícios que elas podem proporcionar. Aqui reunimos todas as informações disponíveis para as espécies taxonomicamente bem definidas de rola-bostas nativos da América do Sul e que são conhecidas por utilizar fezes bovinas como recurso para alimentação e nidificação. Usamos dados encontrados na literatura, em observações de campo e em etiquetas de espécimes depositados na CEMT. São registradas 57 espécies de rola-bostas nativos da América do Sul que se alimentam e nidificam em fezes bovinas, e estas estão distribuídas nos seguintes biomas: Chaco, Pantanal, Cerrado, Caatinga, Pampa, áreas abertas da Mata Atlântica e da Floresta Amazônia, Paramo, Puna, Llanos e Patagônia. A maioria das espécies são de paracoprídeos e estes são considerados os mais importantes para as áreas de pastagem. No entanto, existe uma grande lacuna de conhecimento em história natural, o que dificulta a efetividade da conservação dessas espécies. Todas as espécies listadas neste trabalho têm potencial relevância econômica e ambiental na pecuária sustentável e, portanto, o estudo e conservação delas devem ser priorizadas.
Palavras-chave*: Scarabaeinae; pecuária; áreas abertas; conservação.*

Introduction

Pasturelands characterized by grasses and used for cattle raising are a significant component of South American landscapes. These grasslands exhibit diverse ecological characteristics, ranging from tropical to temperate climates. While tropical grasslands dominate regions such as the Cerrado, Chaco, Pantanal, Llanos, and Caatinga, temperate or temperate-like grasslands are prevalent in the Pampas, Patagonia, Paramo, and Puna (the latter two being high altitude grasslands) (Dixon et al. 2014). The term "derived savannas" refer to areas that were once forests but were deforested for crop cultivation or livestock management. Despite this transformation, natural grasslands remain highly attractive to farmers due to their flat terrain and cost-effective deforestation methods. However, the widespread conversion of natural grasslands into croplands or extensive planted pastures raise significant conservation concerns (Overbeck et al. 2015, Oliveira et al. 2017).

Insect biodiversity in grazing environments is highly valuable, especially when sustainable production is considered crucial. Bioindicators, which include several animal groups (such as dung beetles, birds, mammals, and butterflies) play a vital role in evaluating environmental quality. Our focus here is on dung beetles (Coleoptera, Scarabaeinae), known for their sensitivity to grazing intensity, land conversion, and abandonment (Tonelli et al. 2019). Dung beetles offer economically efficient means of assessing pasturelands, whether they are natural or disturbed habitats, thanks to cost-effective standardized protocols for evaluating dung beetle richness, abundance, and community structure (Halffter & Favila 1993, Gardner et al. 2008, Tonelli et al. 2019).

Dung beetles play a pivotal role in ensuring sustainability within pasturelands through the burial of feces, thereby fostering bioturbation. This process enhances aeration, humidity, and the redistribution of organic matter and microorganisms across varying depths, consequently increasing the nutritional value of grasses (Bornemissza & Williams 1970, Bang et al. 2005, Farias & Hernández 2017, Barragán et al. 2022). Furthermore, dung beetles contribute significantly to parasitic control, targeting flies and nematodes (Bornemissza 1960, 1970, Nichols et al. 2008, Sands & Wall 2016). Noteworthy environmental benefits include a reduction in greenhouse gas emissions with a decrease of 7% in dung pads and 12% in pasture ecosystems (Slade et al. 2016). This is predominantly due to mitigating methane (CH_4) emissions, a gas that typically forms under anaerobic conditions, since dung beetle activities facilitate oxygenation within pads, therefore diminishing methanogenesis (Slade et al. 2016).

The functional classification of dung beetles into three types reflects their distinct approaches to managing and storing food and nest resources: telecoprids (rollers), paracoprids (tunnellers), and endocoprids (dwellers) (Halffter & Matthews 1966) (Figure 1). There is a fourth guild called "kleptocoprids" (Halffter & Matthews 1966), but precise information is lacking on how deep or how far they nest, or even if it is within their host nest, thus we use this class apart from the three main functional types. Although these functional types are common in grasslands, they exhibit disparities in terms of soil preferences and when they are active (Halffter & Edmonds 1982). According to Farias & Hernández (2017), paracoprids exhibit a positive association with soil organic matter components and quantity, while telecoprids typically favor specific soil textures, particularly sandy soil. Endocoprids, on the other hand, exhibit no particular preference for soil components, nesting either within the dung pad or at the interface between soil and dung. Notably, they tend to be active during drier periods of the day, strategically avoiding competition with tunnellers and rollers, which thrive in more humid conditions (Halffter & Edmonds 1982).

Diverse body sizes and distinct food preferences among dung beetle species yield varied environmental benefits. Hence high species diversity within pastures correlates with many advantages. These benefits encompass diverse levels of bioturbation, characterized by shallow, medium, or deep burrows, nests, and galleries containing one, two, or multiple chambers. Furthermore, disparate rates of feces disaggregation and the integration of organic matter into the soil occur across various horizontal levels (Flechtmann et al. 1995a, Bornemissza 1960, Halffter & Edmonds 1982).

In the Brazilian context, 76 dung beetle species are documented in grazing areas (Tissiani et al. 2017). However, a reassessment of this list is imperative due to discrepancies observed in feeding habits or habitat preferences of some reported species, particularly in open conditions. Additionally, several taxonomic revisions have been published since the publication of this list. Although recent efforts have comprehensively reviewed published information on the ecological functions of dung beetles in South American pasturelands (Arellano et al. 2023), the need for a comprehensive taxonomic list remains. This study aims to compile a taxonomically well-defined list of dung beetle species native to South America, focusing on those known to feed on cattle dung. Such endeavor not only contributes to a clearer understanding of biodiversity but also highlights the potential economic and environmental relevance of these species within pastureland ecosystems (Losey & Vaughan 2006, Beynon et al. 2015).

Material and Methods

We compiled a list of dung beetle species exhibiting coprophagous behavior, specifically those associated with cattle dung in pastures. This compilation is grounded in bibliographic sources and observational data. Our methodology involved an exhaustive bibliographic search focused on dung beetle species within South American pasturelands. To accomplish this, we employed a systematic review across two prominent academic databases: Web of Science for comprehensive bibliographic coverage and SciELO for papers presented in Portuguese and Spanish. The search query was: "(dung beetle* OR Scarabaeinae*) and (pastures* OR grasslands*) and (cattle dung) and (South America* OR Argentina* OR Brazil* OR Bolivia* OR Chile* OR Colombia* OR Ecuador* OR French Guiana* OR Guyana* OR Paraguay* OR Uruguay* OR Peru* OR Venezuela*)". All articles meeting the predetermined criteria and published until 2022 were included, with books and technical reports also considered, even if not explicitly listed in the systematic search. Our focus was on papers presenting lists of dung beetle species collected from native or exotic pasturelands within the South American territory.

To address historical nomenclature challenges, wherein certain Geotrupidae and Aphodiinae (Scarabaeidae) species have been designated as "dung beetles," we made a deliberate choice to exclusively concentrate on Scarabaeinae (Coleoptera: Scarabaeidae) species in this study. Geotrupidae species associated with feces are confined to Southern Argentina and Chile (Lobo & González-Chang 2022), and

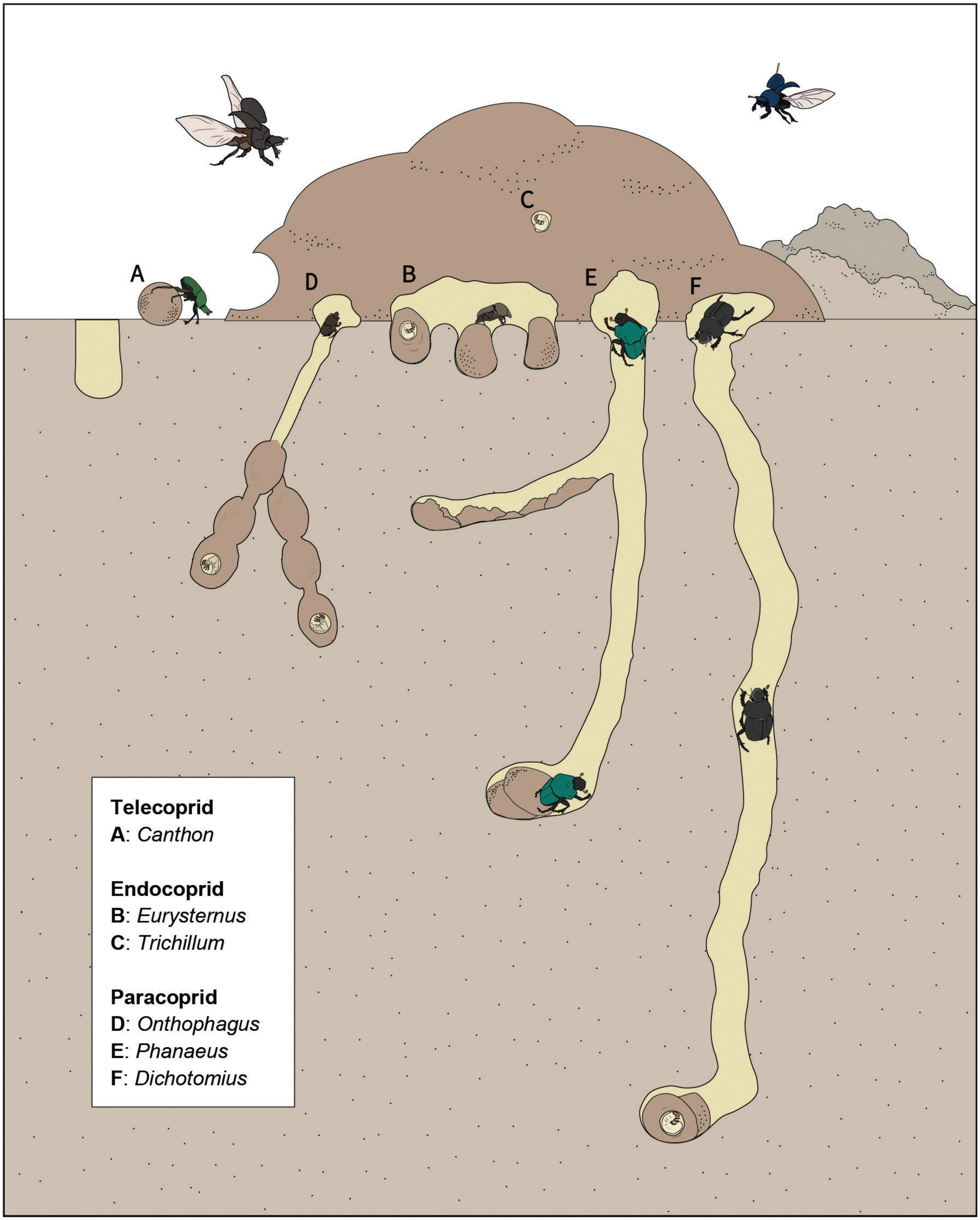

Figure 1. Functional groups of dung beetles based on nesting behavior. Illustration: Bruna Bordin.

Aphodiinae are small dwellers, whose present identification challenges in tropical regions of the continent. Additionally, our focus was refined to exclude Scarabaeinae species that, while inhabiting pasturelands, do not commonly engage in coprophagous behavior on cattle dung.

To compile our list, we relied on reported localities derived from taxonomic revisions and specimen labels housed at Coleção Entomológica de Mato Grosso Eurides Furtado (CEMT). This effort yielded 9,558 geographical records, including 5,935 from CEMT, 2,603 from bibliographic sources, and 1,020 yet unpublished records from ongoing taxonomic revisions provided by respective authors (Supplementary Material).

Geospatial maps were generated using a suite of R packages, including "ggsn," "RColorBrewer," "raster," "rgdal," "sf," "tidyverse," "wesanderson," "ggspatial," "viridis," and "scales" (R Core Team 2022). We chose not to include a map (or layer) of South American pasturelands because the available data is outdated, however, this product is being actively developed as part of the Global Pasture Watch initiative. The initial maps expected in the second quarter of 2024 [https://www.landcarbonlab.org/news-updates/tag/global+pasture+watch]. High-quality photographic documentation was facilitated using a Leica model m205C (7.8 × –160.0 ×) stereo microscope equipped with an MC190 HD image capture system.

Results

During our comprehensive search, we identified 43 articles containing reports on dung beetle species collected on cattle dung in South American pasturelands. It is pertinent to note that dung beetle species observed in cattle dung in forests or within forested areas were excluded from our consideration. The resultant list comprises 57 species documented in South American pasturelands actively feeding on cattle dung (Table 1). Notably, in Brazil, where the largest pasturelands in the Neotropical region are found, a total of 48 dung beetle species engaging in the consumption of cattle manure have been recorded in grazing areas. These occurrences span various biomes with native and/or introduced grasses, including Chaco, Cerrado, Caatinga, Pampa, Atlantic Forest, and Amazon Forest, as detailed in Table 1 and Figures 2–11. Furthermore, our findings extend beyond Brazil, encompassing nine species in other South American countries that exhibit coprophagous behavior on cattle dung. These countries host unique biomes not found within Brazil. Specifically, these biomes include Paramo (Colombia and Peru), Puna (Peru to Argentina), Llanos (Venezuela and Colombia), and Patagonia (Chile and Argentina) (Figures 2–11). This comprehensive listing provides a nuanced understanding of the distribution and feeding habits of dung beetle species across diverse South American ecosystems.

Discussion

In the context of climate variables, distribution of dung beetles is predominantly shaped by temperature and precipitation dynamics (Halffter & Edmonds 1982). Nevertheless, at finer spatial scales, factors such as landscape configuration, soil composition, vegetation structure, and habitat heterogeneity emerge as primary influencers on dung beetle communities (Sowig 1995, Almeida & Louzada 2009, Louzada et al. 2010, Silva et al. 2010, Almeida et al. 2011). Species inhabiting cattle pastures are generally exposed to higher temperatures, lower humidity, and higher soil compaction compared to those in forests (Soto et al. 2019). Species adapted to natural grasslands may be more resilient to these variables, and, indeed, we find that the most common dung beetle species in pastures are native to the Cerrado, Caatinga, or other natural South American grasslands (Almeida & Louzada 2009, Louzada & Carvalho e Silva 2009, Louzada et al. 2010, Silva et al. 2014).

Southwestern Amazonian pasturelands were colonized by dung beetle species from the Cerrado and other adjacent dryer habitats; these habitats typically serve as the primary source of native species for introduced grasslands (Silva et al. 2014). Northern Amazon pasturelands exhibit a dung beetle fauna similar to that found in intra-Amazonian savannas and Llanos (Matavelli & Louzada 2008). However, as certain species are found in Cerrado areas south of the Amazon, we hypothesize that these populations may have dispersed along with large groups of cattle transported during the northern expansion of grasslands (and consequently, of cattle) from the Cerrado areas.

A comparable pattern is observed in pastures located in Atlantic Forest areas, where dung beetle fauna is allochthonous (see Louzada & Carvalho e Silva 2009). Based on our understanding, it is expected that species adapted to forests would not endure in dry environments, and this indeed occurs in pasturelands established in areas where there was once a closed canopy. In Northeastern Brazil, the species found in pastures also inhabit Cerrado and/or Caatinga areas. However, for the Central and Southern regions of Brazil, the dung beetle fauna found in pasturelands is similar to that in Cerrado and/or Pampa regions.

The species composition between pasturelands and forests differs, and presence of surrounding forests does not increase dung beetle richness in pastures (Silva et al. 2014). Feeding guilds of dung beetles in forests consist of 40% specialists and 60% generalists, while in pastures, 75% of dung beetle species are specialists (coprophagous), and 25% are generalists (Silva et al. 2014). It has been suggested that the development and dominance of coprophagous behavior began in savannas, potentially influenced by herds of large herbivorous mammals (Halffter & Matthews 1966). An intriguing fact is that the greatest diversity of coprophagous dung beetles in Africa is found in savannas, while in South America, where megafauna became extinct during the Pleistocene, dung beetles in savannas also exhibit frugivorous and necrophagous behaviors (Halffter & Matthews 1966).

In the context of large dung pats and their remarkable diversity, it is frequently observed that species colonizing a pat exhibit varying sizes, even when the allocation strategy is alike. This diversity in size may account for the coexistence of numerous species (and specimens) within a dung pat (Hanski & Cambefort 1991). The abundance of specimens in a dung pat can each over 1500 individuals, encompassing all three functional types with a predominant representation by small endocoprids (Flechtmann et al. 1995b). This is reasonable given that paracoprids and telecoprids tend to swiftly disappear after extracting a portion from the source.

Dung removal is directly correlated with the body size of dung beetles, with the largest species excavating the deepest galleries (Gregory et al. 2015). The most extensive tunnel documented, created by the native North American dung beetle *Dichotomius carolinus* (Linnaeus, 1767), measured 162 cm in length and 55 cm in depth (Lindquist 1933). While substantial research on dung beetle's nesting behavior was compiled by Halffter and Edmonds (1982) there remains much to uncover. Although different specimens of the same species share

Table 1. List of dung beetle species registered in South American pasturelands.

Species	Author	Region	Functional Type	Size (mm)	Burial depth (cm)	Reference
Agamopus unguicularis	(Harold, 1883)	Cerrado	Kleptocoprid	4.5	–	Harold (1883); Vaz-de-Mello (2007); Costa-Silva et al. (2022); CEMT.
Agamopus viridis	Boucomont, 1928	Cerrado	Kleptocoprid	4.5	–	Boucomont (1928); Vaz-de-Mello (2007); Costa-Silva et al. (2022); CEMT.
Ateuchus striatulus	(Preudhomme de Borre, 1886)	Cerrado	Paracoprid	5	unknown	Cupello (2023) personal communication – to be published); CEMT.
Ateuchus vividus	Germar, 1823	Cerrado	Paracoprid	5	unknown	Cupello (2023) (personal communication – to be published); CEMT.
Canthon septemmaculatus histrio	(Lepeletier de Saint-Fargeau & Audinet-Serville, 1828)	Cerrado, Caatinga, Chaco, Pantanal, Amazon	Telecoprid	6–11	shallow*	Halffter & Edmonds (1982); Nunes (2015)[1]; Correa & da-Silva (2022); Correa et al. (2022); CEMT.
Canthon ornatus bipunctatus	(Burmeister, 1873)	Chaco, Pantanal	Telecoprid	6–9	shallow*	Burmeister (1873); Halffter & Edmonds (1982); CEMT.
Canthon ornatus ornatus	Redtenbacher, 1868	Cerrado	Telecoprid	6–8	shallow*	Balthasar (1939); Halffter & Edmonds (1982); Tissiani et al. (2015); CEMT.
Canthon ornatus thoracicus	Harold, 1868a	Pampa	Telecoprid	7–9	shallow*	Halffter & Edmonds (1982); CEMT
Canthon rutilans cyanescens	Schmidt, 1922	Pampa, Atlantic Forest	Telecoprid	10	shallow*	Harold (1868); Halffter & Edmonds (1982); Medina Hernández et al. (2020); Hensen et al. (2021)[2]; CEMT.
Canthon rutilans rutilans	Castelnau, 1840	Pampa	Telecoprid	9–11.5	shallow*	Castelnau (1840); Halffter & Edmonds (1982); Hensen et al. (2021)[2]; CEMT.
Canthon septemmaculatus linearis	Schmidt, 1920	Llanos, Amazon	Telecoprid	8–11	shallow*	Halffter & Edmonds (1982); Nunes (2015); CEMT.
Diabroctis mimas	(Linnaeus, 1758)	South America	Paracoprid	20–32	unknown	Valois et al. (2018); CEMT.
Dichotomius bos	(Blanchard, 1845)	Cerrado, Atlantic Forest, Chaco, Pantanal	Paracoprid	25–28	>100**	Luederwaldt (1929); Lindquist (1933); Correa & da-Silva (2022); Correa et al. (2022); CEMT.
Dichotomius cotopaxi	(Guérin-Méneville, 1855)	Paramo	Paracoprid	16–24	unknown[1]	Luederwaldt (1929); CEMT.
Dichotomius crinicollis	(Germar, 1823)	Cerrado	Paracoprid	20–28	unknown[1]	Luederwaldt (1929); CEMT.
Dichotomius cuprinus	(Felsche, 1901)	Cerrado	Paracoprid	15–20	unknown[1]	Luederwaldt (1929); Cassenote et al. (2023) (personal communication – to be published); CEMT.
Dichotomius fimbriatus	(Harold, 1869)	Atlantic Forest	Paracoprid	16–23	unknown[1]	CEMT

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Continuation

Species	Author	Region	Functional Type	Size (mm)	Burial depth (cm)	Reference
Dichotomius geminatus	(Arrow, 1913)	Northern Atlantic Forest, Caatinga	Paracoprid	12.5–13.5	unknown[!]	Luederwaldt (1929); CEMT.
Dichotomius glaucus	(Harold, 1869)	Cerrado	Paracoprid	17–19	unknown[!]	Luederwaldt (1929); Cassenote et al. (2023) (personal communication – to be published); CEMT.
Dichotomius longiceps	(Taschenberg, 1870)	Amazon, Cerrado	Paracoprid	27–33	>100**	Luederwaldt (1929); Lindquist (1933); CEMT.
Dichotomius lycas	(Felsche, 1901)	Amazon, Cerrado	Paracoprid	15–20	unknown[!]	Felsche (1901); Cassenote et al. (2023) (personal communication – to be published); CEMT.
Dichotomius monstrosus	(Harold, 1875)	Paramo	Paracoprid	27–33	>100**	Luederwaldt (1929); Lindquist (1933); CEMT.
Dichotomius nisus	(Olivier, 1789)	South America	Paracoprid	16–25	unknown[!]	Luederwaldt (1929); CEMT.
Dichotomius opacipennis	(Luederwaldt, 1931)	Chaco, Pantanal	Paracoprid	12–14	unknown[!]	Luederwaldt (1931); Tissiani et al. (2015); Correa & da-Silva (2022); Correa et al. (2022); CEMT.
Dichotomius opacus	(Blanchard, 1845)	Chaco, Pantanal, Cerrado, Atlantic Forest	Paracoprid	14–17	unknown[!]	Cassenote et al. (2023) (personal communication – to be published); CEMT.
Dichotomius rugatus	(Luederwaldt, 1935)	Paramo	Paracoprid	23–27	>100**	Luederwaldt (1935); Lindquist (1933); CEMT.
Dichotomius semiaeneus	(Germar, 1823)	Cerrado	Paracoprid	11–15	90**	Luederwaldt (1929); CEMT.
Dichotomius semisquamosus	(Curtis, 1844)	Atlantic Forest, East Amazon, Caatinga	Paracoprid	20–25	unknown[!]	CEMT
Digitonthophagus gazella	(Fabricius, 1787)	South America	Paracoprid	7–13	20–25	Génier & Moretto (2017); CEMT; DBI (2023).
Eurysternus caribaeus	(Herbst in Jablonsky & Herbst, 1789)	South America	Endocoprid	10.5–20	–	Génier (2009); CEMT.
Eurysternus deplanatus	Germar, 1823	Atlantic Forest	Endocoprid	8–11	–	Génier (2009); CEMT.
Eurysternus jessopi	Martínez, 1988	Cerrado, Atlantic Forest, Amazon	Endocoprid	9–13	–	Génier (2009); CEMT.
Eurysternus nigrovirens	Génier, 2009	Cerrado, Caatinga, Atlantic Forest	Endocoprid	5–7.5	–	Génier (2009); CEMT.
Eurysternus parallelus	Castelnau, 1840	Atlantic Forest	Endocoprid	9.5–14	–	Génier (2009); CEMT.

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Continuation

Species	Author	Region	Functional Type	Size (mm)	Burial depth (cm)	Reference
Genieridium bidens	(Balthasar, 1938)	Cerrado	Endocoprid	3.8–5.3	–	Vaz-de-Mello (2008); CEMT.
Gromphas lacordairii	(Oken, 1834)	Pampa, Chaco, Pantanal	Paracoprid	9.3–17.4	unknown	Cupello & Vaz-de-Mello (2013); Cupello (2024); CEMT
Homocopris achamas	(Harold, 1867)	Paramo	Paracoprid	20–31	unknown	CEMT
Ontherus appendiculatus	(Mannerheim, 1829)	South America	Paracoprid	7–13	>10***	Génier (1996); CEMT.
Ontherus dentatus	Luederwaldt, 1930	Cerrado, Chaco, Pantanal	Paracoprid	8–9	10***	Génier (1996); CEMT.
Ontherus sulcator	(Fabricius, 1775)	Pampa, Chaco, Pantanal	Paracoprid	9–18	>10***	Génier (1996); Gregory et al. (2015); Tissiani et al. (2015); CEMT.
Onthophagus bidentatus	Drapiez, 1819	Llanos, Amazon	Paracoprid	4–7	10–20**	Zunino & Halffter (1997); CEMT; DBI (2023).
Onthophagus buculus	Mannerheim, 1829	Cerrado, Chaco, Pantanal, Pampa	Paracoprid	4–12	10–30**	Rossini et al. (2018); CEMT; DBI (2023).
Onthophagus hircus	Billberg, 1815	Cerrado, Chaco, Pantanal, Pampa	Paracoprid	4–12	10–30**	Rossini et al. (2018); CEMT; DBI (2023).
Onthophagus ptox	Erichson, 1847	South America	Paracoprid	4–7	10–20**	Zunino & Halffter (1997); CEMT; DBI (2023).
Onthophagus ranunculus	Arrow, 1913	Caatinga, Atlantic Forest, Cerrado	Paracoprid	4–6	10–15**	CEMT
Oruscatus davus	(Erichson, 1847)	Puna	Paracoprid	12–19	unknown	CEMT
Oruscatus opalescens	Bates, 1870	Paramo	Paracoprid	18–29	unknown	Chamorro et al. (2014); CEMT
Oxysternon palemo	Castelnau, 1840	Cerrado, Chaco, Pantanal	Paracoprid	12–18	15–25**	Halffter & Matthews (1966); Edmonds & Zídek (2004); CEMT.
Phanaeus kirbyi	Vigors, 1825	Cerrado, Chaco, Pantanal	Paracoprid	13–20	15–35**	Edmonds (1994); CEMT.
Phanaeus palaeno	Blanchard, 1845	Cerrado, Chaco, Pantanal	Paracoprid	16	15–30**	Blanchard (1845); Edmonds (1994); Price & May (2009); Correa & da-Silva (2022); Correa et al. (2022); CEMT.
Sulcophanaeus menelas	(Castelnau, 1840)	Cerrado, Pantanal, Pampa	Paracoprid	11–20	25–30**	Edmonds (2000); Matthews (1966); CEMT.
Tetraechma liturata	(Germar, 1813)	South America	Telecoprid	5–6.5	shallow*	Balthasar (1939); Nunes & Vaz-de-Mello 2022; CEMT.
Trichillum adjunctum	Martínez, 1969	Cerrado	Endocoprid	4–5	–	Vaz-de-Mello (2008); CEMT.

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Species	Author	Region	Functional Type	Size (mm)	Burial depth (cm)	Reference
Trichillum externepunctatum	Preudhomme de Borre, 1880	Cerrado, Atlantic Forest, Chaco, Pantanal	Endocoprid	3–3.5	–	Vaz-de-Mello (2008); Tissiani et al. (2015); Correa & da-Silva (2022); Correa et al. (2022); CEMT.
Uroxys coarctatus	Harold, 1867	Paramo	Paracoprid	7–12	unknown	CEMT
Uroxys latesulcatus	Bates, 1892	Paramo	Paracoprid	10–15	unknown	CEMT
Uroxys rugatus	Boucomont, 1928	Paramo	Paracoprid	7–11	unknown	CEMT

*Halffter & Edmonds (1982) defined patterns of nests and, however with no measure, Deltochilini species were classified as telecoprids with shallow or superficial nests, i.e. close to soil surface.

**Estimated based on close species (same genus) with same or approximate size.

***Based on mean values published by Gregory et al. (2015).

[ı]*Dichotomius* species with potential to burrow deep galleries with no close species (in size or same subgenus) to estimate depth.

[1]Nunes (2015) cite that *Canthon* histrio does not occur in the Amazon Region, but it does, as we observed in recent specimens deposited at CEMT.

[2]Hensen et al. (2021) cite that the geographical distribution of *Canthon rutilans rutilans* and *Canthon rutilans cyanescens* include French Guiana, but that is probably a citation mistake, as these species do not occur in Amazon Region.

Observation: South America is here considered three or more biomes located East of Andes. Exception: *Eurysternus caribaeus* occurs in both East and West of Andes. Pampa here comprehend Patagonia species.

nesting patterns, their nests can still vary in depth and length (Lindquist 1933). We utilized published data on known species to estimate the potential depth that closely related species might achieve (Table 1). However, we strongly advocate for future research to undertake these measurements on a species-specific basis.

A comparison between the native *Dichotomius bos* (Blanchard 1845) and the introduced species *Digitonthophagus gazella* (Fabricius 1787) highlights that *D. bos* is more effective than *D. gazella* in terms of dung removal and nutrient intake from the soil (Galbiati et al. 1995). While *D. bos* is indeed larger than *D. gazella*, the more crucial factor is that *D. bos* is native to South America. Given its larger size and superior efficiency compared to *D. gazella*, *D. bos* emerges as a preferable choice for dung beetle conservation in pasturelands. While a high number of native species, along with their abundance, might have a negative impact on the presence and invasion of *D. gazella* (Matavelli & Louzada 2008), as observed in intra-Amazonian savannas, the same effect was not observed in the Cerrado region (Mesquita-Filho et al. 2018), probably due to high specialization of *D. gazella* in broader savanna-like habitats (Matavelli & Louzada 2008).

Even without considering Aphodiinae species in this study, it is essential to emphasize their significance in pasturelands. Although not typically recognized as paracoprids, some Aphodiinae larvae create small cavities in the ground for pupation, a behavior similar to paracoprids (Yamada et al. 2007, Tonelli 2022). Even species exclusively identified as endocoprids play a crucial role in pastures disintegrating dung pats from the inside out (Flechtmann et al. 1995a). The knowledge of Aphodiinae in Brazil and most other South American countries is limited, and we emphasize the urgent need for studies on this group.

This work gathers all available information on dung beetle species that feed on cattle dung and inhabit pasturelands in South America, including estimates of burrow capacities and distribution maps. However, it is important to regard this review as a new starting point for dung beetle conservation and its applicability to sustainable livestock production, complementing the works of Martínez & Lumaret (2022) and the ecological functions review by Arellano and colleagues (Arellano et al. 2023). The current scenario is concerning, given the vulnerability of dung beetles to parasiticides (Correa et al. 2021), competition with *D. gazella*, and anticipated climate change impacts (Noriega et al. 2020, Maldaner et al. 2021). To preserve the ecological functions provided by dung beetles in pasturelands, sustainable practices must become a priority in livestock production, drawing inspiration from successful examples in Mexico and South America (Halffter et al. 2018).

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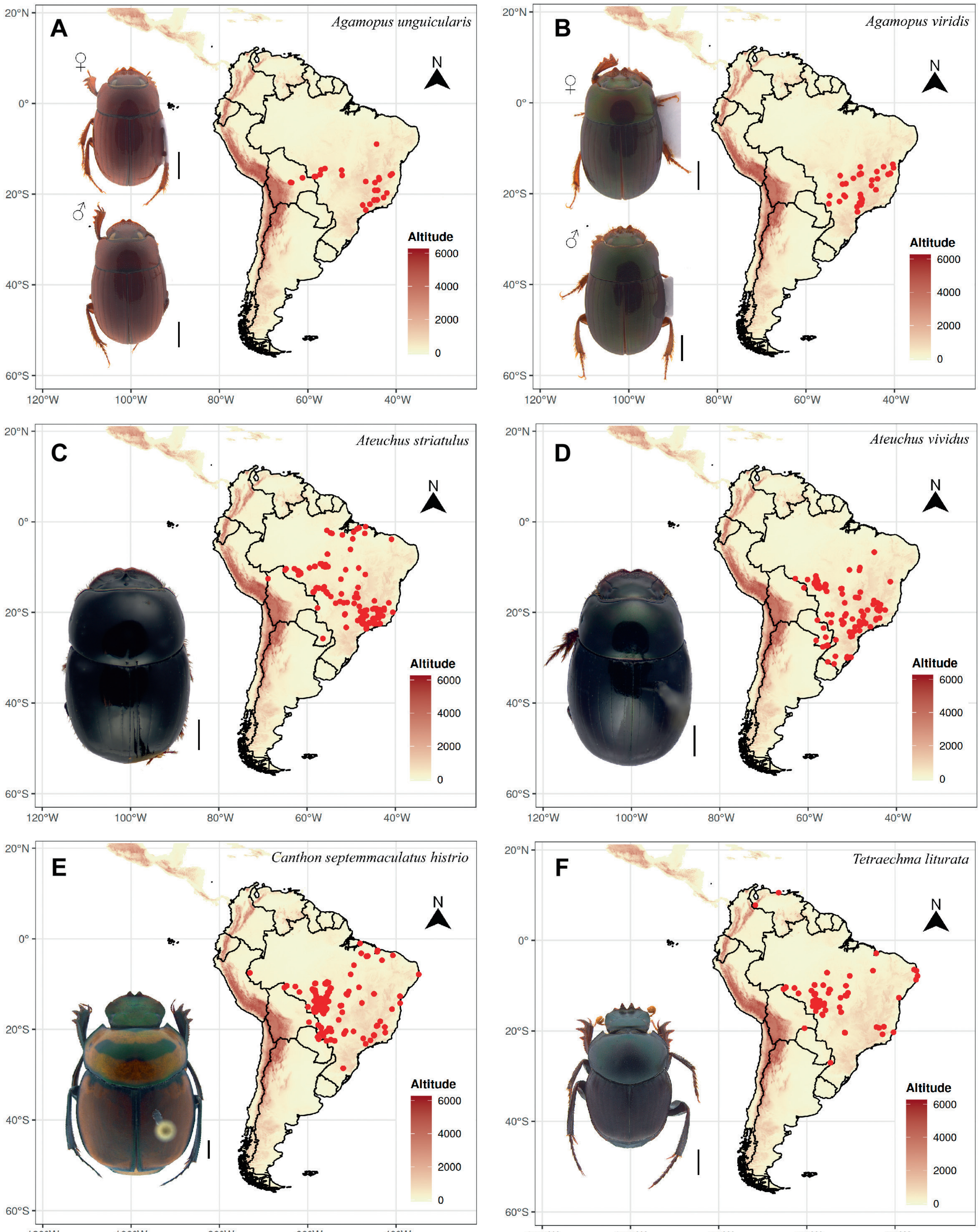

Figure 2. Geographical distribution and dorsal view of specimens for each species. (A) *Agamopus unguicularis*. (B) *Agamopus viridis*. (C) *Ateuchus striatulus* and (D) *Ateuchus vividus* (Photos: Mario Cupello). (E) *Canthon septemmaculatus histrio*. (F) *Tetraechma liturata*. Scale: 1 mm.

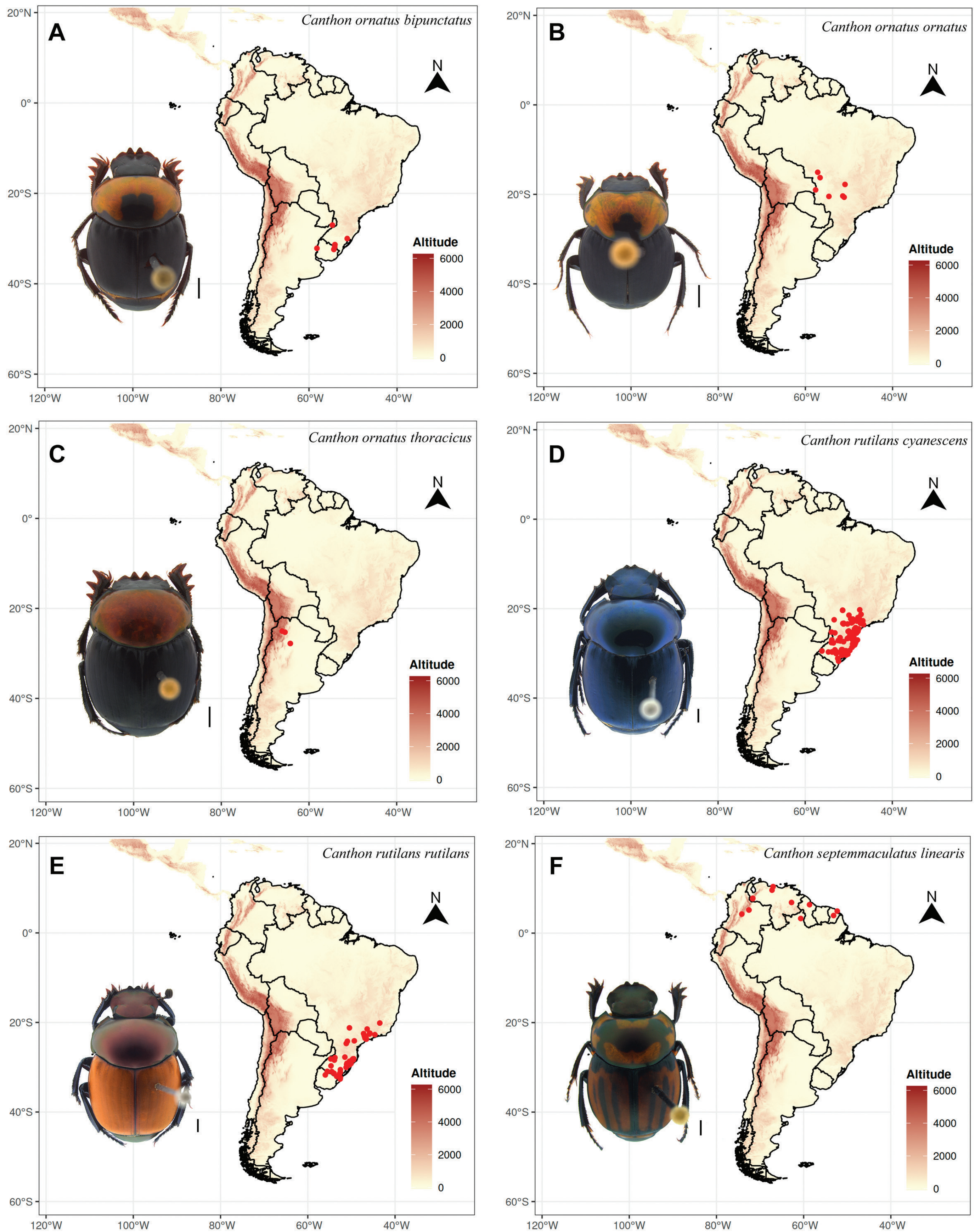

Figure 3. Geographical distribution and dorsal view of specimens for each species. (A) *Canthon ornatus bipunctatus*. (B) *Canthon ornatus ornatus*. (C) *Canthon ornatus thoracicus*. (D) *Canthon rutilans cyanescens*. (E) *Canthon rutilans rutilans*. (F) *Canthon septemmaculatus linearis*. Scale: 1 mm.

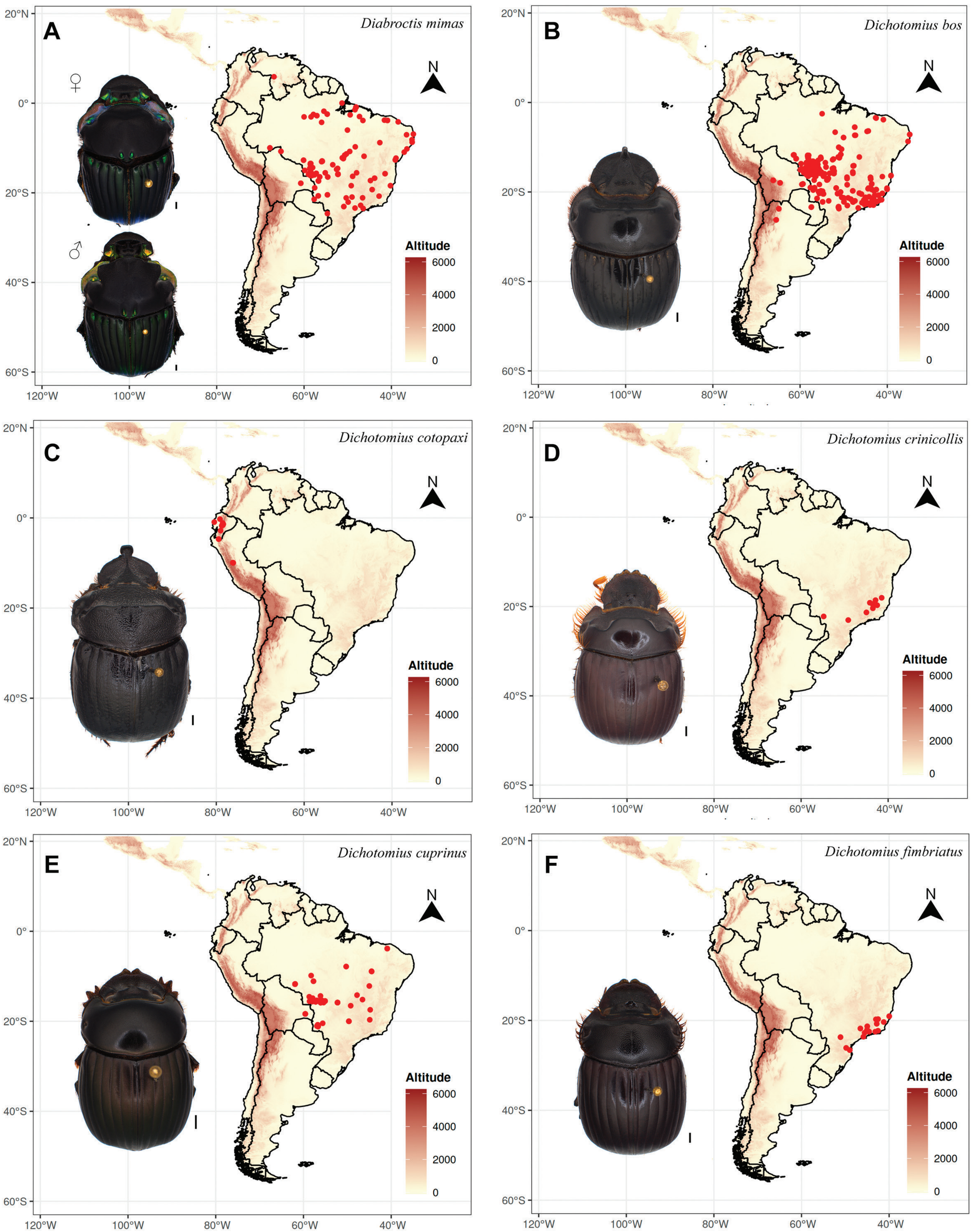

Figure 4. Geographical distribution and dorsal view of specimens for each species. (A) *Diabroctis mimas*. (B) *Dichotomius bos*. (C) *Dichotomius cotopaxi*. (D) *Dichotomius crinicollis*. (E) *Dichotomius cuprinus*. (F) *Dichotomius fimbriatus*. Scale: 1 mm.

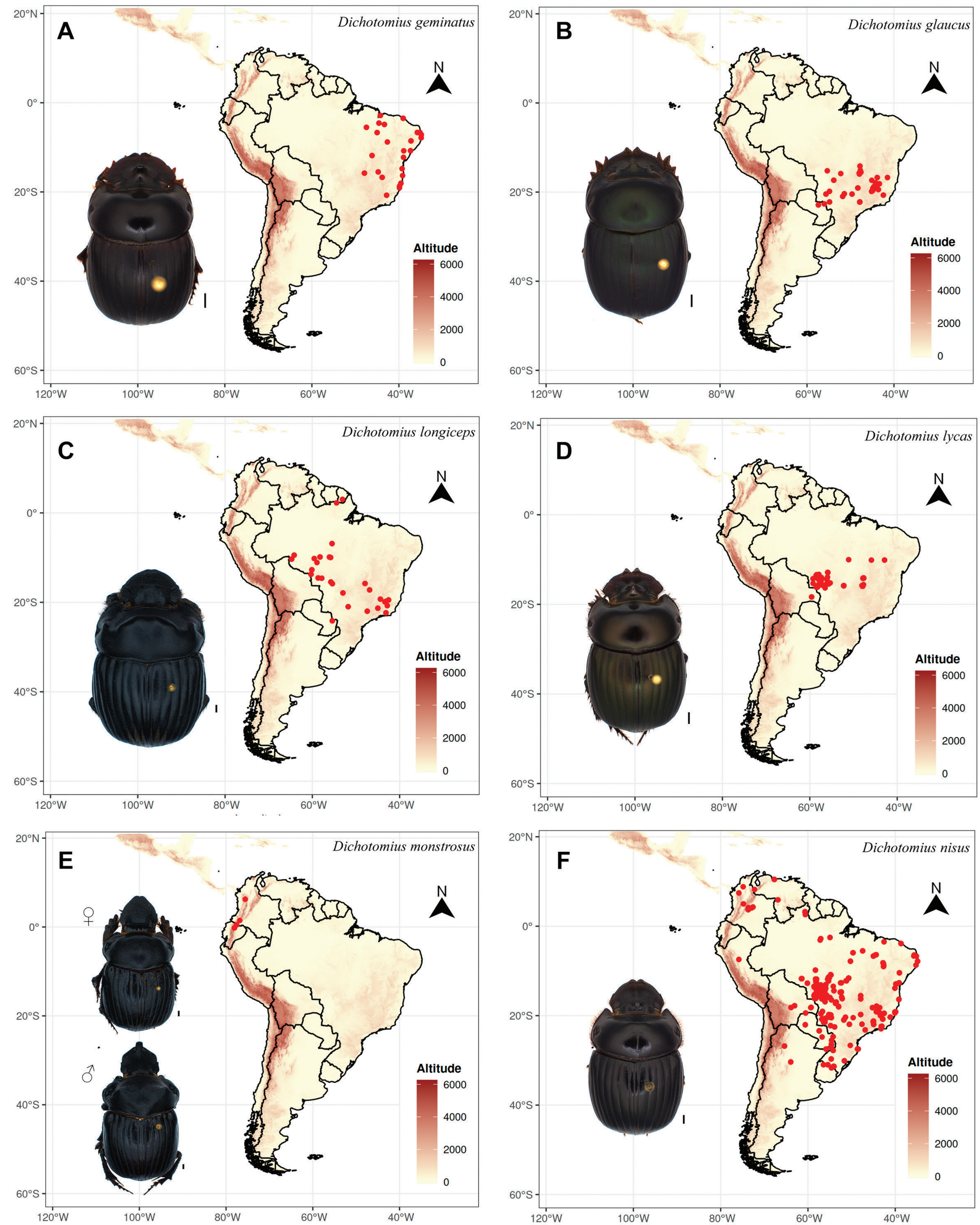

Figure 5. Geographical distribution and dorsal view of specimens for each species. (A) *Dichotomius geminatus*. (B) *Dichotomius glaucus*. (C) *Dichotomius longiceps*. (D) *Dichotomius lycas*. (E) *Dichotomius monstrosus*. (F) *Dichotomius nisus*. Scale: 1 mm.

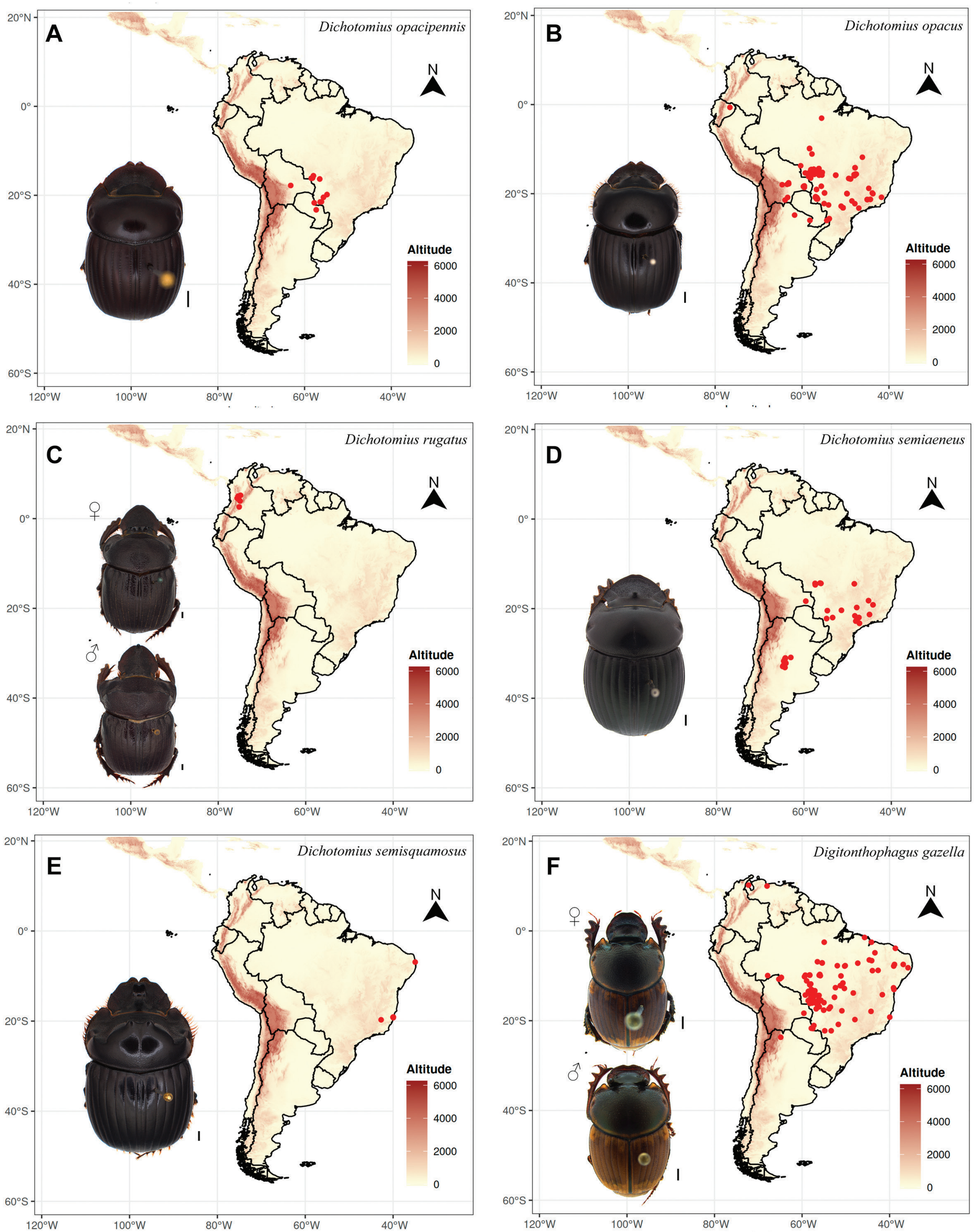

Figure 6. Geographical distribution and dorsal view of specimens for each species. (A) *Dichotomius opacipennis*. (B) *Dichotomius opacus*. (C) *Dichotomius rugatus*. (D) *Dichotomius semiaeneus*. (E) *Dichotomius semisquamosus*. (F) *Digitonthophagus gazella*. Scale: 1 mm.

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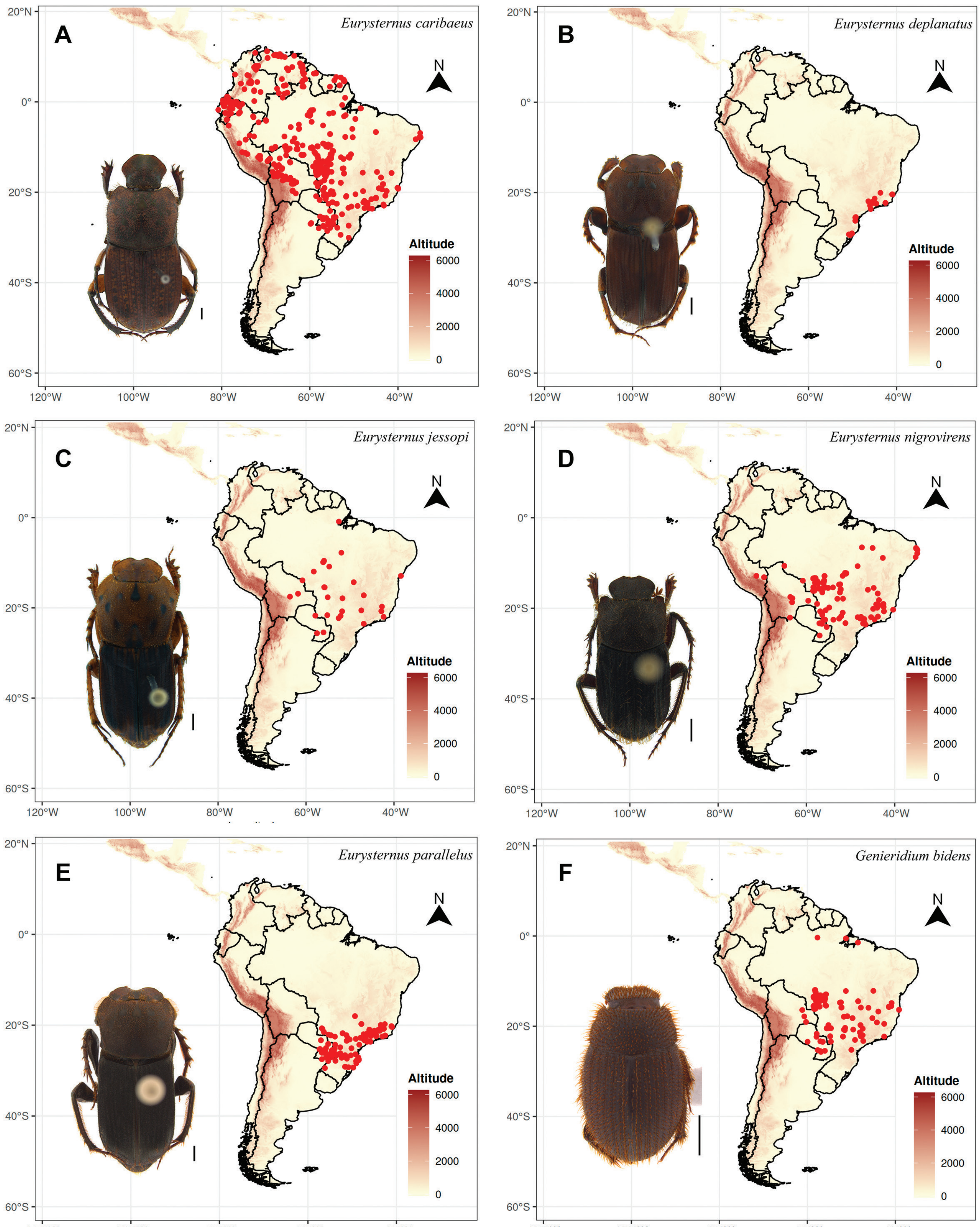

Figure 7. Geographical distribution and dorsal view of specimens for each species. (A) *Eurysternus caribaeus*. (B) *Eurysternus deplanatus*. (C) *Eurysternus jessopi*. (D) *Eurysternus nigrovirens*. (E) *Eurysternus parallelus*. (F) *Genieridium bidens* (Photo: Edrielly Carvalho). Scale: 1 mm.

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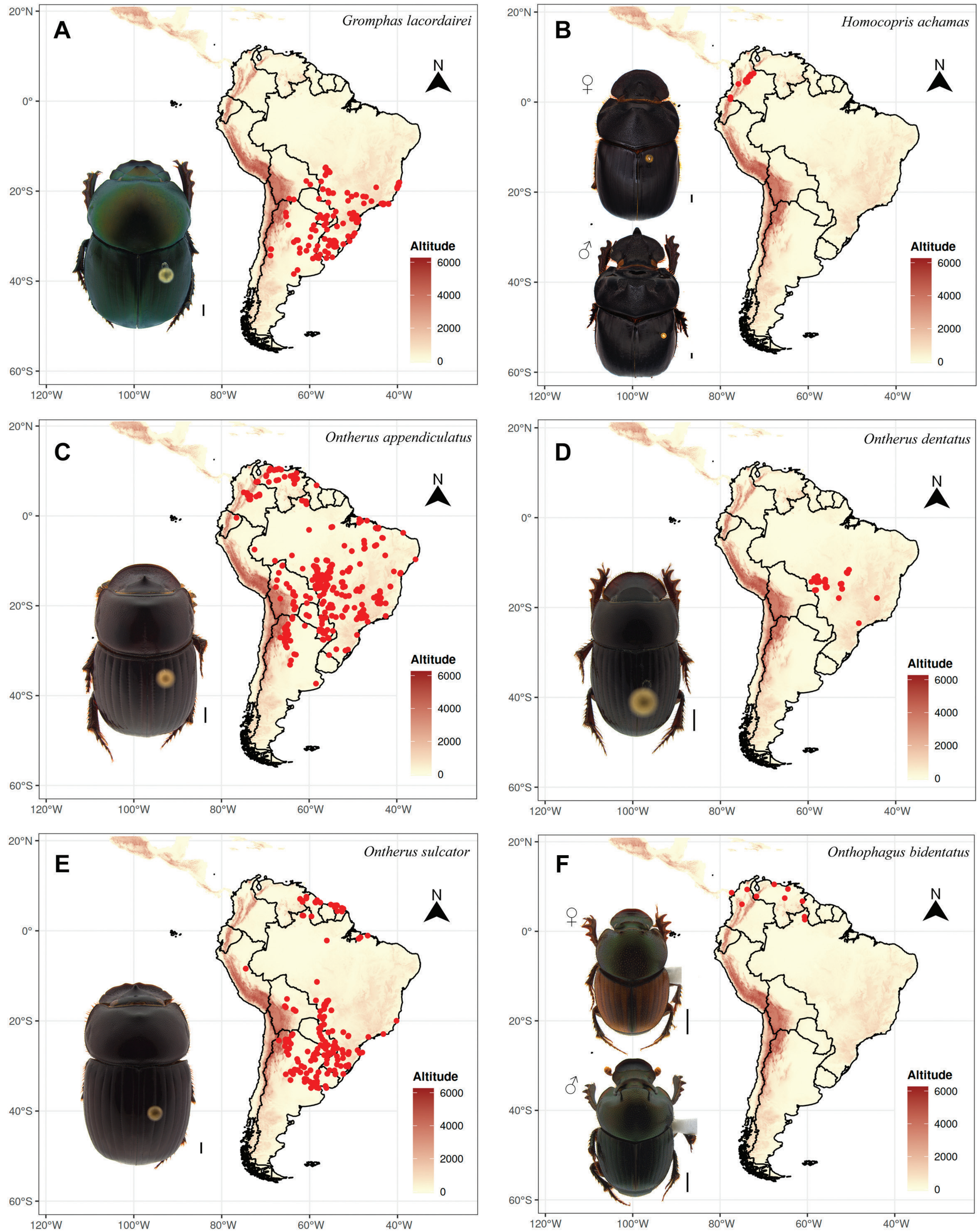

Figure 8. Geographical distribution and dorsal view of specimens for each species. (A) *Gromphas lacordairei*. (B) *Homocopris achamas*. (C) *Ontherus appendiculatus*. (D) *Ontherus dentatus*. (E) *Ontherus sulcator*. (F) *Onthophagus bidentatus*. Scale: 1 mm.

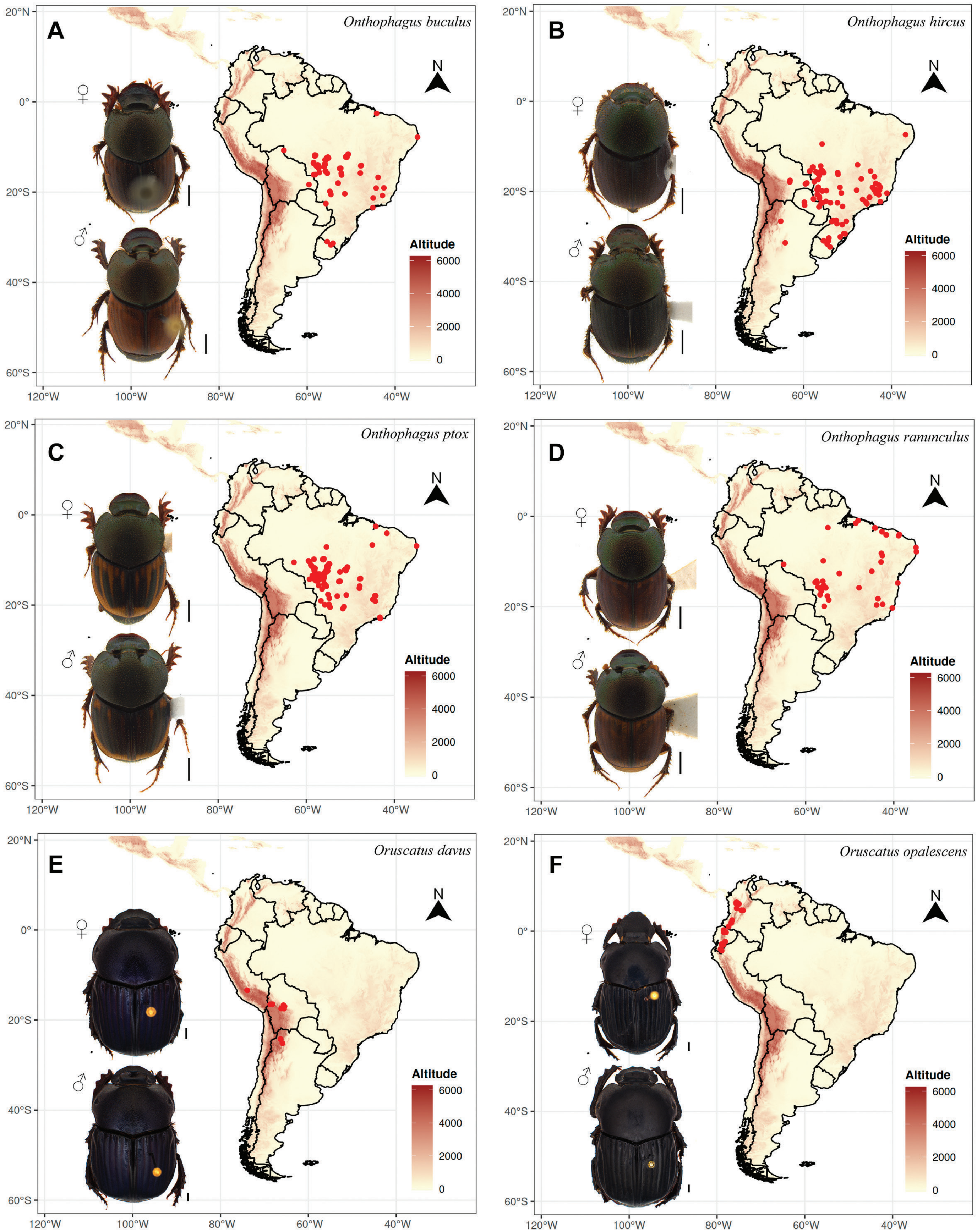

Figure 9. Geographical distribution and dorsal view of specimens for each species. (A) *Onthophagus buculus*. (B) *Onthophagus hircus*. (C) *Onthophagus ptox*. (D) *Onthophagus ranunculus*. (E) *Oruscatus davus*. (F) *Oruscatus opalescens*. Scale: 1 mm.

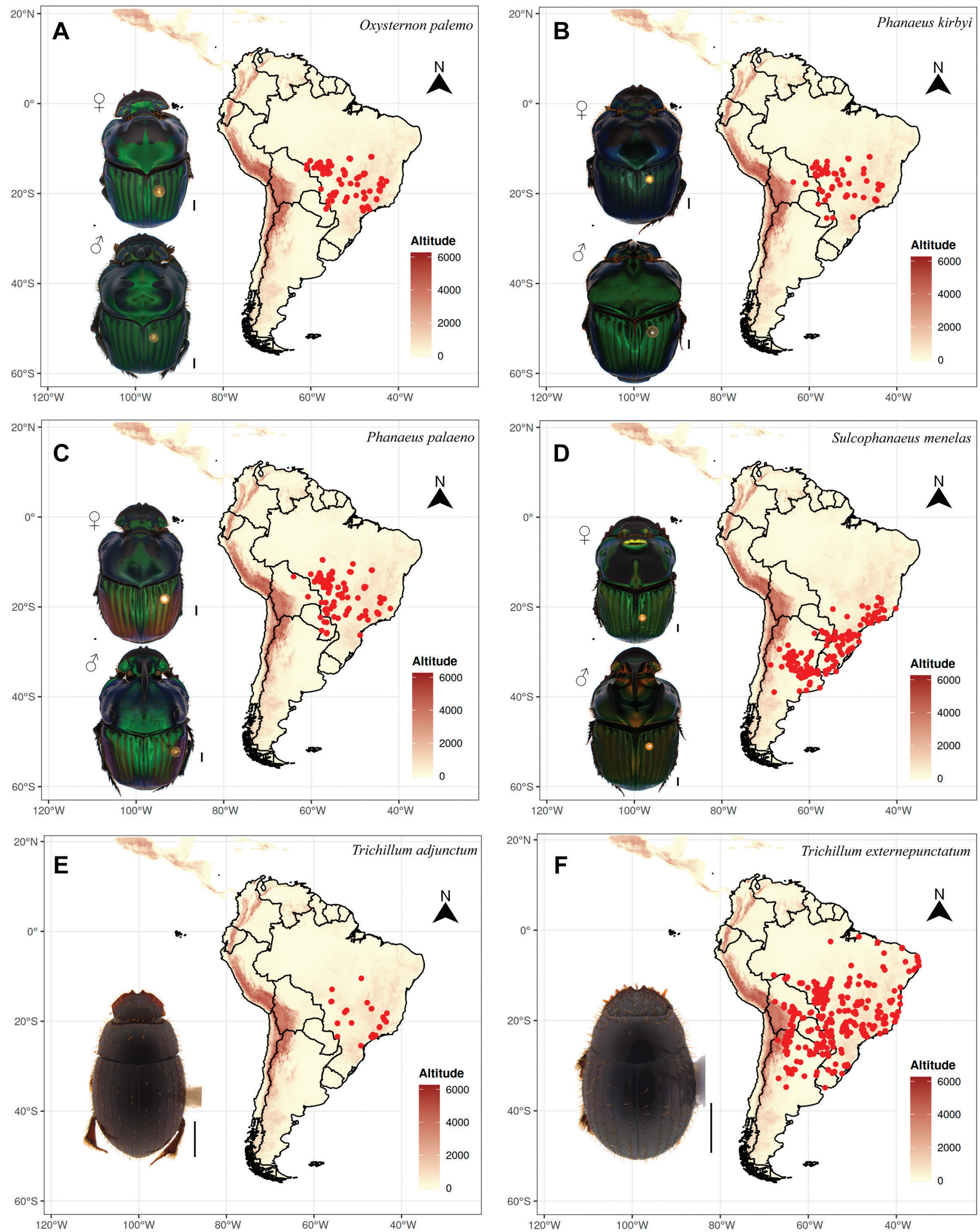

Figure 10. Geographical distribution and dorsal view of specimens for each species. (A) *Oxysternon palemo*. (B) *Phanaeus kirbyi*. (C) *Phanaeus palaeno*. (D) *Sulcophanaeus menelas*. (E) *Trichillum adjunctum*. (F) *Trichillum externepunctatum*. Scale: 1 mm.

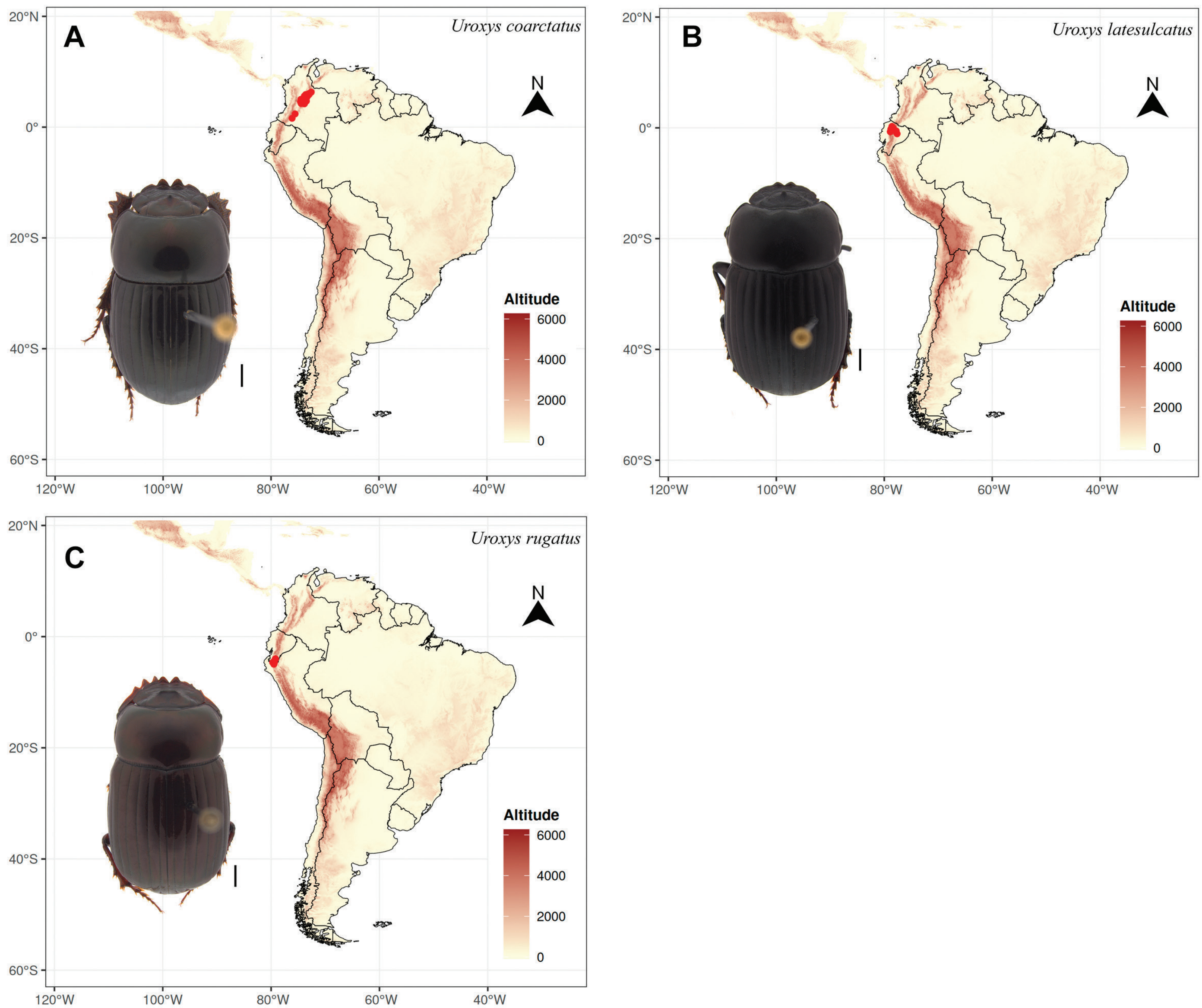

Figure 11. Geographical distribution and dorsal view of specimens for each species. (A) *Uroxys coarctatus*. (B) *Uroxys latesulcatus*. (C) *Uroxys rugatus*. Scale: 1 mm.

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Fernando Z. Vaz-de-Mello: Conceptualization, Resources, Methodology, Writing – review & editing.

Conflicts of Interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by an Institutional Committee.

Data Availability

The datasets generated during and/or analyzed during the current study are available at: https://doi.org/10.48331/scielodata.82AEC8

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