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Edentata

The Newsletter of the IUCN/SSC Anteater, Sloth and Armadillo Specialist Group

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IUCN SSC Species Survival Commission

IUCN/SSC Anteater, Sloth & Armadillo Specialist Group

Edentata

The Newsletter of the IUCN/SSC Anteater, Sloth and Armadillo Specialist Group

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Front Cover Photo
Silky anteater (*Cyclopes didactylus*). Photo: Karina Theodoro Molina, Instituto Tamanduá

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IUCN/SSC Anteater, Sloth and Armadillo Specialist Group logo courtesy of Stephen D. Nash, 2009.

IUCN/SSC
Anteater, Sloth
& Armadillo
Specialist Group

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Letter from the Editors

We're excited to present to you another issue of *Edentata*! *Edentata 19* starts with an impressive review of the distribution and status of Paraguayan Xenarthra. Three short communications provide new information on the distribution of Xenarthra in Argentina and Brazil, two describe unusual behaviors observed in giant anteaters, and another one reports agonistic interactions in a group of brown-throated three-toed sloths. There are also two interesting notes on predator-prey interactions, one describing how a nine-banded armadillo killed a coral snake and the other documenting how a tayra (*Eira barbara*) preyed on a brown-throated three-toed sloth.

We're extremely happy to let you know that our Specialist Group has recently established an agreement with Animal Educators Inc. and Nurtured by Nature. To show their commitment to the conservation of Xenarthra, these institutions will be supporting the Brazilian three-banded armadillo conservation program both financially and by contributing their vast knowledge on the maintenance and captive reproduction of *Tolypeutes* to the Brazilian *ex situ* breeding program. We've also had the pleasure of getting to know artist Ryan Felton, who celebrated his passion for armadillos by writing a beautiful book called *Little Armored Ones* and hosting an exhibition of his armadillo paintings (and armadillo-shaped cupcakes!). Ryan encouraged the exhibition attendees to make donations to our Specialist Group, which allowed us to publish this issue of *Edentata*. We invite you to read more about these initiatives in the News section, and would like to extend a huge thanks to Animal Educators Inc., Nurtured by Nature, and Ryan Felton for their commitment and generous donations.

Our News section is packed with other information, too! You'll find announcements of new books, the recent re-assessments of the conservation status of Xenarthra in Brazil and Argentina, and the openings of new rescue centers in Suriname and Colombia. We're very proud of our Specialist Group member Flávia Miranda, who received recognition from the Brazilian Academy of Sciences for having produced one of the best doctoral theses in the country. We invite you to read more about it in the News section.

We'd like to give a warm welcome to Gabriela Ruellan, who has joined the *Edentata* team as our new graphics designer. Gabriela made small improvements to the Newsletter's layout that we hope will make it even more attractive. Welcome to the team, Gabriela!

Let us take the opportunity to thank all anonymous reviewers for their excellent work. We also thank Sarina Van der Ploeg, Publications Officer at IUCN's Science & Knowledge Unit, for her invaluable help with tracking down all the DOIs in the References sections as well as with assigning the DOIs to all articles published in *Edentata*.

Last, but not least, we'd like to make a call for help. We're looking for a sponsor for upcoming issues of *Edentata*. If your institution is interested in supporting our Newsletter, please contact us at edentata@xenarthrans.org. Thank you!

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Distribution and status of Paraguayan Xenarthra: towards a better understanding

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Abstract Despite great xenarthran biodiversity, the Paraguayan armadillos and anteaters have received little attention from biologists and few data have been published about the distribution and status of the species. Furthermore, errors and contradictions persist in the literature. This paper collates specimen and literature data about this group to act as a basis for the stimulation of future research. Xenarthran specimens in all the major Paraguayan collections and all significant specimens in international collections were examined. Specimen data were collated and supplemented with literature and photographic data. Distribution data are provided according to a hierarchy of record reliability including examined specimens, non-examined specimens, literature records, photographic records, and significant observations. Thirteen species (11 armadillos and two anteaters) are confirmed to be present in Paraguay. Relevant discussion and distribution maps are provided for each species. Specimens of both *Dasypus septemcinctus septemcinctus* and *D. s. hybridus* were examined and their distribution is clarified. There is no evidence that *Bradypus variegatus* occurs in Paraguay. Most xenarthran specimens were collected at least 35 years ago, and the specimen record may no longer represent current distribution given the rapidly changing landscape in the country. It is concluded that available data on Paraguayan Xenarthra shows a heavy bias taxonomically towards a few species (*Dasypus novemcinctus*, *Tolypeutes matacus*, and *Euphractus sexcinctus*) and geographically towards the Chaco region. Distribution in the Oriental region is poorly understood, and species that are confined to that region are known from few specimens. The southern portion of the Oriental region has been virtually unsampled.

Keywords: anteaters, armadillos, Chlamyphoridae, Dasypodidae, Myrmecophagidae

Distribución y estado de los Xenarthra de Paraguay: hacia una comprensión más completa

Resumen A pesar de su riqueza en cuanto a número de especies, los armadillos y osos hormigueros del Paraguay han recibido poca atención de biólogos o naturalistas y pocos datos fueron publicados sobre la distribución y estatus de las especies. Más aún, errores y contradicciones persisten en la literatura. Este trabajo pretende reunir información de especímenes y literatura que pueda servir de base para la estimulación de futuras investigaciones sobre las especies del país. Fueron examinados especímenes de xenartros de todas las principales colecciones paraguayas y especímenes depositados en colecciones internacionales. Los datos de los ejemplares fueron cotejados y suplementados con literatura y registros fotográficos. Los datos de distribución se proveen de acuerdo a una jerarquía de confianza, incluyendo ejemplares examinados, ejemplares no examinados, registros de literatura, registros fotográficos y observaciones significativas. Trece especies (11 armadillos y dos osos hormigueros) se confirman como presentes en el Paraguay. Para cada especie se provee una discusión relevante y mapas de distribución. Fueron examinados especímenes de *Dasypus septemcinctus septemcinctus* y *D. s. hybridus* y su distribución esclarecida. No existe evidencia de que *Bradypus variegatus* ocurra en Paraguay. La mayor parte de los especímenes fueron colectados al menos 35 años atrás y su registro puede no representar la distribución actual de las especies,

considerando el constante cambio de uso de la tierra en el país. Se concluye que los datos disponibles sobre xenartros paraguayos muestran un gran sesgo taxonómico hacia ciertas especies (*Dasypus novemcinctus*, *Tolypeutes matacus* y *Euphractus sexcinctus*) y geográfico hacia la región chaqueña. La distribución en la Región Oriental es pobremente comprendida y las especies presentes en esa región se conocen de muy pocos especímenes. La porción sureña de la Región Oriental prácticamente no ha sido muestreada.

***Palabras clave*:** armadillos, Chlamyphoridae, Dasypodidae, Myrmecophagidae, osos hormigueros

Introduction

The Magnorder Xenarthra as traditionally understood consists of two orders: Pilosa, which includes the anteaters (Myrmecophagidae and Cyclopedidae) and the sloths (Megalonychidae and Bradypodidae); and Cingulata, which contains the armadillos (Dasypodidae and Chlamyphoridae) split into the four subfamilies Dasypodinae (*Dasypus*), Euphractinae (*Chaetophractus*, *Euphractus*, and *Zaedyus*), Chlamyphorinae (*Chlamyphorus* and *Calyptophractus*), and Tolypeutinae (*Cabassous*, *Priodontes*, and *Tolypeutes*) (Gardner, 2008; Gibb *et al.*, 2016).

The xenarthran fauna of Paraguay is amongst the richest on the continent, with a proposed 14 species (three Dasypodidae, nine Chlamyphoridae, and two Myrmecophagidae) (Smith, 2012; de la Sancha *et al.*, 2017; Saldívar *et al.*, 2017). However, studies on the group in Paraguay have been few and far between, and even basic data on the distribution of many species is lacking, confused or inadequate (Smith *et al.*, 2012; Abba *et al.*, 2017). With a view towards consolidating the available data on the distribution and status of Paraguayan Xenarthra a review of the specimens, literature, and reliable field records was performed. The results are presented here.

The history of Xenarthra studies in Paraguay

The fauna of the Jesuit territory of "Paraquaria" (which encompassed a large area of northern Argentina, Paraguay, southern Brazil, and eastern Bolivia) were described by several early Jesuit missionaries, notably Dobrizhoffer (1784) who mentioned three armadillos, the Tatùpoyù (*Euphractus sexcinctus*), the Mulita (*Dasypus* sp.) and the Bolita (*Tolypeutes matacus*), as well as the Osso hormigero (*Myrmecophaga tridactyla*), without clarifying where he observed them. Writing around the same time Sánchez Labrador (1910, reproduced from a late 18th Century manuscript) noted that armadillos of this region were "composed under four different names" (presumably referring to four species?), which he elected not to name, and the Bidioni (*M. tridactyla*).

The first systematic treatise dealing with the Paraguayan species was Azara (1801, 1802) who described five species of armadillos (*Dasypus novemcinctus*, *D. hybridus*, *Priodontes maximus*, *E. sexcinctus*, *Cabassous tatouay*) and both species of anteater (*M. tridactyla* and *Tamandua tetradactyla*). Azara (1801, 1802) gave only common names for his species, but two of these descriptions would later form the basis for scientific names still in use today (*Dasypus hybridus* and *Ca. tatouay*). Rengger (1830) cited the same species, noting however that he had never personally encountered either *D. hybridus* or *P. maximus*. Indeed, such was the lack of study in the country, that the base list for Paraguay was still derived entirely from Azara as late as Gray (1869) and Bertoni (1914), who cited the same species. Sanborn (1930) reported the first specimen of *T. matacus* for Paraguay, but this was overlooked by Bertoni (1939) who continued to treat the species as hypothetical.

Nomenclatural confusion in the genus *Cabassous* was reflected in Bertoni (1939) and he followed Yepes (1928) in listing the composite species *Ca. loricatus* for Paraguay without sound basis. At this point just over half of the Paraguayan Cingulata fauna had been recorded in the country, but it was not until much later with the first explorations deep into the Chaco region that the true diversity of the country became apparent. Myers & Wetzel (1979) added three armadillo species from the Dry Chaco (*Chaetophractus villosus*, *C. vellerosus*, and *Calyptophractus retusus*), and the diligent taxonomic work of Wetzel (1980) finally clarified species limits in the genus *Cabassous* with the description of a new species, *Ca. chacoensis,* from a Paraguayan type locality. The last species to be confirmed in Paraguay was *Ca. unicinctus* (Roguin, 1986).

The identity of the small *Dasypus* inhabiting Paraguay has long been the subject of debate, with these animals being alternatively referred to as *D. septemcinctus* or *D. hybridus* or both. Feijó *et al.* (2018) attempted to resolve this by declaring a neotype for *D. hybridus*, which they considered a subspecies of *D. septemcinctus*, and referring the only Paraguayan specimen available to them to the nominate *D. s. septemcinctus*. However, possibly based on the coordinates provided by Azara (1801, 1802) for *D. hybridus*, which theoretically includes the southern part of the Oriental region of Paraguay, they highlighted a potential zone of contact for the

two subspecies that covers much of eastern and southern Paraguay. Unfortunately no specimens are available from this proposed contact zone in order to test hypotheses. Consequently, 13 species of Xenarthra (11 armadillos, 2 anteaters) are now considered to occur in Paraguay.

Materials and Methods

Specimens of xenarthrans from the major zoological collections in Paraguay were reviewed during 2011 to 2015, identifications were confirmed by inspection of the specimens, and locality data were collated from museum databases and specimen labels. Specimens at national park collections are also included, though these collections are uncatalogued, unregistered, and specimens are unlabelled. Data for these specimens was obtained where available by personal communication with the collectors and curators. The location of specimens in foreign museums was gleaned from the literature and from Vert Net (which returned 222 results for armadillos and 26 results for Myrmecophagidae). Where possible, specimens considered to represent significant geographical range extensions were reviewed with the assistance of museum curators. Those that did not present noteworthy distributions were assumed to be correct and not examined.

Collection codes for museums housing Paraguayan Xenarthran specimens are as follows:

ASNHC Angelo State University Natural History Collection, USA.

CBMI Colección Biológica Museo de Itaipú, Hernandarias, Paraguay.

CM Carnegie Museum of Natural History, Pittsburgh, USA.

CONN University of Connecticut Museum of Natural History, USA.

CZCEN Colección Zoológica de la FACEN, San Lorenzo, Paraguay.

CZPLT Colección Zoológica Para La Tierra, Pilar, Paraguay.

FLMNH Florida Museum of Natural History, Gainesville, USA.

FMNH Field Museum of Natural History, Chicago, USA.

MCNM Museo de Ciencias Naturales de Madrid, Spain.

MJUF Museo Jakob Unger, Filadelfia, Paraguay.

MACN Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", Buenos Aires, Argentina.

MLP Museo de La Plata, Argentina.

MHNG Musée d´Histoire Naturelle de Genève, Switzerland.

MNC Museo Nacional de Chile, Santiago, Chile (currently the Museo Nacional de Historia Natural de Chile).

MNHNP Museo Nacional de Historia Natural del Paraguay, San Lorenzo, Paraguay.

MSB Museum of Southwestern Biology, Albuquerque, USA.

MTD Museum für Tierkunde, Dresden, Germany.

MZ Museo Zoológico Universidad Nacional de Asunción, Agronomía y Veterinaria, San Lorenzo, Paraguay (currently the Museo Schade SCH).

MZB Museu de Ciències Naturals de Barcelona, Spain.

MZS Musée Zoologique de l'Université et de la Ville, Strasbourg, France.

NHM Natural History Museum, London, United Kingdom.

NHMB Naturhistorisches Museum Basel, Switzerland.

RBINS Royal Belgian Institute of Natural Sciences, Belgium.

ROM Royal Ontario Museum, Ontario, Canada.

SCH Museo Schade, Facultad de Ciencias Agrarias, San Lorenzo, Paraguay.

TTU Museum of Texas Tech University, Texas, USA.

UAM University of Alaska Museum, USA.

UMZC University Museum of Zoology, Cambridge, United Kingdom.

USNM National Museum of Natural History, Smithsonian Institute, Washington, USA.

SMNH Swedish Museum of Natural History, Stockholm, Sweden.

ZFMK Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany.

Species accounts begin with the current common name, scientific name, and author following Bertassoni (2018), McDonough & Loughry (2018), and Superina & Abba (2018) with one taxonomic change proposed by Feijó *et al*. (2018). The original described name, author, and type locality follow. There then follows a referenced list of the synonyms used in the Paraguayan literature with a (hopefully self-explanatory) single word descriptor of the subject of the publication, as follows: conservation, diet, distribution, ecology, dictionary, ethnography, genetics, guide, habitat, list, mention, parasitology, records, specimen/s, taxonomy, tracks, and use.

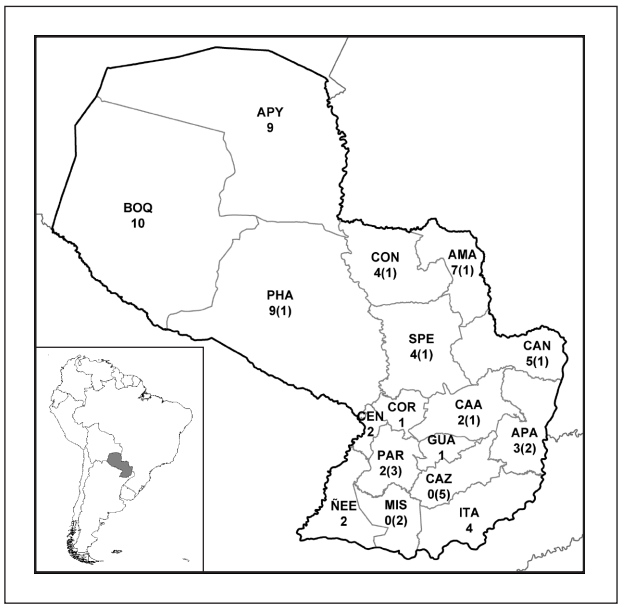

FIGURE 1. Xenarthran biodiversity by department. **NUMBER** represents species documented with specimens, **NUMBER IN PARENTHESES** additional species with reliable reports documented in this paper but with no voucher specimen. **AMA:** Amambay; **APA:** Alto Paraná; **APY:** Alto Paraguay; **BOQ:** Boquerón; **CAA:** Caaguazú; **CAN:** Canindeyú; **CAZ:** Caazapá; **CEN:** Central; **CON:** Concecpción; **COR:** Cordillera; **GUA:** Guairá; **ITA:** Itapúa; **MIS:** Misiones; **ÑEE:** Ñeembucú; **PAR:** Paraguarí; **PHA:** Presidente Hayes; **SPE:** San Pedro.

The synonymy deals only with Paraguayan literature or literature citing Paraguayan specimens and is not intended to be a complete list of synonymy for the species.

Local names: Local common names published in the Paraguayan literature are provided. An attempt to reference the earliest published usage for each name is made.

Comments: Addressing noteworthy or confusing themes in the Paraguayan literature.

There then follows a "hierarchical reliability" approach to the Paraguayan distribution of each species. This approach is taken so as to not unduly bias understanding by depending solely on the limited specimen record. The hierarchies are, in order of documented reliability: 1) examined specimen, 2) specimen not examined, 3) published literature record, 4) published photographic record, 5) reliable field observation by one of the authors or knowledgeable local observer. The vast majority of the photographic records referred to are available online at http://www.faunaparaguay.com and can be found using their unique photo code preceded with FPMAMM. Records are presented with the political department in bold capitals, followed by the details of the record (in alphabetical order; **FIG. 1**). For specimen records this involves the specimen number followed by the locality. These records are also mapped distinguishing the hierarchical categories so that readers may interpret their reliability for themselves (**FIGS. 3–15**). Records corresponding to categories 4) published photographic records and 5) reliable field observation include only localities that are not covered by any one of the previous three categories. A full gazeteer of the localities mentioned in the text is provided as **SUPPLEMENTARY MATERIAL** on the Edentata website (http://www.xenarthrans.org/newsletter/Smith&Rios_Supplementary_material.pdf).

The criteria for inclusion of literature was that it was published in Paraguay or specifically deals with Paraguay, or in the case of international publications, that it makes specific reference to Paraguayan specimens. Every effort was made to be thorough in this regard, though undoubtedly some obscure references will have been missed.

The conservation status for all Paraguayan species was assessed by Smith (2012) and Abba *et al.* (2017) and is not repeated here. Detailed compiled reviews of the ecology of all species are provided by Smith (2007a–f, 2008a–f, 2009, 2011) and these data are also not repeated here. However, the distribution information that is provided here should be understood as replacing the Paraguayan distribution data provided in those works.

A statement on the ecological affinities of each species in Paraguay is provided based on the ecoregions defined by Olson *et al.* (2001) (**FIG. 2**), and later updated by Guyra Paraguay (2005) and Mereles (2013) (no map shapes currently available). These can be broadly defined as follows: Alto Paraná Atlantic Forest (subtropical humid forests of eastern Paraguay); Cerrado (central South American savanna of northern eastern Paraguay); Dry Chaco (low, arid thorn forest and scrub of the western Occidental region); Humid Chaco (palm savanna and marshlands of the Paraguay River Basin); Pantanal (gallery forests and swamps of the north-eastern Chaco); Cerrados del Chaco (an area of Cerrado in the northern Chaco contiguous with the Chiquitania of Bolivia) and Southern Cone Mesopotamian Savanna (flooded Mesopotamian grasslands of the southern Oriental region) (**FIG. 2**).

RESULTS

Locality data for 13 species and 14 subspecies of Xenarthra in four families is provided (**FIG. 2**) and one species is rejected. Distributions for each of the confirmed species are mapped (**FIGS. 3–15**) and confidence levels are distinguished from each other in the map keys, allowing future researchers to make their own decisions on reliability of records consistent with the demands of their own research.

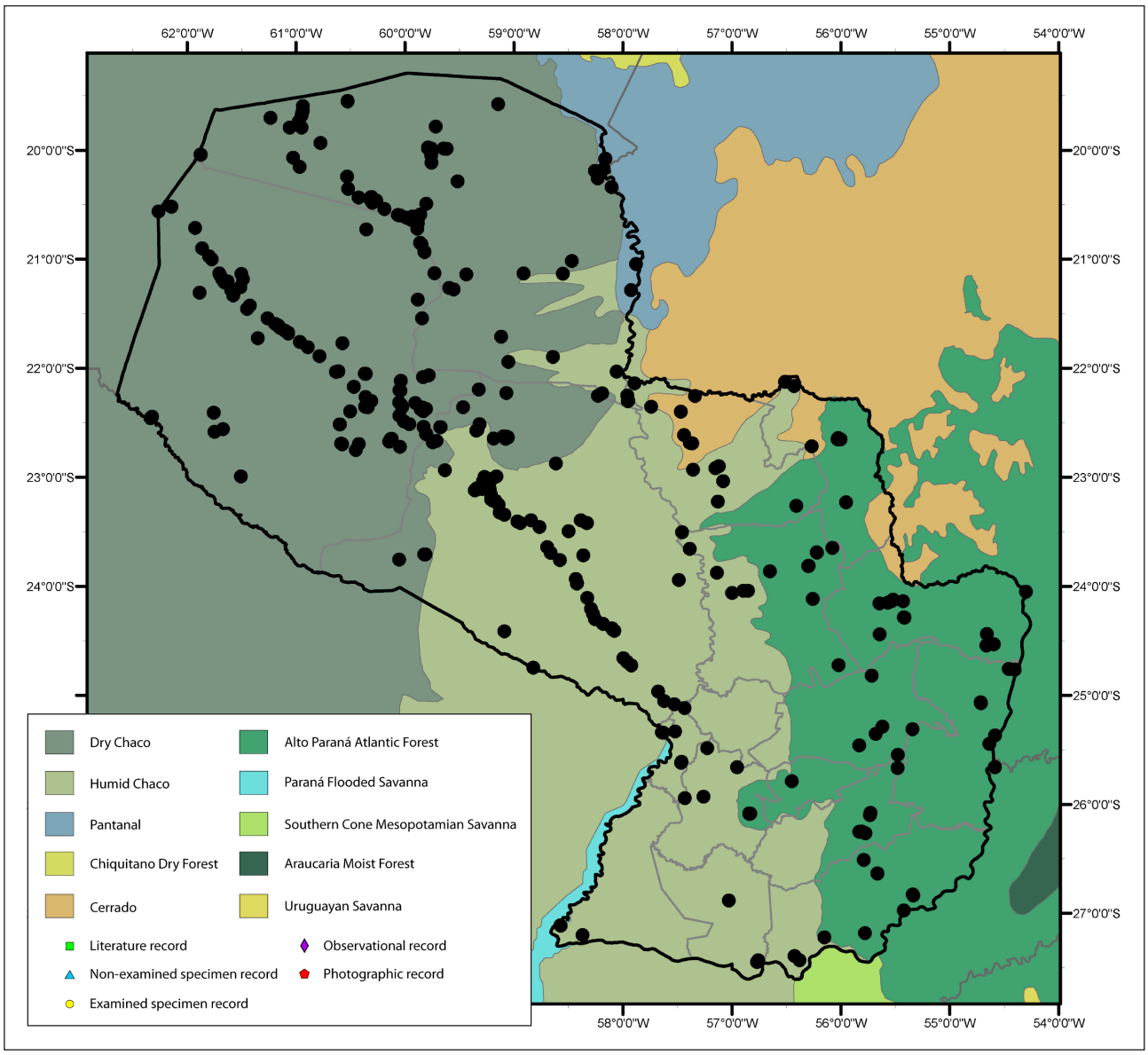

FIGURE 2. Geographical coverage of all the localities cited in this paper on a base map of the regional ecoregions, and with key to symbols used on species maps.

DASYPODIDAE: Long-nosed armadillos

SEVEN-BANDED ARMADILLO

Dasypus septemcinctus
(Linnaeus, 1758) (**FIG. 3**)

[*Dasypus*] *septemcinctus* Linnaeus 1758:51. Type locality "in Indiis" corrected to "Brasilia" by Erxleben (1777) and restricted to Pernambuco, Brazil by Cabrera (1958).

lor[*icatus*] *hybridus* Desmarest 1804:28. No type locality given. Based on Azara (1801). Restricted to San Ignacio, Misiones, Paraguay by Cabrera (1958), neotype designated by Feijó *et al.* (2018) from Estancia Jeffries, eight miles East of Treinta y Tres, department of Treinta y Tres, Uruguay.

Dasypus hibridus Rengger (1830: ecology).

Dasypus hybridus Rengger (1830: ecology); Bertoni (1939: list); Cabrera (1958: taxonomy); Wetzel & Mondolfi (1979: taxonomy); Gamarra de Fox & Martin (1996: records); Neris *et al.* (2002: distribution); Smith (2008f: ecology); Smith (2012: conservation).

Tatusia hybrida Bertoni (1914: list).

Dasypus septemcinctus Masi Pallarés & Benítez Usher (1982: parasitology); Gamarra de Fox & Martin (1996: no records); Gamarra de Fox *et al.* (1998: no records); Yahnke *et al.* (1998: distribution); Villalba & Yanosky (2000: tracks); Esquivel (2001: guide); Neris *et al.* (2002: distribution); Nava *et al.* (2007: parasitology); Abba & Vizcaíno (2008: specimens); Smith (2008e: ecology); Smith (2012: conservation).

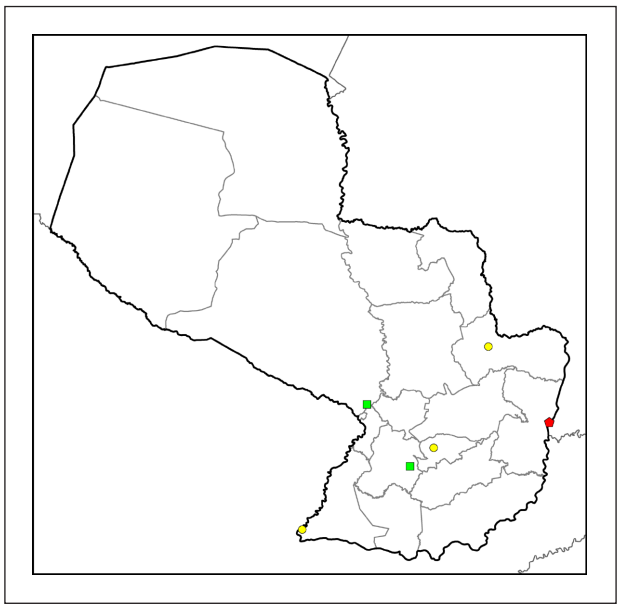

Figure 3. Distribution of *Dasypus septemcinctus* in Paraguay.

Dasypus hybridis Yahnke *et al.* (1998: distribution).

Dasypus sp. Fariña & Hostettler (2003: distribution).

Tolypeutes matacus Fariña & Hostettler (2003: distribution).

Dasypus septencinctus Masi Pallarés (2011: ecology).

Dasypus septemcinctus hybridus Feijó *et al.* (2018: taxonomy).

Dasypus septemcinctus septemcinctus Feijó *et al.* (2018: taxonomy).

Local names: **Aché:** Tatu kuju (Fariña & Hostettler, 2003); **Guaraní:** Tatú-mburicá (Azara, 1802); Tatu-mburica (Rengger, 1830); Tatu Hu (Gamarra de Fox *et al.*, 1998); Tatu Hu'i (Neris *et al.*, 2002); Tatu bolita, Tatu'i (Fariña & Hostettler, 2003); **Spanish:** Mulita (Azara, 1802); Mulita orejuda, Armadillo siete bandas, Mulita de las pampas (Gamarra de Fox & Martin, 1996); Mulita común (Neris *et al.*, 2002); Armadillo (Morales, 2007).

Comments: Following persistent confusion between *D. septemcinctus* and *D. hybridus* (*e.g.*, Gray, 1874; Lönnberg, 1928), the first attempt to elucidate their identities was by Hamlett (1939) who restricted the range of *D. septemcinctus* to Brazil. He noted that it was replaced by *D. hybridus* in Rio Grande do Sul and southern Mato Grosso, the states that immediately border Paraguay. Despite this subsequently becoming the taxonomic orthodoxy, *D. septemcinctus* continued to figure frequently in Paraguayan publications dealing with armadillos since then (*e.g.*, Yahnke *et al.*, 1998; Neris *et al.*, 2002; Smith, 2012), as well as in significant taxonomic works (*e.g.*, Wilson & Reeder, 2005; Wetzel *et al.*, 2008) even though none specifically referenced Paraguayan specimens. This issue was recognized by Gamarra de Fox & Martin (1996) and Gamarra de Fox *et al.* (1998) who listed the species as one with "problems with records" for Paraguay.

Feijó *et al.* (2018) reviewed the global taxonomy of the genus *Dasypus*, and considered *D. hybridus* to be a subspecies of *D. septemcinctus*, identifiying one "small *Dasypus*" specimen available from Paraguay (MNHNP 3365, collected on 7 December 2006 by Ismael Mora) as *D. septemcinctus*, but not examining any additional specimens.

The subspecies *D. s. hybridus* was first associated with Paraguay on the basis of Azara (1801, 1802). Azara noted that the Guaraní name Tatú-mburicá means "mule armadillo", presumably in reference to the long, mule-like ears (and this may also be the source of the scientific name *hybridus*—Feijó *et al.* (2018)). Azara stated that he had "never found the species north of 26.5 degrees", leading Cabrera (1958) to fix the type locality of *D. hybridus* as San Ignacio, Paraguay (Misiones department) on the basis that it represented approximately the northern limits of the range mentioned by Azara (1801, 1802). However, the area covered by Azara's work was much greater than the boundaries of modern-day Paraguay and the latitude given also covers large areas of Argentina and Brazil, rendering Cabrera's restriction somewhat arbitrary. It is often overlooked that in the introduction to his armadillos Azara (1802) stated that his fourth, sixth, seventh, and eighth armadillo species (*D. hybridus* is the sixth) were distributed in the "southern part" of his geographic area (approximating to the River Plate basin) and "not in Paraguay", though he added that "in truth the sixth can be seen only in the most southerly part of the province" (Paraguay) (Azara, 1802:105). Given that the Paraguay of Azara's time included the now Argentine provinces of Misiones and Formosa, it is by no means clear that he was referring to an area north of the Paraná River, in modern-day Paraguay. Though the latitude he provided does include a portion of the southern part of the Oriental region of Paraguay, it also perhaps importantly includes substantial areas of Formosa and Misiones, Argentina (Abba & Superina, 2016).

Gray (1869) (who never visited Paraguay) described *D. hybridus* as "very common" in Paraguay, but this was not an opinion shared by Rengger (1830) (who lived in Paraguay for many years) who said he searched for the species "in vain". Azara's statement about the great abundance of the species clearly referred to the "austral part" of the "La Plata province" rather than the northern reaches that incorporate modern Paraguay.

Feijó *et al.* (2018) declared a neotype (FMNH 29334) from Estancia Jeffries, eight miles East of Treinta y Tres, department of Treinta y Tres, Uruguay

TABLE 1. Types of records of xenarthrans by department. **APY:** Alto Paraguay; **BOQ:** Boquerón; **PHA:** Presidente Hayes; **AMA:** Amambay; **CON:** Concepción; **SPE:** San Pedro; **CAN:** Canindeyú; **CEN:** Central; **COR:** Cordillera; **CAA:** Caazapá; **APA:** Alto Paraná; **PAR:** Paraguarí; **GUA:** Guairá; **CAZ:** Caazapá; **ITA:** Itapúa; **MIS:** Misiones; **ÑEE:** Ñeembucú; **NO LOC:** No locality. For each species the upper line is the number of specimen records and the lower the number of localities in non-specimen records reported in this publication. In the line "Dept. Total" the first number refers to the number of species represented in specimen collections for that department. Then in parentheses (the total number of specimens from the department / number of localities with non-specimen records reported in this publication). The total for Itapúa (marked with a *) does not include the questionable *Chaetophractus vellerosus* specimen.

Species	Chaco			Oriental region														NO LOC	TOT
	APY	BOQ	PHA	AMA	CON	SPE	CAN	CEN	COR	CAA	APA	PAR	GUA	CAZ	ITA	MIS	ÑEE		
Dasypus hybridus	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	1 0	2 1	4 1
Dasypus septemcinctus	0 0	0 0	0 1	0 0	0 0	0 0	2 0	0 0	0 0	0 0	0 1	0 1	0 0	0 0	0 0	0 0	0 0	0 0	2 3
Dasypus novemcinctus	7 1	4 3	15 3	2 1	3 0	6 3	18 4	4 1	0 0	3 2	3 3	0 1	0 0	0 2	4 2	0 1	0 0	5 0	74 27
Tolypeutes matacus	45 2	54 8	39 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	26 0	164 11
Priodontes maximus	8 5	1 1	5 1	0 1	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 1	0 0	0 0	0 0	0 0	0 0	20 0	35 9
Cabassous chacoensis	1 1	5 4	3 2	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	6 1	8 7
Cabassous tatouay	0 0	0 0	0 0	1 0	0 0	0 1	2 2	0 0	0 0	0 1	0 2	0 0	0 0	0 1	1 1	0 1	1 0	2 0	7 9
Cabassous unicinctus	0 0	0 0	0 0	2 1	1 0	2 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	5 1
Calyptophractus retusus	0 0	4 2	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	5 2
Euphractus sexcinctus	9 2	5 3	15 2	1 0	1 0	2 3	1 1	3 0	0 0	0 0	1 1	2 0	0 0	0 1	1 0	0 0	0 0	7 0	48 13
Chaetophractus villosus	3 1	20 10	4 1	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	27 12
Chaetophractus vellerosus	1 2	13 5	1 4	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1? 0	0 0	0 0	1 0	17 11
Myrmecophaga tridactyla	6 1	7 2	4 1	1 0	0 1	0 0	0 1	0 0	0 0	2 0	0 0	0 0	0 0	0 1	0 0	0 0	0 0	14 0	34 7
Tamandua tetradactyla	5 0	5 1	10 4	2 0	1 3	1 1	3 1	0 0	0 0	0 0	1 1	1 1	0 0	0 1	1 1	0 0	0 0	20 0	50 14
Dept. Total	**9** **(87/15)**	**10** **(118/39)**	**9** **(96/20)**	**7** **(9/3)**	**4** **(6/4)**	**5** **(11/8)**	**5** **(27/9)**	**2** **(7/1)**	**0** **(0/0)**	**2** **(5/3)**	**3** **(4/8)**	**2** **(3/4)**	**1** **(1/0)**	**0** **(0/6)**	**4*** **(7/4)**	**0** **(0/2)**	**2** **(2/0)**	**11** **(104/2)**	**480/113**

collected on December 1, 1926 by Colin Campbell Sanborn.

A mounted specimen in the Royal Ontario Museum (ROM 9508130010) was bequeathed to the museum by Toronto University, which in turn received the material from a now defunct and unidentified educational institution. The institution had purchased the specimen from "Gerrard's of London", a company well known for inexact localities. Consequently this specimen may or may not have originated in Paraguay.

An individual from the Mbaracayú Reserve, Canindeyú department was identified as *D. septemcinctus* "based on measurements" (Hugo del Castillo, pers. comm.). The specimen was captured between 10–14 November 2000 by Aché indigenous hunters who referred to it as "tatu bolita", a common name usually associated with the Chaco species *T. matacus* (and possibly contributing to baseless reports of that species in eastern Paraguay; *e.g.*, Fariña & Hostettler, 2003). Although the specimen was apparently collected, its current whereabouts are unknown.

Specimen MACN 28.226 identified in the museum catalogue as *D. septemcinctus* is a badly stuffed juvenile specimen with skull included from "Puerto Guarany" collected by Juan B. Daguerre (Abba & Vizcaíno, 2008). The specimen lacks a tail, appears to lack at least one movable band and has been poorly repaired. We suspect it is likely a juvenile *D. novemcinctus*, but consider it unidentifiable. Daguerre is known to have collected in this area during at least August and September 1928, but two specimens of *D. novemcinctus* in the MACN (28.224, 28.225) also bear the exact same collection data. Consequently, we consider the identification and data accompanying this specimen to be suspect.

Skull specimen MVZ 4824, which appears in the museum catalogue as *D. septemcinctus* and on the specimen label as *Dasypus sexcinctus*, is actually referable to *D. novemcinctus* on the basis of size and the presence of eight teeth in each tooth row.

We attribute the specimen from Canindeyú (MNHNP 3365) and the photographs from Alto Paraná (FPMAMM 1174–1175) to *D. s. septemcinctus*, and the specimens from Guairá (ZMB 40472, bought by the museum in December 1927 from J. Flemming and illustrated at FPMAMM 1179) and Ñeembucú (NHMB 1450, collected on 27 June 1904 by Carl Ternetz and illustrated at FPMAMM 1176–1178) to *D. s. hybridus* based on morphometrics (notably ratio of head length to ear length). The limited information on Paraguayan specimens suggests that *D. s. septemcinctus* occurs at very low density in a restricted area of the eastern Oriental region of Paraguay at the interface of the Cerrado and Atlantic Forest ecoregions, and it is replaced in the grasslands and Humid Chaco of the southwestern Oriental region by *D. s. hybridus*. However, the extent to which these populations contact in central Paraguay is unknown. There is no physical evidence to support the literature citations for the presence of "*D. hybridus*" in Paraguarí or Presidente Hayes departments, and these may represent range extrapolations or identification errors (Masi Pallarés & Benítez Usher (1982), for example, contains several serious nomenclatural errors). We recommend that they be treated with caution pending further data.

Specimens examined: "Paraguay" MZS 01598 (Wetzel & Mondolfi, 1979), ROM 9508130010; **Canindeyú:** "Estancia La Rama III, 24°09.426'S, 55°34.299'W" MNHNP 3365; **Guairá:** Villarrica ZMB 40472 (Wetzel & Mondolfi, 1979); **Ñeembucú:** Curupayty NHMB 1450 (Wetzel & Mondolfi, 1979).

Specimens not examined: None.

Literature citations: "South of 26.5°S (Azara 1801, 1802); **Paraguarí:** "Parque Nacional Ybycuí" (Yahnke *et al.*, 1998); **Presidente Hayes:** "Villa Hayes" (Masi Pallarés & Benítez Usher, 1982).

Photographic documentation: **Alto Paraná:** Refugio Biológico Tati Yupí FPMAM1174–1175 (Nelson Pérez in FAUNA Paraguay, 2018).

Nine-banded Armadillo

Dasypus novemcinctus
Linnaeus, 1758 (**Fig. 4**)

[*Dasypus*] *novemcinctus* Linnaeus 1758:51. Type locality "in America Meridionali" restricted to Pernambuco, Brazil by Cabrera (1958).

Dasypus novemcinctus Rengger (1830: ecology); Bertoni (1939: list); Wetzel & Mondolfi (1979: taxonomy); Masi Pallarés & Benítez Usher (1982: parasitology); Servicio Forestal Nacional (1982: guide); Roguin (1986: distribution); Fujita *et al.* (1994: parasitology); Fujita *et al.* (1995: parasitology); Gamarra de Fox & Martin (1996: records); Lowen *et al.* (1996: distribution); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Villalba & Yanosky (2000: tracks); Areskoug (2001: habitat); Esquivel (2001: guide); Neris & Colman (2001: guide); Frutos & Van den Bussche (2002: genetics); Neris *et al.* (2002: distribution); Fariña & Hostettler (2003: distribution); Hill *et al.* (2003: use); Neris & Franco Rivarola (2005: guide); Yeo *et al.* (2005: parasitology); Cartes (2007: use); Nava *et al.* (2007: parasitology); Smith (2007c: ecology); Meritt (2008: ecology); Ramírez Pinto & Velázquez (2010, distribution); Masi Pallarés (2011: ecology); Smith (2012: conservation); Acosta & López (2013: parasitology); Centrón *et al.* (2013: use);

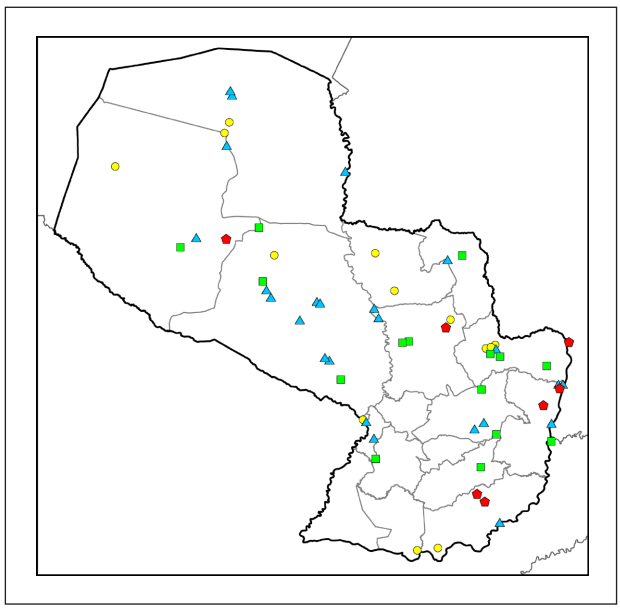

FIGURE 4. Distribution of *Dasypus novemcinctus* in Paraguay.

Velázquez & Ramírez Pinto (2014: guide); Epp (2018: guide).

Tatusia novemcincta Bertoni (1914; list).

Dasypus novemcinctus novemcinctus Cabrera (1958: taxonomy).

Dasypus novecinctus Gatti (1985: dictionary).

Local names: **Aché:** Tatu kuju (Esquivel, 2001); Tatu (Fariña & Hostettler, 2003); **Ayoreo:** Ajamei (Neris & Colman, 2001); **Guaraní:** Tatuhú (Azara, 1802); Tatu-hu (Rengger, 1830); Tatú-hû (Bertoni, 1914); Tatu hu (Servicio Forestal Nacional, 1982); Tatú-eté, Tatujú (Gatti, 1985); Tatu hû (Velázquez & Ramírez Pinto, 2014); **Spanish:** Quirquincho negro (Azara, 1802); Armadillo negro (Servicio Forestal Nacional, 1982); Mulita grande (Gamarra de Fox & Martin, 1996); Armadillo (Esquivel, 2001); Mulita de nueve bandas (Velázquez & Ramírez Pinto, 2014).

Comments: The species was first cited for Paraguay by Azara (1801) citing the common name Tatuhú, meaning "black armadillo". The species occurs throughout the country in all the ecoregions.

Two stuffed specimens on display at the Museo de la Entidad Binacional Yacyretá, Ayolas, Misiones department lack collection data but may have been collected locally as the species is known to occur in this area.

A female specimen MNHNP 543 (Ruta Transchaco 0.5 km S Fortín Teniente Enciso) is notably smaller and with lower scute counts for the cephalic shield and fourth movable band than other adult Paraguayan specimens in the MNHNP. The measurements and counts are consistent with the description of *Dasypus mazzai* Yepes, 1933 and geographically the specimen comes from an area where *D. mazzai* might perhaps be most likely to occur should it be present in Paraguay. However, the specimen was catalogued as a juvenile (perhaps on the basis of small size?) and no skeletal material is available to confirm or dismiss that assertion, except for a mandible. Given that the morphological characteristics that define *D. mazzai* are unclear (they overlap almost entirely with *D. novemcinctus*) and that no genetic material is available for this specimen, for the time being we maintain the identification as *D. novemcinctus* pending additional material, but alert future researchers to the possibility of *D. mazzai* occurring in this area of Paraguay.

Specimens examined: Mounted specimen lacking data MJUF; "Paraguay" MVZ 4824; **Alto Paraguay:** "58 km SO de Agua Dulce" MNHNP 542; **Boquerón:** "4 km south Madrejón, admin. Parque Nacional Defensores del Chaco" MNHNP 541; "Ruta Transchaco 0.5 km S Fortín Teniente Enciso" MNHNP 543; **Canindeyú:** no specific locality MNHNP 2038; "Jejui" SCH 810; "Mbaracayú Wildlife Reserve 2 km NE central camp 24°07'S, 57°55'W" MNHNP 917; "Reserva Mbaracayú" MNHNP 2032, 2033, 2040, 2042, 2043, 2045; **Central:** "Cerro Lambaré, 25°20.517'S, 57°38.404'W" MNHNP 3366; **Concepción:** "Estancia Cerrito" MNHNP 2507; "Parque Nacional Serranía San Luís, 22°37.43'S 57°21.28'W" MNHNP 2506; "Rio Apa" SCH 52; **Itapúa:** skull lacking data at Pro Cosara museum; MACN 25173 "Isla Yacyretá, Barranquita"; "Reserva Natural Yacyreta" skeleton lacking data on display at park headquarters. **Presidente Hayes:** "Reserva Laguna Porá" MNHNP 1188; **San Pedro:** "Estancia Las Mañanitas" CZPLT 220, 221, 224, 225.

Specimens not examined: "Paraguay" MACN 9.2, 29.209; 43.064 (Abba & Vizcaíno, 2008); **Alto Paraná:** "Refugio Fauna" CBMI 155; "Puerto Sauce" CBMI 0005; "Refugio Biológico Tati Yupi, Hernandarias" CBMI 0088; **Alto Paraguay:** no specific locality FLMNH 20653, 20654; "67 km by road N Fortín Madrejón" UMMZ 126293; "120 km E of Mayor Pablo Lagarenza, W of Aguadulce" CONN 19910; "Puerto Guarany" MACN 28.224, 28.225 (Abba & Vizcaíno, 2008); **Amambay:** "28 km SW Pedro Juan Caballero" UMMZ 125246, 125247; **Boquerón:** "Fortín Toledo" MTD 24981 (Ziegler *et al.*, 2002); "Teniente Martínez, 175 km N Filadelfia" MSB 54421; **Caaguazú:** "3 km N of Campo 9" MSB 135356; "Estancia Primera, Guayraungua River" (= Río Guyrauguá) MCZ 30943, 30944; **Canindeyú:** no specific locality UAM 46587, 46588, 46590, 46591, 46604, 46605; "Reserva Natural del Bosque Mbaracayú" TTU 80202, 80206, UAM 46589; **Central:** "Colonia Nueva Italia" FMNH 54354, 54355; Lambaré ZMB 85906; **Itapúa:** "1 km N of Rio Paraná, E of Rio Pirapó" CONN 16894; **Presidente Hayes:** "85 km E Loma Plata, Laguna Pora" CONN 19959;

"211 km NW (by road) Villa Hayes" MVZ 145362; "Chaco Experimental Station 295 km NW (by road) Villa Hayes" CONN 15760, 15761, MVZ 145363, 145364; "km 96 Transchaco" CONN 17517; "km 150 rte Transchaco" MNHG 1690.090; "km 159 rte Transchaco" MNHG 1689.090 (Roguin, 1986); "km 305 Transchaco" CONN 17333; "Estancia Deolinda" SMNH 600182; "Waikthlatingmayalwa" UMZC E954, E955 E956; **San Pedro:** "11 km S (by air) of Concepción, E bank of Rio Paraguay" 23°30'S, 57°29'W" UMMZ 166715; "Puerto Ybapobo" FMNH 26649.

Literature citations: **Alto Paraguay:** "Casanillo" (Frutos & Van den Bussche, 2002); **Alto Paraná:** "Puerto Bertoni" (Bertoni, 1914; 1939); **Amambay:** "Parque Nacional Cerro Corá" (Lowen *et al.*, 1996); **Boquerón:** "Gran Siete" (Areskoug, 2001); **Caaguazú:** no specific locality (Masi Pallarés & Benítez Usher, 1982); "Estancia Kaa'gua Rory" (Lowen *et al.*, 1996); **Caazapá:** "Estancia Golondrina-Caazapa" (Frutos & Van den Bussche, 2002); "Parque Nacional Caaguazú" (Lowen *et al.*, 1996); **Canindeyú:** "Mbaracayú Reserve" (Hill *et al.*, 2003); "Reserva Natural Privada Itabó" (Lowen *et al.*, 1996); "Reserva de Patrimonio Aché de Kuetuvy" (Centrón *et al.*, 2013); **Central:** "Asunción" (Bertoni, 1939); **Presidente Hayes:** "Estancia Juan de Salazar" (Frutos & Van den Bussche, 2002); "Ruta Transchaco km 106" (Frutos & Van den Bussche, 2002); **Paraguarí:** "Lago Ypoa" (Frutos & Van den Bussche, 2002); **San Pedro:** "Chamorro Cué outskirts of San Pedro de Ycuamandyyú" (Fujita *et al.*, 1995); "Patiño outskirts of San Pedro de Ycuamandyyú" (Fujita *et al.*, 1995).

Photographic documentation: **Alto Paraná:** "Reserva Itabó Itaipú" FPMAM69 (Paul Smith in FAUNA Paraguay, 2018); "Reserva Limoy Itaipú" FPMAM1165 (Paul Smith in FAUNA Paraguay, 2018); **Boquerón:** "Loma Plata" FPMAM71 (Paul Smith in FAUNA Paraguay, 2018); **Canindeyú:** "Reserva Mbaracayú Itaipú" FPMAM887 (Paul Smith in FAUNA Paraguay, 2018); **Itapúa:** "Estancia Nueva Gambach" FPMAM68, 70, 72–76 (Pro Cosara in FAUNA Paraguay, 2018); "Reserva Kanguery" FPMAM895-896 (Paul Smith in FAUNA Paraguay, 2018); **San Pedro:** "Reserva Natural Laguna Blanca" (PLT camera trap photo 2 December 2011).

Reliable observations: **Boquerón:** "Tunacojai Indigenous Reserve" (Paul Smith); **Misiones:** "Ñu Guazu" (*fide* Arne Lesterhuis); **Presidente Hayes:** "Laguna Capitán" (Paul Smith).

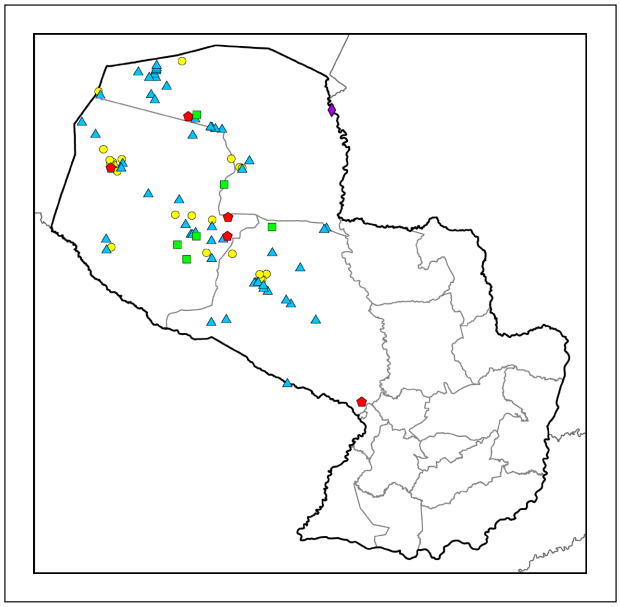

Figure 5. Distribution of *Tolypeutes matacus* in Paraguay.

Chlamyphoridae: Tolypeutinae: Tolypeutine armadillos

Southern Three-banded Armadillo

Tolypeutes matacus
(Desmarest, 1804) (**Fig. 5**)

Lor[*icatus*]. *matacus* Desmarest 1804:28. No locality mentioned. Based on Azara (1801). Sanborn (1930) restricted the type locality to Tucumán, Argentina.

Tolypeutes matacus Sanborn (1930: distribution, taxonomy); Cabrera (1958: taxonomy); Wetzel & Lovett (1974: specimens); Wetzel (1985b: distribution); Roguin (1986: distribution); Brooks (1995: distribution); Fujita *et al.* (1995: parasitology); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Villalba & Yanosky (2000: tracks); Areskoug (2001: habitat); Neris & Colman (2001: guide); Neris *et al.* (2002: distribution); Fast Schartner (2004: guide); Neris & Franco Rivarola (2005: guide); Yeo *et al.* (2005: parasitology); Cartes (2007: use); Smales (2007: parasitology); Smith (2007f: ecology); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Vinke & Vinke (2008: popular); Ramírez Pinto & Velázquez (2010: distribution); Smith (2012: conservation); Acosta & López (2013: parasitology).

Tolypeustes matacos Bertoni (1939: list); Gatti (1985: dictionary).

Tolypeustes Seelwische (1980: ethnography).

Tolypeutes mataco Masi Pallarés & Benítez Usher (1982: parasitology); Chase Sardi (1983: ethnography); Nava *et al.* (2007: parasitology).

Tolypeutes macatus Smales (2007: parasitology).

Local names: **Ayoreo:** Auco (Neris & Colman, 2001); **Enhlet:** Yalva (Fast Schartner, 2004); **Guaraní:** Tatu bolita (Azara, 1802); Tatú-bolito, Tatú-apará (Wetzel & Lovett, 1974); Tatú bolita (Gamarra de Fox & Martin, 1996); Tutú bolita (Morales, 2007); **Mennonite dialect:** Bauljirtillschwien

(Fast Schartner, 2004); **Nivaclé:** C'acjo (Seelwische, 1980); **Spanish:** Bolita (Dobrizhoffer, 1784); Matáco (Azara, 1802); Tatú naranja (Chase Sardi, 1983); Armadillo (Gamarra de Fox *et al.*, 1998); Mataco (Gamarra de Fox & Martin, 1996); Quirquincho bola (Neris & Colman, 2001).

Comments: Dobrizhoffer (1784) described the "Bolita" from the Paraquaria region, noting that it was capable of rolling itself into a ball, but Azara (1802) specifically stated that the species did not occur in Paraguay. The earliest citation we can find affirming the species presence in Paraguay is Sanborn (1930) who mentions a specimen collected by Alexander Wetmore "110 km west of Puerto Pinasco" (USNM 236356). According to his own notes, Wetmore collected at this locality on 23 September 1920 (Wetmore, 1926). However, there are earlier specimens: UMZC E1184, a foetus with placenta collected during 1907 by W.E. Agar in an unspecificed locality in the Paraguayan Chaco, and three undated partial specimens (UMZC E1181, E1182, E1183) collected by Kerr at Waikthlatingmayalwa, Presidente Hayes department. According to his writings Kerr was at this locality from late October 1896 until mid-February 1897 and again in May 1897 (Kerr, 1901). Bertoni (1939), apparently unaware of these reports, listed the species as hypothetical in the Paraguayan Chaco.

A carapace of *T. matacus* in the Pro Cosara museum at Estancia Nueva Gambach, Itapúa department was not collected locally and originated from an unspecified locality in the Dry Chaco of Boquerón department.

The specimens in the MNHNG cited by Smales (2007) with inventory numbers only (39690, 39691, 39692) are extremely geographically confused. The locality "Estancia La Conquista close to Fortín Pratt Gill" is not "in Central Province" as stated but in Boquerón department. These records refer to the three specimens (MNHG 1689,061; 1689,062; 1689,063) published in Roguin (1986), two of which were collected at Estancia La Conquista on 27 July 1985 and the other on 26 July 1985 "15 km west of Pratts Gill" according to the museum catalogue. Roguin's (1986) text description of this locality as "15 km Fortín Boquerón direction de Pratts Gill" creates confusion with Fortín Boquerón on the border of Boquerón and Presidente Hayes departments.

The *Tolypeutes* sp. listed by Smales (2007) for "Caazepa [*sic*] Province" refers to *Ca. unicinctus* MNHG 1875,003 (see species description below) and was actually collected in Concepción department. There is no evidence that *T. matacus* occurs east of the Río Paraguay in Paraguay. *Tolypeutes matacus* is confined to the Occidental region of Paraguay, occuring in the Dry Chaco, Humid Chaco, and Cerrados del Chaco ecoregions, and marginally in the Pantanal.

Specimens examined: Alcohol specimens lacking data in MNHNP with field numbers Z1, Z3; "Chaco" SCH 359, 699, 1818; Carapace lacking data MJUF; **Alto Paraguay:** "Destacamento Militar Gabino Mendoza" uncatalogued specimens in MNHNP with field numbers TK 65701, TK 65745; "Estancia Tres Marias 21°15.81.5'S, 59°35.59'W" MNHNP 2505; "Estancia Tres Marias 21°16.82'S, 59°32.89'W" MNHNP 2504; "Palmar de las Islas 19°39.11'S, 60°35.88'W" MNHNP 3367; **Boquerón:** "Approx. 2 km norte de la casa de admin, PN Tte Enciso" MNHNP 511; "5 km N Cruce de los Pioneros" uncatalogued alcohol specimen in MNHNP with field number SF02; "15 km al sur de la casa de la admin por la picada nueva de la Empresa de Madelon, PN Tte Enciso" MNHNP 512; "24.4 km E Mariscal Estigarribia, 22°02.85S 60°21.93W" uncatalogued specimen in MNHNP with field number TK 60234; "25 km N of Filadelfia" MNHNP 2894; "Approx. 30 km NO casa de control, PN Tte Enciso sobre la Transchaco" MNHNP 514; "Approx 150 km North of Filadelfia sobre la ruta" MNHNP 510; "Base Aeronautica Pratts Gill" MNHNP 1654; "Mariscal Estigarribia" MNHNP 1655; "Newland" (= Neuland) MNHNP 1895, 1896; "PN Tte Enciso" MNHNP 834; "PN Tte Enciso 21°08.20'S, 61°30.17'W" MNHNP 3369; "PN Tte Enciso 21°11.12'S, 61°41.27'W" MNHNP 3368; "PN Tte Enciso" MSB 54420 two carapaces lacking data at park headquarters; "Ruta Transchaco 8 km north, casa de admin., PN Tte Enciso" MNHNP 513; **Presidente Hayes:** "Estancia Salazar, Buey" uncatalogued alcohol specimen in MNHNP with field number SFUH23; "Estancia Salazar, Galpón" uncatalogued alcohol specimens in MNHNP with field number SFUH28, SFUH29; "Estancia Salazar, Represa Valente (?)" uncatalogued alcohol specimen in MNHNP with field number SFUH24; "Estancia Salazar, Retiro 3° tramo" uncatalogued alcohol specimen in MNHNP with field number SFUH4, SFUH17, SFUH18; "Estancia Salazar, Romualdo Cue" uncatalogued alcohol specimens in MNHNP with field numbers SFUH8, SFUH9, SFUH27; "Estancia Salazar, Tajamar Tereré" uncatalogued specimen in MNHNP with field number SFUH3; "Estancia J. Salazar, 5 km N Embarcadero" uncatalogued specimen in MNHNP with field number SFUH1.

Specimens not examined: "Paraguay" ASNHC 12916, CONN 16652, MACN 13.782, 27.147 (Abba & Vizcaíno, 2008), RBINS 386137, 386138, 391699, 391700, 502640, 502641, 502642, 502643, 569741, 569742, 688821, 688822, 699124, 699125, 699126, 699127; "Paraguayan Chaco" UMZC E1184; **Alto Paraguay:** "8 km N and 37 km W of Mayor Pablo Lagerenza" CONN 19890; "18 km by rd W Fortín Madrejón" UMMZ 124718; "28 km N and 52 km W of Mayor Pablo Lagerenza" CONN 19884, 19885, 20484; "30 km W of Puerto Casado along railroad" FMNH 54353; "39 km WNW Mayor Pablo Lagarenza" CONN 19868, 19869; "41 km WNW Mayor Pablo

Lagarenza" CONN 19871; "42 km WNW Mayor Pablo Lagarenza and 6 km N" CONN 19873; "42 km WNW Mayor Pablo Lagarenza and 8 km N" CONN 19874; "42 km WNW Mayor Pablo Lagarenza and 11 km N" CONN 19883; "42 km WNW Mayor Pablo Lagarenza and 16 km N" CONN 19942, 19943; "45 km WNW Mayor Pablo Lagarenza" CONN 19872; "50 km WNW Madrejón, Misión Nuevo Tribu" UMMZ 124719, 125621, 126292; "Capitán Pablo Lagerenza" TTU 79709; "Estancia Tres Marías" TTU 79817, 79819, 79820; "Gabino Mendoza" TTU 79721; "Laguna Placenta" TTU 79876, 79878, 79879; "Madrejón" CONN 19892; "Road to Fortín Lagarenza-i" TTU 79911, 79912; "Road to Puerto Casado" TTU 79913; "Palmar de las Islas" TTU 79881, 79883, 79884, 79885, 79886, 79887, 79907, 79908, 79909, 79910; **Boquerón:** "10 km south of Filadelfia" TTU 79951; "11.8 km by rd W Fortín Madrejón" UMMZ 124721; "15 km Fortín Boquerón direction de Pratts Gill" MNHG 1689.061 (Roguin, 1986); "20.1 km by rd W Fortín Madrejón" UMMZ 124720; "30 km N Mariscal Estigarribia" TTU 79953; "40 km NW of Pratt-Gill A.F. Base" CONN 19893; "50 km WSW of Fortín Madrejón" AMNH-M-248394; "474 km (by road) NW Villa Hayes" MVZ 145365; "km 483 Transchaco" CONN 18313; "km 590 Transchaco" CONN 18311; "km 764 Transchaco" CONN 17608; "Estancia Iparoma, 19 km N Filadelfia" CONN 19817, 19818, 19897, 19904, 19905, 19906, 19907, 19909, 19913, 19914, 19915, 19916, 19917, 19918; "Estancia La Conquista, Pratts Gill" MNHG 1689.062, 1689.063 (Roguin, 1986); "Estancia Madelon, 15 km S Tte Enciso park HQ" FLMNH 20652; "Filadelfia, 37 km W; Estancia Toledo-Molineros" FMNH 164098; "Fortín Toledo" MTD 24890 (Ziegler *et al.*, 2002); "Guachalla, Rio Pilcomayo" FMNH 54405; "Loma Plata Mennonite Colony" KU 92664; "Nueva Asunción" FLMNH 20652; "Teniente Enciso" CONN 17513, 17520, 18142; **Presidente Hayes:** "1.5 km W of line camp, Juan de Zalazar" CONN 16637; "4 km W of line camp, Juan de Zalazar" CONN 16649; "4 km S of Rio Verde, 5 km E of Trans-Chaco" CONN 16650; "5 km NE of line Camp, on Rio Verde; Juan de Zalazar" CONN 16743; "5 km NE Pozo Colorado" CONN 17518; "10 km E of Nuevo Retiro Aloncito" MSB 57376, 57399; "km 305 Transchaco, Retiro" CONN 19797; "Laguna Pora, 85 km E Loma Plata" CONN 19919, 19920, 19820, 20485, 20486; "Chaco Experimental Station 295 km NW (by road) Villa Hayes" MVZ 145366, 145367; "Estancia Elsita" SMNH 603568; "Estancia Hermosa, Rio Siete Puntas, 100 km W Concepción" SMNH 603503, 603509, 603526, 603528; "General Bruguez" CBMI 0245; "Puerto Pinasco, 110km W" USNM 236356; "Transchaco -23.351, -58.737" MNHG 1701.100; "Vicinity of km 300; Juan de Zalazar" CONN 16882; "Waikthlatingmayalwa" UMZC E1181, E1182, E1183.

Literature citations: **Alto Paraguay:** "Cerro León" (Nava *et al.*, 2007); **Boquerón:** "22°13'S, 59°04'W" (Ziegler *et al.*, 2002); "22°45'S, 60°27'W" (Ziegler *et al.*, 2002); "Gran Siete" (Areskoug, 2001); "surroundings of 21°21-39'S, 59°51-54'W (Ziegler *et al.*, 2002); "Toledo" (Nava *et al.*, 2007); **Presidente Hayes:** "Juan de Salazar" (Wetzel, 1985b).

Photographic documentation: **Alto Paraguay:** "PN Defensores del Chaco" FPMAM94 (Sjeff Ollers in FAUNA Paraguay, 2018); **Boquerón:** "Loma Plata" FPMAM1105 (Paul Smith in FAUNA Paraguay, 2018); "Parque Nacional Teniente Enciso" FPMAM95 (Marcelo Bombaci in FAUNA Paraguay, 2018); FPMAM96-100 (Paul Smith in FAUNA Paraguay, 2018); "Tunakojai Indigenous Reserve" FPMAM916-917 (Paul Smith in FAUNA Paraguay, 2018); **Presidente Hayes:** "Estancia Golondrina" FPMAM1187PH (Sergio D. Ríos in FAUNA Paraguay, 2018).

Reliable observations: **Alto Paraguay:** "Puerto 14 de Mayo–Karcha Bahlut" (Sergio D. Ríos July 2015).

Giant Armadillo

Priodontes maximus
(Kerr, 1792) (**Fig. 6**)

Dasypus maximus Kerr 1792:112. Type locality "Cayenne", French Guiana.

Dasypus giganteus Rengger (1830: ecology).

Priodontes giganteus Cabrera (1912: specimen); Cabrera (1958: taxonomy); (Masi Pallarés 2011: ecology).

Prionodontes gigas Bertoni (1914: list).

Prionodontes giganteus Bertoni (1939: list); Meritt (1973: records); Gatti (1985: dictionary).

Priodontes maximus Wetzel & Lovett (1974: specimens); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Villalba & Yanosky (2000: tracks); Esquivel (2001: guide); Neris *et al.* (2002: distribution); Fariña & Hostettler (2003: distribution); Neris & Franco Rivarola (2005: guide); Cartes (2007: use); Smith (2007b: ecology); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Smith (2012: conservation); Weiler & Nuñez (2012: distribution, conservation); GAT & OPIT (2014: ethnography).

Local names: **Aché:** Kry'y pura vachu (Esquivel, 2001); Kry'y pura (Fariña & Hostettler, 2003); **Ayoreo:** Jochacai (GAT & OPIT, 2014); **Guaraní:** Tatú-wasú (Bertoni, 1914); Tatú-asú, Tatú-guasú (Gatti, 1985); Tatú guazú (Gamarra de Fox & Martin, 1996); Tatu guasu (Gamarra de Fox *et al.*, 1998); **Nivaclé:** Pôlhenjataj (Seelwische, 1980); **Spanish:**

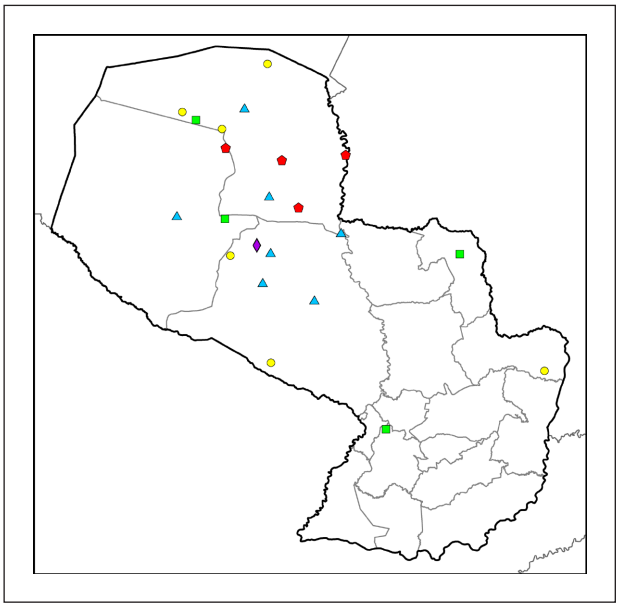

FIGURE 6. Distribution of *Priodontes maximus* in Paraguay.

Tatú negro grande de bosque (Azara, 1802); Tatu carreta (Bertoni, 1914); Tatú-carreta (Gatti, 1985); Tatú carreta (Gamarra de Fox & Martin, 1996); Armadillo gigante (Gamarra de Fox *et al.*, 1998).

Comments: First cited for Paraguay by Azara (1801, 1802) who called it "Máximo" noting that the species did not have a common name and referring to it as "very scarce". Azara (1802) stated that the species was found only in "the great forests of the north of Paraguay" and this was echoed by Rengger (1830) who stated that the species could be found only in northeastern Paraguay in "lands inhabited only by a few Guaraní". These references were presumably the basis of Bertoni's (1914, 1939) statement that the species "still exists in the north of Paraguay". Sánchez-Labrador (1910) makes a possibly veiled 18th Century reference to this species when he alludes to a species of armadillo "the size of a medium-sized dog" that was hunted and roasted by the indigenous "Mbayá" and which "feeds many". Mbayá was the pejorative name given by the indigenous Guaraní to the indigenous Guaycurú (today known as the Caduveo) of the northern part of the Oriental region of Paraguay and adjacent Mato Grosso do Sul.

An illustration in Cabrera (1912) purports to show an Azara specimen of this species from "Paraguay" (MCNM 504). Cabrera (1958) restricted the type locality of the name *Priodontes giganteus* to Pirayú, Paraguay on the basis of Azara (1801, 1802).

Bertoni stated that his friend "Prof. Dr. Anisits had a live specimen". Dr. Anisits was a well-known Hungarian professor who resided in Asunción (Benítez, 1986), so this statement unfortunately sheds little light on the origin of the specimen. The only specimen we could trace from the Oriental region of Paraguay is CBMI 0037 from Pozuelo, Canindeyú department supposedly collected on 19 July 1979. The species is frequently listed for the Reserva Natural Bosque Mbaracayú in Canindeyú department (Esquivel, 2001; Fariña & Hostettler, 2003) but there is no documentation of its occurrence in the reserve and no solid reports of its existence there could be traced. A carapace on display at the Museo de la Entidad Binacional Yacyretá, Ayolas, Misiones department lacks collection data and probably did not originate locally.

Weiler & Nuñez (2012) list additional localities for the species in Boquerón and Alto Paraguay departments based on records of burrows, but these are omitted here as secondary evidence of occurrence. The core of the Paraguayan range is now the Dry Chaco and Cerrados del Chaco ecoregions west of the Paraguay River, the species being close to extinction in the Cerrado ecoregion of eastern Paraguay (Smith, 2012).

Specimens examined: Mounted specimen and carapace lacking data MJUF; "Chaco" SCH 2398; "Paraguay" MACN 9.1, 10.21, 11.41, 13.23, MCNM 504 (Cabrera, 1912); **Alto Paraguay:** "Chovoreka" MNHNP 2011; "Fortín Madrejón" MNHNP 1170; "PN Defensores del Chaco" MNHNP 820; **Canindeyú:** "Pozuelo" CBMI 0037; **Presidente Hayes:** "Estancia Sofía" MNHNP 1126; "Ruta Trans-Chaco km 379" MNHNP 1075.

Specimens not examined: "Paraguay" AMNH-M-42697, NHM 1978.3255, FLMNH 72913, MACN 13.80 (Abba & Vizcaíno, 2008); "Paraguay, Zoo Buenos Aires" MACN 11.14, 13.68 (Abba & Vizcaíno, 2008); **Alto Paraguay:** "144 km NE Filadelfia" CONN 19507, 19926; "Colonia San Miguel Arcángel, Distrito de Fuerte Olimpo" CZCEN 059, 060; "Puerto Casado" MACN 45.029 (Abba & Vizcaíno, 2008); **Boquerón:** "Mariscal Estigarribia" CONN 18310; **Presidente Hayes:** "85 km E Loma Plata, Laguna Pora" CONN 19957; "Estancia Deolinda" SMNH 622705; "Rio Verde, Estancia Kent" CONN 15978 (Wetzel & Lovett, 1974).

Literature citations: **Alto Paraguay:** "surroundings of 20°29'S, 60°18'W" (Ziegler *et al.*, 2002); **Amambay:** "Parque Nacional Cerro Corá" (Yahnke *et al.*, 1998); **Boquerón:** "Area of Mariscal Estigarribia" (Meritt, 1973); "Colonia Ayoreo Campo Loro" (Weiler & Nuñez, 2012); **Paraguarí:** "Pirayú" (Azara, 1801, 1802).

Photographic documentation: **Alto Paraguay:** "approximately 35 km S of Madrejón by road" roadkill 13 October 2017 FPMAM1180-1185 (Paul Smith in FAUNA Paraguay, 2018); "near Fuerte Olimpo" FPMAM92 (Arne Lesterhuis in FAUNA Paraguay, 2018); "Estancia Beatriz close to Cruce Paragro"

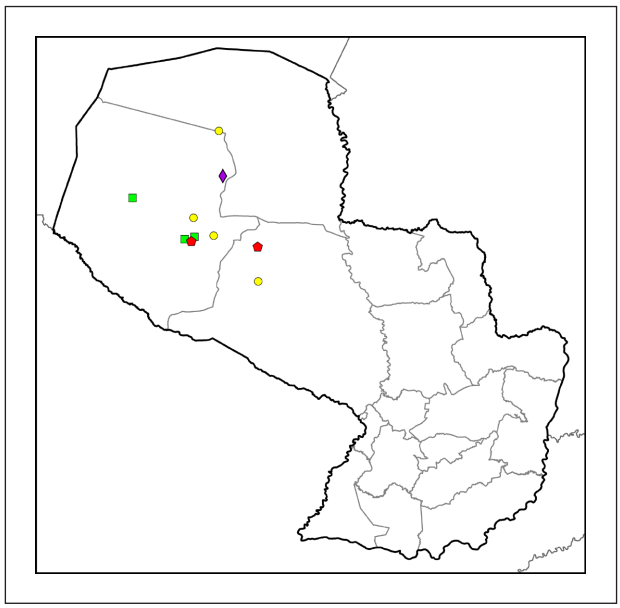

Figure 7. Distribution of *Cabassous chacoensis* in Paraguay.

roadkill 13 July 2012 FPMAM1158 (Hugo del Castillo in FAUNA Paraguay, 2018); "Estancia Morocha" roadkill 19 July 2002 FPMAM93 (Hugo del Castillo in FAUNA Paraguay, 2018).

Reliable observations: **Presidente Hayes:** "Chaco Lodge" (*fide* Norbert Epp).

Chaco Naked-tailed Armadillo

Cabassous chacoensis
Wetzel, 1980 (**Fig. 7**)

Cabassous chacoensis Wetzel 1980:335 Type locality "5–7 km W of Est. Juan de Zalazar, Presidente Hayes department, Paraguay".

Cabassous chacoensis Wetzel (1980: taxonomy); Wetzel (1985b: distribution); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998: conservation); Neris *et al.* (2002: distribution); Neris & Franco Rivarola (2005: guide); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Vinke & Vinke (2008: ecology); Smith (2009: ecology); Hutterer & Peters (2010: specimens); Smith *et al.* (2011: mention); Smith (2012: conservation); GAT & OPIT (2014: ethnography).

Cabossus chacoensis Yahnke *et al.* (1998: distribution).

Local names: **Ayoreo:** Ogode (GAT & OPIT, 2014); **Guaraní:** Tatú'ai menoré (Gamarra de Fox & Martin, 1996); Tatu'ai menore (Gamarra de Fox *et al.*, 1998); Tatu A'i (Neris *et al.*, 2002); **Spanish:** Tatú de rabo molle (Gamarra de Fox & Martin, 1996); Armadillo (Gamarra de Fox *et al.*, 1998); Armadillo chaqueño de cola desnuda (Morales, 2007); Cabasú chico (Vinke & Vinke, 2008).

Comments: Described on the basis of Paraguayan specimens (Wetzel, 1980). Contra Roguin (1986), *Ca. loricatus* of Bertoni (1939) does not refer to this species. Bertoni (1939), who was unfamiliar with the Chaco mastofauna, cites *loricatus* for Paraguay *fide* Yepes. However, the only pre-1939 reference to *loricatus* in Paraguay by that author is Yepes (1928) in an unannotated checklist employing numerous synonyms as valid species. His distribution of "Guyanas, Paraguay, Brasil" demonstrates that the name is not applicable to *chacoensis* and, as he cites no specimens, it is clearly a composite of different species. *Cabassous loricatus sensu* Yepes (1935) is a synonym of *Ca. chacoensis*, but no reference is made to the species in Paraguay in that work and its contents are clearly different to those of Yepes (1928). The *Ca. loricatus* of Cabrera (1958) that mentions the Paraguayan Chaco in the distribution is again a composite of at least two species according to the distribution provided. The first reference to this species in Paraguay is thus its description by Wetzel (1980).

The known Paraguayan range is restricted to the central Chaco, an area of transition between Dry and Humid Chaco.

Specimens examined: Mounted specimen lacking data MJUF (same as FPMAM915); alcohol specimen lacking data in MNHNP; **Boquerón:** "Philadelfia" (= Filadelfia) uncatalogued specimen in MNHNP with field number SFZ01.

Specimens not examined: "Paraguay" MLP843, MLP16.IX.35.86, MLP16.IX.35.85 (Abba & Vizcaíno, 2008); "Chaco" MZ 1600 (Wetzel, 1980); **Alto**

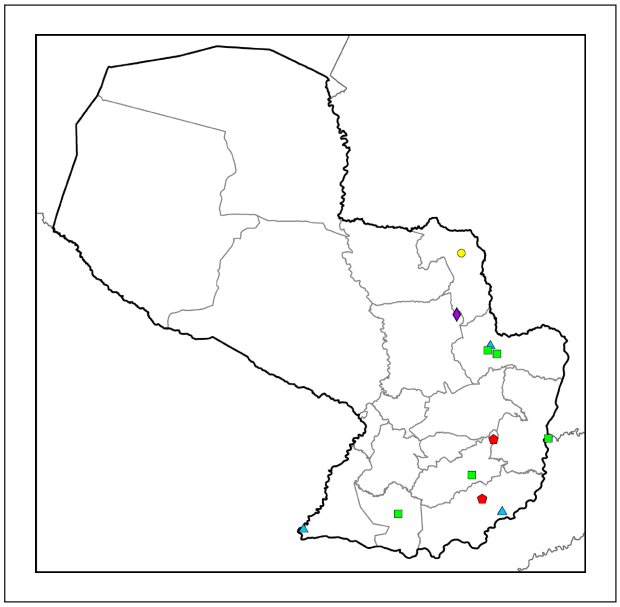

Figure 8. Distribution of *Cabassous tatouay* in Paraguay.

Paraguay: "Estancia Toro 1–Madrejón" TTU 79816; **Boquerón:** "27 km S Madrejón" FLMNH 20650; "Filadelfia" USNM 531004, ZFMK 60.317 (Wetzel, 1980; Hutterer & Peters, 2010); "26.5 km east of Mariscal Estigarribia" TTU 79952; **Presidente Hayes:** "5–7 km W Juan de Zalazar" CM 67067 (holotype), CONN 16891, 16892 (Wetzel, 1980; Hutterer & Peters, 2010).

Literature citations: **Alto Paraguay:** "Campo Loa area in front of Estancia Amistad" December 2010 (Sabine & Thomas Vinke in DVD Paraguay Salvaje 1, Filadelfia, Paraguay); **Boquerón:** "area around Toledo" (= Fortín Toledo) (Meritt, 2008); "Estancia Mariposa" (Vinke & Vinke, 2008) though locality not specified in the text; **Presidente Hayes:** "Juan de Zalazar" (Wetzel, 1985b).

Photographic documentation: Jakob Unger Museum, Filadelfia FPMAM915 (Paul Smith in FAUNA Paraguay, 2018); **Boquerón:** "Fortín Toledo" FPMAM81-82 newborns 30 June 2009 (Hugo del Castillo in FAUNA Paraguay, 2018); **Presidente Hayes:** "Chaco Lodge" (*fide* Joe Sarvary/Para La Tierra).

Reliable observations: **Boquerón:** "Estancia 120 km north of Filadelfia near Picada Ancha 22°27'S, 60°46'W" 25 February 2012 (*fide* Sabine & Thomas Vinke).

Greater Naked-tailed Armadillo

Cabassous tatouay
(Desmarest, 1804) (**Fig. 8**)

Loricatus tatouay Desmarest 1804:28. No type locality given, but restricted to Paraguay 27° latitude south by Cabrera (1958) who considered the description to be based on Azara (1801).

Dasypus gymnurus Rengger (1830: ecology).

Lysiurus unicinctus Bertoni (1914: list).

Cabassous unicinctus Bertoni (1939: list).

Cabassous tatouay Cabrera (1958: taxonomy); Wetzel (1980: taxonomy); Gamarra de Fox & Martin (1996: records); Esquivel (2001: guide); Neris *et al.* (2002: distribution); Fariña & Hostettler (2003: distribution); Hill *et al.* (2003: use); Neris & Franco Rivarola (2005: guide); Abba & Vizcaíno (2008: specimens); Smith (2008c: ecology); Smith *et al.* (2011: mention); Smith (2012: conservation); Velázquez & Ramírez Pinto (2014: guide).

Cabassous tatouai Gamarra de Fox *et al.* (1998: conservation).

Cabossus tatouay Yahnke *et al.* (1998: distribution).

Cabassus tatouay Centrón *et al.* (2013: use).

Local names: **Aché:** Kru'y (Esquivel, 2001); Tatú vai (Centrón *et al.*, 2013); **Guaraní:** Tatuaí (Azara, 1802); Tatu-ay (Rengger, 1830); Tatú' ai (Gamarra de Fox & Martin, 1996); Tatu ai (Esquivel, 2001); Tatu A'i (Neris *et al.*, 2002); Tatu-ai (Velázquez & Ramírez Pinto, 2014); **Spanish:** Armadillo grande (Esquivel, 2001); Armadillo (Neris *et al.*, 2002); Armadillo cola desnuda (Morales, 2007); Cabasú grande, Tatú de rabo molle (Velázquez & Ramírez Pinto, 2014).

Comments: The species was first cited for Paraguay by Azara (1801) who was unsure as to the origin of the common name, speculating that Tatuaí meaning "warty armadillo" was unfitting of the animal and that it may have been a shortening of Taturaí or "naked armadillo" in reference to the tail. Azara's text was based on a description provided to him by his friend the Jesuit priest Pedro Blás Noséda who "received an individual close to his town", modern day San Ignacio, Misiones department.

This species occurs at low density in Cerrado, Atlantic Forest and Mesopotamian Grasslands in eastern Paraguay.

Specimens examined: **Amambay:** "near Cerro Corá" MNHNP uncatalogued, field number TK61367.

Specimens not examined: "Paraguay" MLP16.IX.35.84; "Paraguay" MACN 9.4. (Yepes, 1935); **Canindeyú:** "Reserva Mbaracayú" (= Reserva Bosque Mbaracayú) MNHNP 2049 lost?; no specific locality UAM 46602; **Itapúa:** "Capitán Meza" MACN 47.377 (Wetzel, 1980; Abba & Vizcaíno, 2008); **Ñeembucú:** "Curupaity" (= Curupayty) NHMB (Wetzel, 1980).

Literature citations: **Alto Paraná:** "Puerto Bertoni" (Bertoni, 1914; 1939); **Caazapá:** "Reserva Natural Tapytá" (Velázquez & Ramírez Pinto, 2014); **Canindeyú:** "Reserva Bosque Mbaracayú" (Hill *et al.*, 2003; Cartes, 2007); "Reserva de Patrimonio Aché de Kuetuvy" (Centrón *et al.*, 2013); **Misiones:** "town of my friend Noséda around 27°" (= San Ignacio) (Azara, 1801, 1802).

Photographic documentation: **Caaguazú:** "Reserva Natural Privada Ypeti" FPMAM90-91 between 17 and 20 June 1997 (José Luís Cartes in FAUNA Paraguay, 2018); **Itapúa:** "Estancia Nueva Gambach" approximately 2003 FPMAM1159 (Hans Hostettler in FAUNA Paraguay, 2018).

Reliable observations: **San Pedro:** "Yaguarete Forest" roadkill between 5 and 14 August 2000 (*fide* Hugo del Castillo).

Southern Naked-tailed Armadillo

Cabassous unicinctus
(Linnaeus, 1758) (**Fig. 9**)

Dasypus unicinctus Linnaeus 1758:50. Type locality "Africa", but restricted to Surinam by O. Thomas (1911).

Cabassous unicinctus squamicaudis Roguin (1986: distribution); Smith *et al.* (2011: distribution).

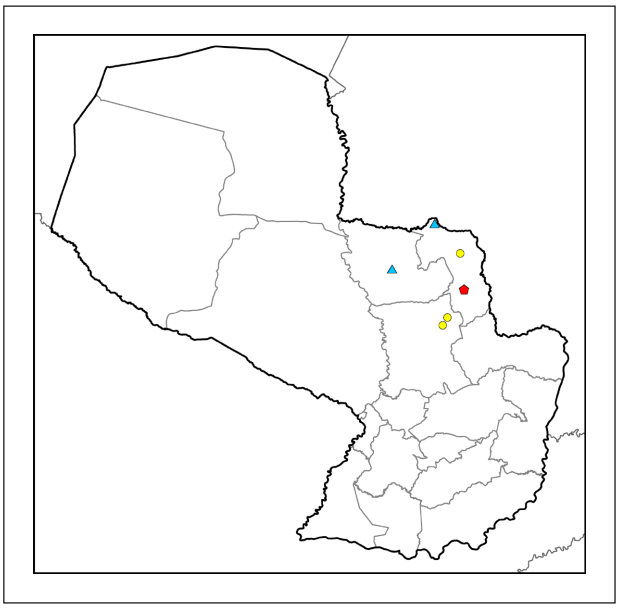

FIGURE 9. Distribution of *Cabassous unicinctus* in Paraguay.

Tolypeutes sp. Smales (2007: parasitology).

Cabassous unicinctus (Masi Pallarés 2011: ecology); Smith (2011: ecology); Smith (2012: conservation).

Local names: None.

Comments: Bertoni (1914) lists *Lysiurus unicinctus* and Bertoni (1939) updates the nomenclature to *Ca. unicinctus*. However, numerous early authors applied the name *Ca. unicinctus* to the large species now known as *Ca. tatouay*, or to composite samples containing large and small specimens (Wetzel, 1980). Bertoni's use of the common name Tatú-aí for the species is the same as that used by Azara (1801) and referable to *Ca. tatouay*.

A review of specimens, localities, and data available for this species in Paraguay was provided by Smith *et al.* (2011), but a previous record of a specimen (MNHG 1636.032) collected on 12 October 1979 and published in Roguin (1986) was overlooked. The measurements provided confirm the identification and thus the latter is the first record of the species in Paraguay and not Smith *et al.* (2011).

A reference to two "rather small" and "probably immature" *Ca. tatouay* seen in Cerrado vegetation at RNBM–Aguara Ñu, Canindeyú department by Lowen *et al.* (1996) would seem more likely to be this species. The species has not yet been confirmed to occur in Canindeyú, but it may be expected to do so in areas of Cerrado.

Smales (2007) lists *Tolypeutes* sp. for "the road to Colonia Sergento [*sic*] E. Lopez, 20 km north to Estancia Laguna Negra in Caazepa [*sic*] Province". The specimen he refers to is MNHG 1875.003, a *Ca. unicinctus* collected by "C. Dlouhy, V. Mahnert & C. Vaucher" on an unspecified date at this locality, which is actually in Concepción department.

All Paraguayan specimens are from the Cerrado zone of eastern Paraguay.

Specimens examined: **Amambay:** "Parque Nacional Cerro Corá (approx. 1.5 km east of administration office)" MNHNP 919; **San Pedro:** "Estancia Las Mañanitas" CZPLT 002; "Reserva Natural Laguna Blanca" CZPLT 001.

Specimens not examined: **Amambay:** "Apa-mi, 10 km S Bella Vista" MNHG 1636,032 (Roguin, 1986); **Concepción:** "road to Sargento E López, 20 km north to Estancia Laguna Negra" MNHG 1875.003 (Smales, 2007).

Photographic documentation: **Amambay:** "Estancia Pa'i Kuará" FPMAM83-89 (Hugo del Castillo in FAUNA Paraguay, 2018).

CHLAMYPHORIDAE: CHLAMYPHORINAE: Fairy Armadillos

CHACOAN FAIRY ARMADILLO

Calyptophractus retusus
(Burmeister, 1863) (**FIG. 10**)

Chlamyphorus retusus Burmeister 1863:167. Type locality "Santa Cruz de la Sierra" Santa Cruz, Bolivia.

Burmeisteria retusa Myers & Wetzel (1979: distribution); Seelwische (1980: ethnography).

Chlamyphorus retusus Wetzel (1985a: distribution, taxonomy); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998:

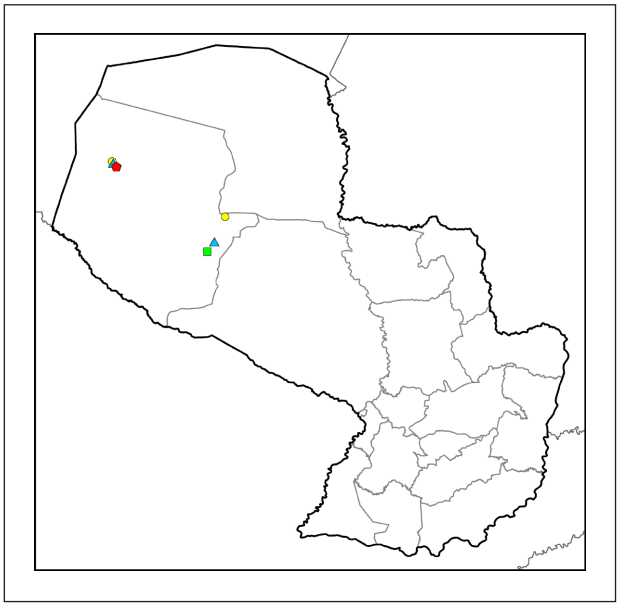

FIGURE 10. Distribution of *Calyptophractus retusus* in Paraguay.

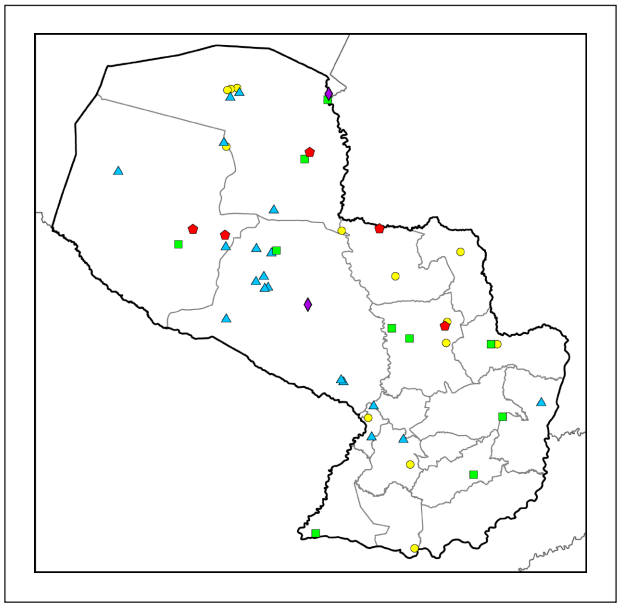

FIGURE 11. Distribution of *Euphractus sexcinctus* in Paraguay.

conservation); Yahnke *et al.* (1998: distribution); Neris *et al.* (2002: distribution); Neris & Franco Rivarola (2005: guide); Meritt (2008: ecology); Vinke & Vinke (2014: ecology).

Calyptophractus retusus Abba & Vizcaíno (2008: specimens); Smith (2008a: ecology); Wetzel *et al.* (2008: distribution, taxonomy); Ramírez Pinto & Velázquez (2010: distribution); Smith (2012: conservation); GAT & OPIT (2014: ethnography); Smith & Owen (2017: ecology).

Local names: **Ayoreo:** Ogode (GAT & OPIT, 2014); **Guaraní:** Tatu de abrigo (Gamarra de Fox *et al.*, 1998); **Nivaclé:** Tacluuc (Seelwische, 1980); **Spanish:** Pichi ciego grande, Tatú de abrigo (Gamarra de Fox & Martin, 1996); Pichiciego grande (Gamarra de Fox *et al.*, 1998); Pichiciego chaqueño (Morales, 2007); Tatú ciego (Ramírez Pinto & Velázquez, 2010).

Comments: The species was first officially reported in Paraguay by Myers & Wetzel (1979) though a photograph dated to 1948 but lacking any data shows the Mennonite collector Jakob Unger with a live specimen in his hand (Vinke & Vinke, 2014). Yepes (1939) had earlier speculated that the species would likely be present in the Paraguayan Chaco. The skull of this species is illustrated and described for the first time from a Paraguayan specimen in Smith & Owen (2017).

The species is confined to the Dry Chaco.

Specimens examined: Alcohol specimen lacking data MJUF; **Boquerón:** "Comunidad Indígena Campo Loro" MNHNP 3362; "Parque Nacional Teniente Enciso" MNHNP 1656; alcohol specimen lacking data at park headquarters.

Specimens not examined: **Boquerón:** "15 km S Filadelfia" CONN 16881 (Myers & Wetzel, 1979; Wetzel, 1985a); "Teniente Enciso" CONN 17609 (Myers & Wetzel, 1979; Wetzel *et al.*, 2008).

Literature citations: **Boquerón:** "Neu Halbstat" (Vinke & Vinke, 2014).

Photographic documentation: **Boquerón:** "Parque Nacional Teniente Enciso" FPMAM67PH (Enrique Bragayrac in FAUNA Paraguay, 2018), probably the same specimen that is located at the PN Teniente Enciso headquarters.

CHLAMYPHORIDAE: EUPHRACTINAE: Hairy Armadillos

SIX-BANDED ARMADILLO

Euphractus sexcinctus
(Linnaeus, 1758) (**FIG. 11**)

Dasypus sexcinctus Linnaeus 1758:51. Type locality "America Meridionali" restricted to Pará, Brazil by O. Thomas (1907).

Dasypus sexcinctus Rengger (1830: ecology); Bertoni (1914: list).

Euphractus sexcinctus gilvipes Bertoni (1939: list); Gatti (1985: dictionary).

Euphractus sexcinctus flavimanus Cabrera (1958: taxonomy); Wetzel & Lovett (1974: specimens).

Euphractus sexcinctus Schmidt & Martin (1978: parasitology); Myers & Wetzel (1979: mention); Masi Pallarés & Benítez Usher (1982: parasitology); Redford (1985: diet); Fujita *et al.* (1994: parasitology); Brooks (1995: distribution); Fujita *et al.* (1995: parasitology); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Villalba & Yanosky (2000: tracks); Areskoug (2001: habitat); Esquivel (2001: guide); Neris & Colman (2001: guide); Neris *et al.* (2002: distribution); Fariña & Hostettler (2003: distribution); Fast Schartner (2004: guide); Neris & Franco Rivarola (2005: guide); Yeo *et al.* (2005: parasitology); Cartes (2007: use); Smith (2007d: ecology); Meritt (2008: ecology); Ramírez Pinto & Velázquez (2010, distribution); Masi Pallarés (2011: ecology); Smith (2012: conservation); Acosta & López (2013: parasitology); Velázquez & Ramírez Pinto (2014: guide).

Euphractus sexinctus Seelwische (1980: ethnography).

Euphractus sexcintus Servicio Forestal Nacional (1982: guide); Hill *et al.* (2003: use); Abba & Vizcaíno (2008: specimens).

Euphractes sexcintus Lowen *et al.* (1996: distribution).

Euphractes sexcinctus Nava *et al.* (2007: parasitology).

Local names: **Aché:** Kry'y pura (Esquivel, 2001); **Ayoreo:** Gatodejai (Neris & Colman, 2001); **Enhlet:** Jatjapa (Fast Schartner, 2004); **Guaraní:** Tatùpoyù (Dobrizhoffer, 1784); Tatú poyú (Azara, 1802); Tatu-poyu (Rengger, 1830); Tatú-podyú, Tatú-vai (Bertoni, 1914); Tatu poju (Servicio Forestal Nacional, 1982); Tatú-pĩtá (Gatti, 1985); **Mennonite dialect:** Jaelit Jirtillschwien (Fast Schartner, 2004); **Nivaclé:** Acôtsejaj (Seelwische, 1980); **Spanish:** Armadillo (Servicio Forestal Nacional, 1982); Tatú-bayo (Gatti, 1985); Armadillo seis bandas (Gamarra de Fox & Martin, 1996); Armadillo de seis bandas (Neris & Colman, 2001); Tatú peludo, Peludo grande (Velázquez & Ramírez Pinto, 2014).

Comments: The use of the Guaraní name Tatùpoyù by Dobrizhoffer (1784) makes it reasonable to suggest that he encountered the species in Paraguayan territory. Azara (1801, 1802) used the same common name, clarifying that it means "armadillo with yellow hands". The common name Tatú-vai listed by Bertoni (1914) approximates to "disgusting armadillo", and is linked to beliefs in certain areas that the animal is inedible because of its habit of eating carrion. Indeed, Dobrizhoffer (1784) described the species as "loathed" because of its tendency to feed on carcasses of mules and horses, and Azara (1801, 1802) stated that nobody eats it because of the "foul tasting and smelling meat". Dobrizhoffer (1784) also observed that "lower orders of Spaniards" used the carapace as a plate. The species is widespread in all ecoregions in Paraguay.

MACN 45.028 has locality "San Pedro, Pto. Casado". It is unclear whether this locality refers to Puerto Casado, Alto Paraguay department or to an unknown locality in San Pedro department. The specimen was collected by Cranwell and Giai in December 1944.

Two stuffed specimens on display at the Museo de la Entidad Binacional Yacyretá, Ayolas, Misiones department lack collection data but may have been collected locally, as the species does occur in the area.

Specimens examined: Alcohol specimen lacking data in MNHNP with field number SF05; Mounted specimen lacking data MJUF; "Chaco" SCH 1263; "Paraguay" MACN 11.24; **Alto Paraguay:** "12 km E of Aguadulce sobre línea 1" MNHNP 519; "Parque Nacional Defensores del Chaco a 8 km E de la Administración sobre Linea 1" MNHNP 518; "Parque Nacional Defensores del Chaco" MNHNP 515; "San Pedro, Pto. Casado" MACN 45.028; **Amambay:** "road to monument 1.5 km N casa de Admin. Parque Nacional Cerro Corá" MNHNP 533; **Boquerón:** "Agua Lidia" MNHNP 517; **Canindeyú:** "Mbaracayú Wildlife Reserve airstrip at central camp (27°07'S, 57°55'W)" MNHNP 918; **Central:** "San Lorenzo" SCH 222; **Concepción:** "Paso Barreto" uncatalogued specimen in MNHNP with field number SFUH40; **Itapúa:** "Isla Yacyreta" MNHNP 1077; **Paraguarí:** "Parque Nacional Ybycuí muerto en el camino a 1 km N de la Fundación La Rosada" MNHNP 520; **San Pedro:** "Reserva Natural Laguna Blanca" CZPLT 420, 425.

Specimens not examined: "Paraguay" NHM 1902.4.7.45, MHNG 1968, 092, MZB 82-7425; **Alto Paraná:** "Refugio Biológico Itabó, Itaipú" CBMI 0110; **Alto Paraguay:** "60 km by road N Fortín Madrejón" UMMZ 125579; "114 km W Puerto Sastre" CONN 19512; "Aguadulce, 90 km NE Madrejón" CONN 19935; "north of Filadelfia" TTU 79880; **Boquerón:** "km 654.5 Transchaco road" CONN 17502; "Sargento Rodríguez, km 764 Transchaco road" CONN 17501, 17607; "surroundings of 22°34'S, 59°20'W" MTD 24889; "road to Loma Plata 4 km N Transchaco" CONN 20870; **Central:** "Colonia Nueva Italia" FMNH 54325; "Salado River" USNM 1482; **Paraguarí:** "Sapucay" NHM 1902.4.7.45; **Presidente Hayes:** "4 km E of Transchaco bridge, right bank of Rio Verde, Juan de Zalazar" CONN 15964 (Wetzel & Lovett, 1974); "4 km NW of Line Camp, Juan de Zalazar" CONN 16646; "8 km NE Juán de Zalazar" UMMZ 134014; "Laguna Pora, 85 km E Loma Plata" CONN 19958, 19960, 20030, 20352, 20432; "km 94 Transchaco road" CONN 20869; "km 100 approximately Transchaco road" CONN 10870; "295 km (by road) Villa Hayes" MVZ 145359, 145360; "Estancia Elsita" SMNH 593524, 593525; "Juan de Zalazar" CONN 15963 (Wetzel & Lovett, 1974).

Literature citations: **Alto Paraguay:** "Puerto Rio Negro" (Masi Pallarés & Benítez Usher, 1982); **Alto Paraná:** no specific locality (Bertoni, 1939); "Estancia San Antonio" (Lowen *et al.*, 1996); **Boquerón:** "Gran Siete" (Areskoug, 2001); "surroundings of 20°46-57'S, 59°48-53'W" (Ziegler *et al.*, 2002); **Caazapá:** "Reserva Natural Tapytá" (Velázquez & Ramírez Pinto, 2014); **Canindeyú:** "Mbaracayú Reserve" (Hill *et al.*, 2003); **Presidente Hayes:** "General Díaz" (Masi Pallarés & Benítez Usher, 1982); "Laguna Pora" (Redford, 1985); **San Pedro:** "Chamorro Cué outskirts of San Pedro de Ycuamandyyú" (Fujita *et al.*, 1995); "Pirí Pucú outskirts of San Pedro de Ycuamandyyú" (Fujita *et al.*, 1995).

Photographic documentation: **Alto Paraguay:** "Toro Pampa" FPMAM1003-1004 (Paul Smith in FAUNA Paraguay, 2018); **Boquerón:** "Central Chaco" FPMAM46 (Paul Smith in FAUNA Paraguay, 2018); "near Loma Plata" FPMAM924 (Paul Smith in FAUNA Paraguay, 2018); **Concepción:** "Cercanías de San Carlos del Apa" FPMAM1186PH (Sergio D. Ríos in FAUNA Paraguay, 2018); **San Pedro:** "Reserva Natural Laguna Blanca" FPMAM45, 47 (Paul Smith in FAUNA Paraguay, 2018).

Reliable observations: **Alto Paraguay:** "Tres Gigantes" (Paul Smith 4 September 2018).

Greater Hairy Armadillo

Chaetophractus villosus
(Desmarest, 1804) (**Fig. 12**)

lor[*icatus*]. *villosus* Desmarest 1804:28. Based on Azara (1801). Type locality "Les Pampas", Buenos Aires, Argentina.

Chaetophractus sp. Wetzel & Lovett (1974: specimens); Areskoug (2001: habitat).

Chaetophractus villosus Myers & Wetzel (1979: distribution); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Neris *et al.* (2002: distribution); Neris & Franco Rivarola (2005: guide); Nava *et al.* (2007: parasitology); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Smith (2008b: ecology); Smith (2012: conservation).

Choetophractus villosus Seelwische (1980: ethnography).

Chaethophractus villosus Ramírez Pinto & Velázquez (2010: distribution).

Local names: **Guaraní:** Tatú-velu (Wetzel & Lovett, 1974); Poju'i (Neris *et al.*, 2002); **Nivaclé:** Casuts'i (Seelwische, 1980); **Spanish:** Peludo (Azara, 1802); Peludo argentino, Tatú peludo (Gamarra de Fox & Martin, 1996); Pichi peludo, Quirquincho grande (Neris *et al.*, 2002).

Comments: Azara (1802) stated that the species did not occur in Paraguay. The species was first cited for Paraguay by Wetzel (1977) and the first specimens were reported by Myers & Wetzel (1979). Unpublished specimens SMNH 593510 (collected by Olrog in January 1948), FMNH 54352 (collected by Willim 6 September 1945), and FMNH 63865 (collected by Unger 18 December 1945) all predate the published specimens. The species is commonest in the Dry Chaco, with marginal occurrence in the Humid Chaco and possibly the Cerrados del Chaco ecoregions.

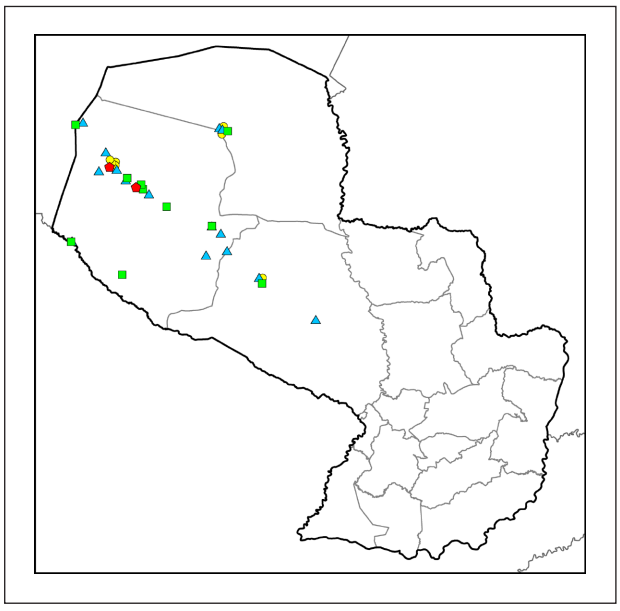

Figure 12. Distribution of *Chaetophractus villosus* in Paraguay.

Specimens examined: **Alto Paraguay:** "5 km north Madrejón admin., PN Defensores del Chaco" MNHNP 530; **Boquerón:** "5 km south Madrejón admin., PN Defensores del Chaco" MNHNP 524; "10 km al sur de Madrejón por el camino" MNHNP 529, 531; "PN Tte Enciso approx 3 km este sobre el límite sur" MNHNP 522; "PN Tte Enciso 500 km SE de la casa de control por la picada" MNHNP 532; "Ruta Transchaco 3 km N casa de admin, PN Tte Enciso" MNHNP 525; "Ruta Transchaco 10 km N casa de admin, PN Tte Enciso" MNHNP 527; **Presidente Hayes:** "Salazar, Galpón" uncatalogued alcohol specimen in MNHNP with field number SF40.

Specimens not examined: **Alto Paraguay:** "6 km NW of Madrejón on old road to Cerro León" FLMNH 20651; "Fortín Madrejón" CONN20435; **Boquerón:** "25 km W Teniente Enciso" CONN 17500; "km 655 Teniente Enciso" CONN 18064; "Copagro, km 590 Transchaco" CONN 18308, 18350, 18952 (Wetzel & Lovett, 1974); "390 km NW (by road) Villa Hayes" MVZ 145361; "Colonia Neuland" MNHNP 1155; "Dr. Pedro P. Peña" CONN 19925; "Estancia Iparoma, 19 km N Filadelfia" CONN 19961; "Garrapatal" CONN 18044; "Guachalla, Rio Pilcomayo, 580 km W Asunción" FMNH 54352; "Orloff" FMNH 63865; "Sargento Rodríguez, Transchaco km 764" CONN 17606; **Presidente Hayes:** "8 km NW headquarters, Estancia Juan de Salazar" MSB 57375; "Estancia Hermosa" SMNH 593510; "Estancia Samaklay" TTU 80408.

Literature citations: **Alto Paraguay:** "Fortín Madrejón" (Myers & Wetzel, 1979); **Boquerón:** "25 km by road NW Mariscal Estigarribia" (Myers & Wetzel, 1979); "27 km by road NW Teniente Ochoa" (Myers & Wetzel, 1979); "30 km by road NW Teniente Ochoa" (Myers & Wetzel, 1979); "35 km by road SE Teniente Enciso" (Myers & Wetzel, 1979); "42 km by road SE Teniente Pratt Gill airforce base" (Myers & Wetzel, 1979); "Dr. Pedro P. Peña" (Myers & Wetzel, 1979); "Estancia Iparoma, 19 km by road N Filadelfia" (Myers & Wetzel, 1979); "Fortín Sargento Rodríguez" (Myers & Wetzel, 1979); **Presidente Hayes:** "Juan de Salazar" (Myers & Wetzel, 1979).

Photographic documentation: **Boquerón:** "Parque Nacional Teniente Enciso" FPMAM59 (Silvia Centrón in FAUNA Paraguay, 2018); "Ruta Transchaco km 634" FPMAM60-66 (Paul Smith in FAUNA Paraguay, 2018).

Screaming Hairy Armadillo

Chaetophractus vellerosus
(Gray, 1865) (**Fig. 13**)

Dasypus vellerosus Gray 1865:376. Type locality "Santa Cruz de la Sierra", Santa Cruz, Bolivia.

Chaetophractus vellerosus Myers & Wetzel (1979: distribution); Seelwische (1980: ethnography); Wetzel (1985b: distribution); Gamarra de Fox & Martin (1996: records); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Neris *et al.* (2002: distribution); Neris & Franco Rivarola (2005: guide); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Smith (2008d: ecology); Smith (2012: conservation).

Local names: **Guaraní:** Tatu peludo (Gamarra de Fox & Martin, 1996); Tatu Poju'i (Neris *et al.*, 2002); **Nivaclé:** Yiclôôj (Seelwische, 1980); **Spanish:** Piche llorón (Gamarra de Fox & Martin, 1996); Pichi llorón (Gamarra de Fox *et al.*, 1998); Armadillo, Pichi peludo (Neris *et al.*, 2002).

Comments: The species was first reported for Paraguay by Myers & Wetzel (1979). The first specimen was CONN 16895 collected by R.L. Martin on 19 July 1974.

MACN 47.378 listed with locality "Alto Paraná, Capitán Meza" is a specimen collected by Adolfo Neuntenfel and purchased by the museum on 30 October 1947. Capitán Meza is in Itapúa department, not Alto Paraná and may have been a shipping locality as MACN 47.377 (*Ca. tatouay*) has the same details. *Chaetophractus vellerosus* does not occur east of the Paraguay River, so this locality is undoubtedly an error. The species is known only from the Dry Chaco ecoregion with marginal occurrence in the Humid Chaco.

Specimens examined: **Alto Paraguay:** "Estancia Campo Grande, 19°46.511'S, 59°46.515'W" MNHNP 3364; **Boquerón:** "3 km norte Filadelfia sobre el camino para Montanía" MNHNP 521; "60 km E Filadelfia" MNHNP 523; "PN Tte Enciso" MSB 54419; "Ruta Transchaco km 697" MSB 54075; "Filadelfia" MNHNP 526, 528, MSB 58990; "Transchaco camino a PN Médanos del Chaco" a carapace lacking data at park headquarters, but deposited there by Hugo del Castillo 12 August 2010 (HDC pers. comm.); **Itapúa:** "Alto Paraná, Capitán Meza" MACN 47.378.

Specimens not examined: "Paraguay" FMNH 157156; **Boquerón:** "Estancia Iparoma, 19 km N Filadelfia" CONN 19927, 19928, 19929, 20015; **Presidente Hayes:** "30 km W of guesthouse, km 320 Transchaco, Juan de Zalazar" CONN 16895.

Literature citations: **Alto Paraguay:** "Parque Nacional Defensores del Chaco" (Yahnke *et al.*, 1998); **Boquerón:** "24 km by road NW Teniente Ochoa" (Myers & Wetzel, 1979); "27 km by road NW Teniente Ochoa" (Myers & Wetzel, 1979); "390 km by road (Route 9) NW Villa Hayes" (Myers & Wetzel, 1979); "Estancia Iparoma, 19 km by road N Filadelfia" (Myers & Wetzel, 1979); "Parque Nacional Teniente Enciso" (Yahnke *et al.*, 1998); **Presidente Hayes:** "between Para Todos and 25 Leguas" (Myers & Wetzel, 1979); "Juan de Zalazar" (Myers & Wetzel, 1979; Wetzel 1985b).

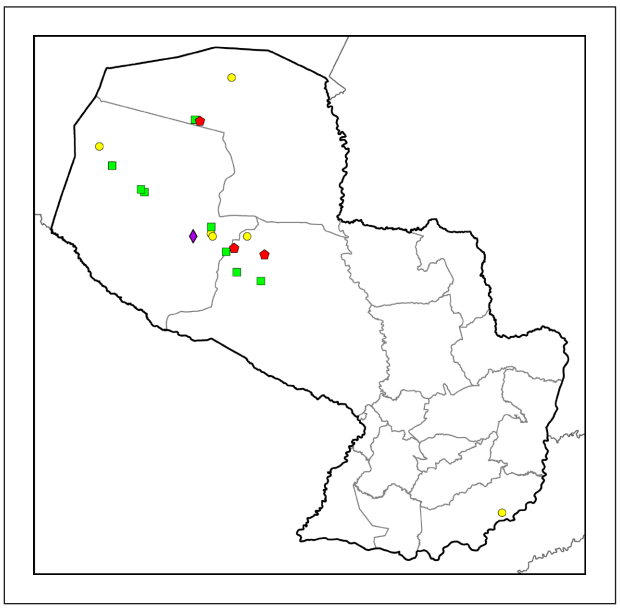

Figure 13. Distribution of *Chaetophractus vellerosus* in Paraguay.

Photographic documentation: **Alto Paraguay:** "Parque Nacional Defensores del Chaco" FPMAM53 (Sjeff Ollers in FAUNA Paraguay, 2018); **Presidente Hayes:** "Cuenca Upper Yacaré Sur" FPMAM54-56 (Paul Smith in FAUNA Paraguay, 2018); "Laguna Capitán" FPMAM48-52 (Paul Smith in FAUNA Paraguay, 2018).

Reliable observations: **Boquerón:** "Fortín Toledo" pair in coitus 23 September 2014 (Paul Smith).

Myrmecophagidae: Anteaters

Giant Anteater

Myrmecophaga tridactyla
Linnaeus, 1758 (**Fig. 14**)

[*Myrmecophaga*] *tridactyla* Linnaeus 1758:35. Type locality "America Meridionali", restricted to Pernambuco, Brazil by O. Thomas (1911).

Myrmecophaga jubata Rengger (1830: ecology); Bertoni (1914: list); Seelwische (1980: ethnography).

Myrmecophaga tridactyla Bertoni (1939: list); Seelwische (1980: ethnography); Masi Pallarés & Benítez Usher (1982: parasitology); Gatti (1985: dictionary); Brooks (1995: distribution); Gamarra de Fox & Martin (1996: records); Lowen *et al.* (1996: distribution); Gamarra de Fox *et al.* (1998: conservation); Villalba &

Yanosky (2000: tracks); Esquivel (2001: guide); Neris *et al.* (2002: distribution); Fast Schartner (2004: guide); Neris & Franco Rivarola (2005: guide); Cartes (2007: use); Nava *et al.* (2007: parasitology); Smith (2007a: ecology); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Itaipú Binacional (2010: guide); Ramírez Pinto & Velázquez (2010: distribution); Smith (2012: conservation); Velázquez & Ramírez Pinto (2014: guide); Epp (2018: guide).

Myrmecophaga tridactyla tridactyla Wetzel & Lovett (1974: specimens).

Myrmechophaga tridactyla Yahnke *et al.* (1998: distribution).

Mymecophaga tridactyla Fariña & Hostettler (2003: distribution).

Local names: **Aché:** Kuare (Fariña & Hostettler, 2003); **Enhlet:** Naayem' (Unruh & Kalisch, 1997); Anim (Fast Schartner, 2004); **Guaraní:** Tamanduà, Yoquì, Nurumì (Dobrizhoffer, 1784); Ñurumi, Yoquí (Azara, 1802); Yurumi (Rengger, 1830); Djurumí (Bertoni, 1914); Tamanduá guasú, Yurumí (Bertoni, 1939); Yurú Mí (Wetzel & Lovett, 1974); Yokĩ, Cúmbirí (Gatti, 1985); Juru mi (Fariña & Hostettler, 2003); Jurumi (Neris *et al.*, 2002); **Mbyá:** Kaguare guachu (Cadogan, 1992); **Nivaclé:** S'uclaj (Seelwische, 1980); **Mennonite dialect:** Emstjiboa (Fast Schartner, 2004); **Spanish:** Osso hormigero (Dobrizhoffer, 1784); Oso hormiguero (Azara, 1802); Oso hormiguero grande, Tamanduá bandera (Velázquez & Ramírez Pinto, 2014).

Comments: The species was first mentioned for Paraguay by Dobrizhoffer (1784) as *Ursus Formicarius*. Azara (1801, 1802) stated that the common name Ñurumi or Yurumí means "small mouth".

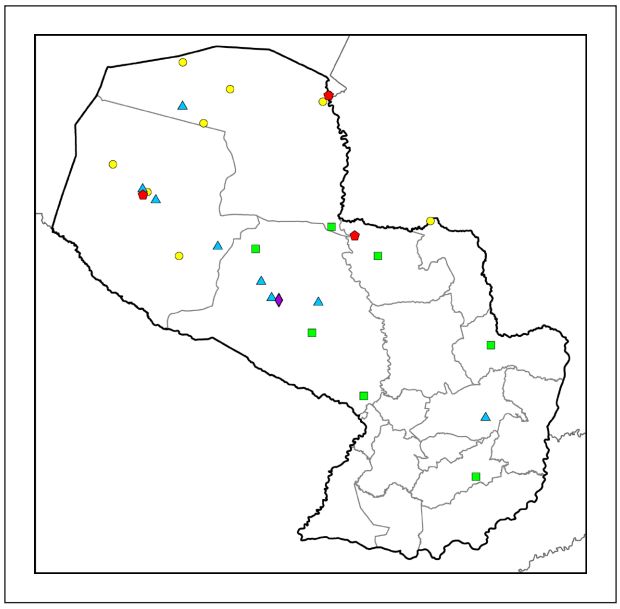

FIGURE 14. Distribution of *Myrmecophaga tridactyla* in Paraguay.

It occurs (or did occur) in all ecoregions, but is most common west of the Paraguay river especially in the Pantanal and Humid Chaco ecoregions. In the Oriental region it is now encountered regularly only in the Cerrado ecoregion, and greatly reduced in the Atlantic Forest zone.

A stuffed specimen on display at the Museo de la Entidad Binacional Yacyretá, Ayolas, Misiones department lacks collection data. Several specimens of this species are also exhibited at the Museo Schade, one of which, a juvenile, lacks a specimen number or collection data and thus is not listed below.

Specimens examined: Mounted specimens of adult and juvenile lacking data MJUF; "Chaco" SCH 384, 385, 1249, 1250; **Alto Paraguay:** "20°11.18'S, 58°15.36'W" MNHNP 3361; "35 km west of administration PN Defensores del Chaco" (= 35 km west of Madrejón?) MNHNP 1124; "Aguadulce" MNHNP 1125; "Palmar de las Islas" MNHNP 3255; "Tres Gigantes" a locally collected skull lacking specimen details in onsite museum; **Amambay:** "Bella Vista" MNHNP 1189; **Boquerón:** no specific locality MNHNP 1169; "km 595 Ruta Trans Chaco" MNHNP 1185; "Estancia San Ramón 48 km west of Colonia Neuland" MNHNP 1123; "runway Teniente Enciso" MNHNP 818.

Specimens not examined: "Paraguay" CONN 24976, MACN 23.28, 27.26, 29.238, 29.243, 30.242 (Abba & Vizcaíno, 2008); "Paraguay, Zoo Buenos Aires" MACN 3.59, 30.35, 25.190 (Abba & Vizcaíno, 2008); **Alto Paraguay:** "77 km NW of Madrejon, 15 km N on Linea 6" CONN 19524; **Boquerón:** no specific locality AMNH-M-48187; "410 km NW (by road) Villa Hayes" MVZ 145368; "Copagro, 4 km SE Transchaco km 589" CONN 18851; **Caaguazú:** "junction of Iguazú and Yuqueri rivers" MCZ 28622, 30738; **Presidente Hayes:** "approx 275 km NW by rd NW Villa Hayes" UMMZ 156446; "Est. Juan de Zalazar" CONN 16067 (Wetzel & Lovett, 1974); "Waikthlatingmayalwa" UMZC E562, E563.

Literature citations: **Boquerón:** "surroundings of 22°34'S, 59°20'W" (Zeigler *et al.*, 2002); **Canindeyú:** "Reserva Bosque Mbaracayú" (Lowen *et al.*, 1996; Esquivel, 2001; Fariña & Hostettler, 2003); **Caazapá:** "Reserva Natural Tapytá" (Velázquez & Ramírez Pinto, 2014); **Concepción:** "Garay Cué" (Masi Pallarés & Benítez Usher, 1982); **Presidente Hayes:** "km 200–250 of Ruta Transchaco" (Meritt, 2008).

Photographic documentation: **Alto Paraguay:** "Tres Gigantes" FPMAM1019-1025, 1075-1077 (Paul Smith in FAUNA Paraguay, 2018); **Boquerón:** "Ruta Transchaco km 600" FPMAM34-36 (Paul Smith in FAUNA Paraguay, 2018); **Concepción:** "Ruta Concepción-Vallemí, 30 km de Vallemí" FPMAM1188PH (Sergio D. Ríos in FAUNA Paraguay, 2018)".

Reliable observations: **Presidente Hayes:** "km 291 Ruta Trans Chaco" (Paul Smith 1 September 2018).

Southern Tamandua

Tamandua tetradactyla
(Linnaeus, 1758) (**Fig. 15**)

Myrmecophaga tetradactyla Linnaeus 1758:35. Type locality "America meridionali". Restricted to Pernambuco, Brazil by O. Thomas (1911).

Myrmecophaga tetradactyla Rengger (1830: ecology).

Tamandua tetradactyla Quijada (1910: specimen); Cabrera (1912: specimen); Bertoni (1914: list); Bertoni (1939: list); Wetzel & Lovett (1974: specimens); Seelwische (1980: ethnography); Masi Pallarés & Benítez Usher (1982: parasitology); Gatti (1985: dictionary); Roguin (1986: distribution); Brooks (1995: distribution); Gamarra de Fox & Martin (1996: records); Lowen *et al.* (1996: distribution); Gamarra de Fox *et al.* (1998: conservation); Yahnke *et al.* (1998: distribution); Villalba & Yanosky (2000: tracks); Esquivel (2001: guide); Neris *et al.* (2002: distribution); Fariña & Hostettler (2003: distribution); Hill *et al.* (2003: use); Neris & Franco Rivarola (2005: guide); Cartes (2007: use); Nava *et al.* (2007: parasitology); Smith (2007e: ecology); Abba & Vizcaíno (2008: specimens); Meritt (2008: ecology); Vinke & Vinke (2008: popular); Smith (2012: conservation); Velázquez & Ramírez Pinto (2014: guide); Epp (2018: guide).

Local names: **Aché:** Kuaremini (Esquivel, 2001); **Guaraní:** Cagüaré (Azara, 1802); Caguaré (Rengger, 1830); Kaaguaré (Bertoni, 1914); Kaguaré (Bertoni, 1939); Kaguare (Neris *et al.*, 2002); Tamandua (Fariña & Hostettler, 2003); Tamanduá (Vinke & Vinke, 2008); Tamandua miri (Ramírez Pinto & Velázquez, 2010); **Mbyá:** Kaguare mirĩ (Cadogan, 1992); **Nivaclé:** S'uclataj (Seelwische, 1980); **Spanish:** Oso hormiguero chico (Azara, 1802); Oso mielero (Gamarra de Fox & Martin, 1996); Oso melero (Esquivel, 2001).

Comments: The species was first cited for Paraguay by Azara (1801, 1802) who states that the common name Cagüaré is a shortened form of Caaigüaré, roughly meaning "smelly beast of the forest". Cabrera (1912) mentions a melanistic specimen with locality "Paraguay" in the Museo de Ciencias Naturales de Madrid (MCNM 490).

Occurs in all ecoregions, though it reaches its greatest abundance in the Humid Chaco, Cerrado and Cerrados del Chaco ecoregions.

Specimens examined: Two mounted specimens lacking data MJUF; "Chaco" SCH 165, 680; "Paraguay" MACN 6.22, 11.38, 17.102, 17.110, 21.25, 30.202 (Abba & Vizcaíno, 2008), MCZ 28640, MCNM 490; "Paraguay, Zoo Buenos Aires" MACN 4.391, 17.104, 24.164 (Abba & Vizcaíno, 2008); **Alto Paraguay:** "PN Defensores del Chaco 3.5 km west of Aguadulce" MNHNP 508; "4 km west of Aguadulce" MNHNP 507; "PN Defensores del Chaco, Cerro León" MNHNP 1068; **Amambay:** "PN Cerro Corá" MNHNP 1070; "PN Cerro Corá 1 km west of administration" MNHNP 509; **Boquerón:** "Estancia La Gama" MNHNP 1071, 1072, 1073; "Estancia San Ramón 48 km west of Colonia Neuland"; **Itapúa:** "Estancia Melgarejo, Isla Yacyreta" MNHNP 1117; **Presidente Hayes:** "km 137 Ruta Trans Chaco" MNHNP 1193; "Approx. km 139 of Ruta Trans Chaco" MNHNP 506; "Ruta Trans Chaco km 182" MNHNP 1074.

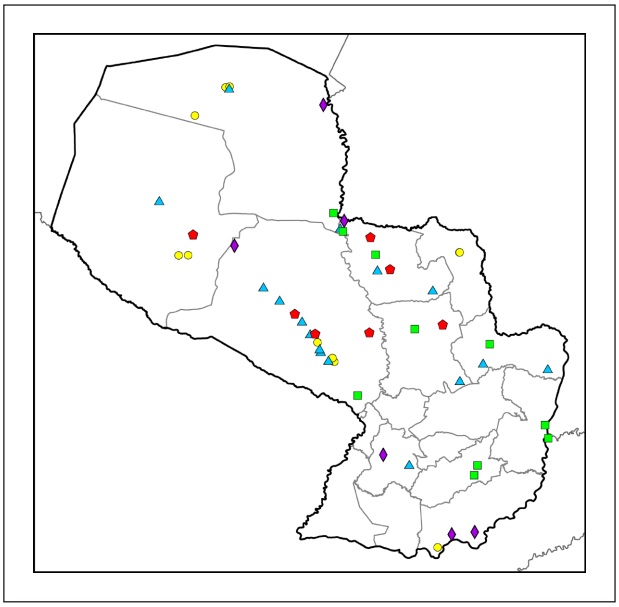

Figure 15. Distribution of *Tamandua tetradactyla* in Paraguay.

Specimens not examined: "Paraguay" CBMI 0259; MNC (Quijada, 1910), MCNM 490 (Cabrera, 1912), MZB 82-7470, MCZ 28640; **Alto Paraná:** "Vivero Forestal, Itaipú" CBMI 0001; **Alto Paraguay:** "Aguadulce 123 km E Mayor Pablo Lagarenza" CONN 19821; "Puerto Casado, Estancia Casilda" MACN 45.022 (Abba & Vizcaíno, 2008); **Boquerón:** "km 567 Transchaco" CONN 18855; **Canindeyú:** "6.3 km by road NE Curuguaty" UMMZ 124687, 124688; "Pozuelo" CBMI 0039; **Concepción:** "30 km SE Estancia Santa Maria" MNHG 1689.059 (Roguin, 1986); **Paraguarí:** "Parque Nacional Ybycuí" UMMZ 146508; **Presidente Hayes:** "24°23'S, 58°06'W" MTD 24888 (Zeigler *et al.*, 2002); "km 165 Ruta Transchaco" TTU 80575; "km 169 Ruta Transchaco" CONN 18294; "km 200 Ruta Transchaco" CONN 17035; "km 285 Ruta Transchaco" CONN 16831; "Chaco Experimental Station 295 km NW (by road) Villa Hayes" MVZ 145369; "km 230 rte Tranchaco" MNHG 1689.060 (Roguin, 1986); **San Pedro:** "46 km by road ENE Mbutuy" UMMZ 146509.

Literature citations: **Alto Paraná:** "Puerto Bertoni" (Bertoni, 1914, 1939); **Caazapá:** "Parque Nacional Caaguazú" (Lowen *et al.*, 1996); "Reserva Natural Tapytá" (Velázquez & Ramírez Pinto, 2014); **Canindeyú:** "Reserva Bosque Mbaracayú" (Lowen *et al.*, 1996; Esquivel 2001; Fariña & Hostettler, 2003, Hill *et al.*, 2003); **Concepción:** "Garay Cué" (Masi Pallarés & Benítez Usher, 1982); **Presidente Hayes:** "Reserva Natural Privada Golondrina" (Lowen *et al.*, 1996); "Transchaco approximately km 345" (Wetzel & Lovett, 1974).

Photographic documentation: **Concepción:** no specific locality FPMAM38-39PH (Hugo del Castillo in FAUNA Paraguay, 2018); "Camino a San Carlos del Apa" FPMAM1189PH (Sergio D. Ríos in FAUNA Paraguay, 2018); **Cordillera:** "Cabañas" FPMAM1190PH (Joaquín Movia in FAUNA Paraguay, 2018); **Presidente Hayes:** "Estancia Cachiveo" FPMAM40-41PH (Karen Penayo in FAUNA Paraguay, 2018); "Ruta Transchaco km 200" FPMAM42-43 (Paul Smith in FAUNA Paraguay, 2018); "Ruta Transchaco km 250" FPMAM903-904PH (Paul Smith in FAUNA Paraguay, 2018); **San Pedro:** "Reserva Natural Laguna Blanca" (PLT camera trap photo 10 May 2012).

Reliable observations: **Alto Paraguay:** "Tres Gigantes" (Paul Smith 2 September 2018); "Linea 2 6 km south of Bahía Negra" 6 September 2018 (Paul Smith); **Boquerón:** "Fortín Toledo" 29 July 2015 (Paul Smith); **Concepción:** "Estancia Tres Hermanas del Apa" 8 August 2011 (Paul Smith); **Itapúa:** "near Carmen del Paraná" roadkill 10 January 2017 (Paul Smith); "Hotel Tirol" 2007 (Paul Smith); **Paraguarí:** "near Quiindy" roadkill 10 January 2017 (Paul Smith); **Presidente Hayes:** "Laguna Capitán" 2 September 2018 (Paul Smith).

Rejected Species

Bradypodidae: Sloths

Brown-throated Three-toed Sloth

Bradypus variegatus
Schinz, 1825

Brad[*ypus*]. *variegatus* Schinz, 1825:510. Type locality "Südamerika," restricted to "Brasilien (wahrscheinlich Bahia) [Brazil, probably Bahia]" by Mertens (1925).

Bradypus tridactylus Bertoni (1914: hypothetical); Bertoni (1939: hypothetical).

Bradypus variegatus Gamarra de Fox & Martin (1996: no records); Gamarra de Fox *et al.* (1998: no records); Yahnke *et al.* (1998: possible); Ziegler *et al.* (2002: specimen); Morales (2007: list); Abba & Vizcaíno (2008: specimens); Smith (2012: rejected).

Local names: **Guaraní:** Ao-aó (Bertoni, 1914); **Spanish:** Perezoso bayo (Gamarra de Fox *et al.*, 1998); Peresozo [*sic*] de tres dedos (Morales, 2007).

Comments: Bertoni (1914, 1939) lists *B. tridactylus* as a hypothetical species, stating that it has a distribution that "encircles Paraguay almost completely", but which in Misiones (presumably Argentina, not Paraguay) "does not come close to the banks of the Paraná". In fact the only mention of the species in Misiones, Argentina seems to be Holmberg (1895) who claimed to have seen skins. Superina *et al.* (2010:124), however, state that it is "historically absent from … northeastern Argentina" and that the southernmost confirmed record of the species in Brazil is in Londrina, Paraná state where it is now considered extinct.

Bertoni (1914, 1939) mentions hearsay reports of the species in the "yerbales del norte" ("yerba mate plantations of the north"). Though it is unclear exactly where this refers to geographically (perhaps the northern Oriental region?), it raises an interesting possibility of a crossover between scientific methodology and local culture. The common name given for the species of Ao-aó, also happens to be the name of a legendary beast in the Guaraní folklore. Regardless of this, the association of the common name of the species with local legend casts serious doubt on the validity of secondhand reports by non-specialists in a scientific context.

A complete skeleton specimen (MACN 4125) dating from 1904 of an individual from Buenos Aires Zoo that supposedly came from "Paraguay" lacks precise locality data and is of dubious provenance (Abba & Vizcaíno, 2008). A specimen in the Jakob Unger Museum, Filadelfia listed by Ziegler *et al.* (2002) and prepared by J. Unger is from Bolivia according to the museum records (L. Bergen, pers. comm.).

Gamarra de Fox & Martin (1996) and Gamarra de Fox *et al.* (1998) list the species as one with "problems with records" for Paraguay, and Yahnke *et al.* (1998) list it as "possible" in Defensores del Chaco National Park. Though the species is frequently cited as present in Paraguay, there remains no evidence to support its presence in the country (Smith, 2012).

Specimens examined: Mounted specimen in Filadelfia Museum.

Specimens not examined: MACN 4125 "Paraguay" from Buenos Aires Zoo 1904, complete skeleton (Abba & Vizcaíno, 2008).

Literature citations: None.

Photographic documentation: None.

Reliable observations: None.

Discussion

Despite being one of the most conspicuous and charismatic mammal groups, the Xenarthra are poorly represented in Paraguayan museum collections and accompanying specimen data are frequently vague or absent. It is lamentable that important specimens are housed in collections that are improperly curated, lacking even basic specimen data, whilst the lack of available funding for the national MNHNP collection is reflected in the deteriorating state of many of the specimens housed there, despite the best efforts of the professional staff to combat it.

Specimen collection localities are biased towards a few, well-sampled sites (particularly in the Central Chaco and Mbaracayú Reserve) whilst other areas of the country have been virtually unsampled (notably the southern Oriental region). Consequently, numbers of specimens represented in collections are heavily biased towards those that are most numerous in the most sampled locations (**Table 1**), thus failing to provide an accurate documentation of the true distribution even of the most numerous species in Paraguay. The current representation of Xenarthra in museum collections is far from adequate and the age of many of the specimens provides only limited and dated information on distribution and status in a country with a rapidly changing landscape.

The availability of reliable and recent information is arguably the most important factor in the accurate determination of the conservation status of a given species, and the partial updating of old information with infrequent and unfocused rapid ecological assessments (REAs) is unsatisfactory and, given the tendency for these to repeat data provided in previous REAs from nearby localities, is often a dangerously misleading substitute. Leaving aside the logistical and financial difficulties of data gathering, we consider it necessary for some kind of estimation of the reliability and modernity of the data upon which conservation assessments are made to accompany such designations in order to correctly highlight weaknesses in the data pool, indicate priorities for investigation, and give weight to real scientific data over opinion and hearsay. A consequence of this has been the repeated appearance in Paraguayan lists of species for which no actual documentation exists, as is the case with *B. variegatus*. We hope that the information provided here will assist with that objective.

An additional and often ignored effect of the lack of available data in conservation assessments is the unconscious tendency for assessors to give more emphasis to the perceived reduction in records of large, charismatic species such as *P. maximus* and *M. tridactyla* than to those of less charismatic yet less-frequently observed species. This bias is reflected in a perceived greater threat status to these "flagship species", coupled with an equally unsupported assumption that the smaller species are less threatened and hence are probably being overlooked. Without real population and distributional data, national threat statuses cannot accurately represent the reality of the conservation statuses of the species they assess, and in fact more accurately reflect the private concerns or level of experience and knowledge of the assessors. The subsequent use of national threat statuses estimated in this way for the assessment of global threat statuses may be having grave consequences for some species that are rapidly, but quietly, declining. Perhaps more worrying is that these weakly supported decisions (by no means unique to xenarthrans) are being relied upon by government officials to determine quotas for the harvesting of wildlife by private, profit-seeking companies. Inaccurate conservation assessments may in fact be exacerbating the problem rather than easing it (Smith, 2012).

This paper represents a first attempt to critically quantify the available data on the distribution of Paraguayan Xenarthra by highlighting gaps in our knowledge, clarifying misunderstandings, and distinguishing between different types of records so that they may be assessed separately according to their level of documentation. With these issues firmly in mind, we make an urgent call for more data on Paraguayan xenarthrans to be collated and for this data to be collected in a standardised way with a view to complementing and/or improving the effectiveness of conservation assessments and the national environmental legislation. A failure to do so may lead to potentially disastrous consequences for populations of xenarthrans in a region of high diversity and importance for their global conservation.

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References

Abba, A.M., S.D. Ríos & P. Smith. 2017. Xenarthra: armadillos y osos hormigueros. Pp. 41–47 in: Libro Rojo de mamíferos del Paraguay (S. Saldívar, V. Rojas & D. Giménez, eds.). Asociación Paraguaya de Mastozoología y Secretaría del Ambiente, Asunción, Paraguay.

Abba, A.M. & M. Superina. 2016. *Dasypus hybridus* (Cingulata: Dasypodidae). Mammalian Species 48: 10–20. https://doi.org/10.1093/mspecies/sew001

Abba, A.M. & S.F. Vizcaíno. 2008. Los xenartros (Mammalia: Xenarthra) del Museo Argentino de Ciencias Naturales «Bernardino Rivadavia» y del Museo de La Plata, Argentina. Contribuciones del Museo Argentino de Ciencias Naturales Bernardino Rivadavia 4: 5–37.

Acosta, N. & E. López. 2013. Reservorios mamíferos del *Trypanosoma cruzi* en Paraguay. Memorias del Instituto de Investigación en Ciencias de la Salud 11: 90–96.

Areskoug, V. 2001. Utilisation of remnant dry-forest corridors by the native fauna in a pastural landscape in the Paraguayan Chaco. CBM:s Skriftserie 3: 25–38.

Azara, F. de. 1801. Essais sur l'histoire naturelle des quadrupèdes de la province du Paraguay. Tome 2. Charles Pougens, Paris, France. 499pp.

Azara, F. de. 1802. Apuntamientos para la historia natural de los quadrúpedos del Paragüay y Río de la Plata. Tomo 2. Imprenta de la Viuda de Ibarra, Madrid, Spain. 328pp.

Benítez, L.G. 1986. Breve historia de grandes hombres. Ediciones Comuneros, Asunción, Paraguay. 390 pp.

Bertassoni, A. 2018. Family Myrmecophagidae (anteaters). Pp. 74–90 in: Handbook of the mammals of the world – volume 8: insectivores, sloths and colugos (D.E. Wilson & R.A. Mittermeier, eds.). Lynx Edicions, Barcelona.

Bertoni, A. de W. 1914. Fauna Paraguaya. Catálogos sistemáticos de los vertebrados del Paraguay. Gráfica M. Brossa, Asunción, Paraguay. 86 pp.

Bertoni, A. de W. 1939. Catálogos sistemáticos de los vertebrados del Paraguay. Revista de la Sociedad Científica del Paraguay 4: 3–60.

Brooks, D.M. 1995. Distribution and limiting factors of edentates in the Paraguayan Chaco. Edentata 2: 10–15.

Burmeister, H. 1863. Ein neuer *Chlamyphorus*. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 7: 165–171.

Cabrera, A. 1912. Catálogo metódico de las colecciones de mamíferos del Museo de Ciencias Naturales de Madrid. Trabajos del Museo de Ciencias Naturales 7: 1–147.

Cabrera, A. 1958. Catálogo de los mamíferos de América del Sur. Revista del Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Zoología 4: 1–307.

Cadogan, L. 1992. Diccionario mbyá guaraní-castellano. Biblioteca Paraguaya de Antropología, Volumen 17. Asunción, Paraguay. 200 pp.

Cartes, J.L. 2007. Patrones de uso de los mamíferos del Paraguay: Importancia sociocultural y económica. Pp. 167–186 in: Biodiversidad del Paraguay: una aproximación a sus realidades (D.A. Salas-Dueñas & J.F. Facetti, eds.). Fundación Moisés Bertoni, Asunción, Paraguay.

Centrón, S., R. Zárate, A. Chivugui, M. Achipurangui, E. Mayeregger & J.L. Cartes. 2013. Patrones de uso de la fauna en la Reserva de Patrimonio Aché de Kuetuvy, Canindeyú. Paraquaria Natural 1: 25–31.

Chase Sardi, M. 1983. Pequeño Decamerón Nivaclé: literatura oral de una etnia del Chaco Paraguayo. Suplemento Antropológico 18: 15–252.

de la Sancha, N., C. López-González. G. D'Elia, P. Myers, L. Váldez & M.L. Ortíz. 2017. An annotated checklist of the mammals of Paraguay. Therya 8: 241-260. https://doi.org/10.12933/therya-17-473

Desmarest, A.G. 1804. Tableau méthodique des mammifères. Pp. 5–58 in: Nouveau dictionnaire d'histoire naturelle, appliquée aux arts, principalement à l'agriculture et à l'économie rurale et domestique: par une société de naturalistes et d'agriculteurs: avec des figures tirées des trois règnes de la nature. Chez Deterville, Paris.

Dobrizhoffer, M. 1784. Historia de Abiponibus equestri, bellicosaque Paraguariae natione, Tomus 1. Josephi Nob. De Kurzbek, Viennae, Austria.

Epp, N. 2018. Die Natur des paraguayischen Chaco. Filadelfia, Paraguay. 217 pp.

Erxleben, J.C.P. 1777. Systema regni animalis per classes, ordines, genera, species, varietates cun synonimia et historial animalium: classis 1 Mammalia. Weygandianus, Leipzig, Germany.

Esquivel, E. 2001. Mamíferos de la Reserva Natural del Bosque Mbaracayú, Paraguay. Fundación Moisés Bertoni, Asunción, Paraguay. 87 pp.

Fariña, R. & T. Hostettler. 2003. Vertebrados de la Reserva Natural del Bosque Mbaracayú. Checklist. Fundación Moisés Bertoni, Asunción, Paraguay. 66 pp.

Fast Schartner, H. 2004. Guía ecológica de la cuenca alta del Riacho Yakaré Sur. Fundación para el Desarrollo Sustentable del Chaco, Loma Plata, Paraguay. 112 pp.

FAUNA Paraguay. 2018. List of the mammals of Paraguay. http://www.faunaparaguay.com/listmammals.html. Downloaded on 5 November 2018.

Feijó, A., B.D. Patterson & P. Cordero-Estrela. 2018. Taxonomic revision of the long-nosed armadillos, Genus *Dasypus* Linnaeus, 1758 (Mammalia, Cingulata). PLoS ONE 13(4): 1–69. https://doi.org/10.1371/journal.pone.0195084

Frutos, S.D. & R.A. Van den Bussche. 2002. Genetic diversity and gene flow in nine-banded armadillos in Paraguay. Journal of Mammalogy 83: 815–823. https://doi.org/10.1644/1545-1542(2002)083<0815:GDAGFI>2.0.CO;2

Fujita, O., L. Sanabria, A. Inchaustti, A.R. De Arias, Y. Tomizawa & Y. Oku. 1994. Animal reservoirs for *Trypanosoma cruzi* infection in an endemic area in Paraguay. Journal of Veterinary Medical Science 56: 305–308. https://doi.org/10.1292/jvms.56.305

Fujita, O., A. Abe, Y. Oku, L. Sanabria, A. Inchaustti & M. Kamiya. 1995. Nematodes of armadillos in Paraguay: A description of a new species *Aspidodera esperanzae* (Nematoda: Aspidoderidae). Journal of Parasitology 81: 936–941. https://doi.org/10.2307/3284045

Gamarra de Fox, I. & A.J. Martin. 1996. Mastozoología. Lista de mamíferos del Paraguay. Pp. 469–573 in: Colecciones de flora y fauna del Museo Nacional de Historia Natural del Paraguay (O. Romero Martínez, ed.). Museo Nacional de Historia Natural del Paraguay, Ministerio de Agricultura y Ganadería. San Lorenzo, Paraguay.

Gamarra de Fox I., J. Van Humbeck, W. Sosa, R. Penayo & R. Villalba. 1998. Mamíferos. Pp. 55–69 in: Fauna amenazada del Paraguay (Dirección de Parques Nacionales y Vida Silvestre, ed.). Ministerio de Agricultura y Ganadería/Fundación Moisés Bertoni, Asunción, Paraguay.

Gardner, A.L. 2008. Magnorder Xenarthra. Pp. 127–176 in: Mammals of South America. Volume 1: Marsupials, xenarthrans, shrews, and bats (A.L. Gardner, ed.). The University of Chicago Press, Chicago.

GAT & OPIT. 2014. El territorio Ayoreo Totobiegosode. Patrimonio Natural y Cultural, Alto Paraguay, Chaco Paraguayo. Gente Ambiente y Territorio – Organización Payipie Ichadie Totobiegosode, Asunción, Paraguay. 96 pp.

Gatti, C. 1985. Enciclopedia Guaraní-Castellano de ciencias naturales y conocimientos paraguayos. Arte Nuevo Editores, Asunción, Paraguay. 331 pp.

Gibb, G.C. *et al.* 2016. Shotgun mitogenomics provides a reference phylogenetic framework and timescale for living xenarthrans. Molecular Biology and Evolution 33: 621–642. https://doi.org/10.1093/molbev/msv250

Gray, J.E. 1865. Revision of the genera and species of entomophagous Edentata, founded on the examination of the specimens in the British Museum. Proceedings of Zoological Society of London 33: 359–386. https://doi.org/10.1111/j.1469-7998.1865.tb02351.x

Gray, J.E. 1869. Catalogue of the carnivorous, pachydermatous and edentate mammalia in the British Museum. British Museum of Natural History, London, UK.

Gray, J.E. 1874. On the short-tailed armadillo *Muletia septemcincta*. Proceedings of Zoological Society of London 42: 244–246. https://doi.org/10.1111/j.1096-3642.1874.tb02479.x

Guyra Paraguay. 2005. Atlas de las aves del Paraguay. Guyra Paraguay, Asunción, Paraguay. 212 pp.

Hamlett, G.W.D. 1939. Identity of *Dasypus septemcinctus* Linnaeus with notes on some related species. Journal of Mammalogy 20: 328–336. https://doi.org/10.2307/1374259

Hill, K., G. McMillan & R. Fariña. 2003. Hunting-related changes in game encounter rates from 1994 to 2001 in the Mbaracayú Reserve, Paraguay. Conservation Biology 17: 1312–1323. https://doi.org/10.1046/j.1523-1739.2003.01135.x

Holmberg, E.L. 1895. La fauna argentina. Pp. 477–577 in: Segundo censo nacional (D.G. de la Fuente, ed.). Taller Tip, Penitenciaría Nacional, Buenos Aires, Argentina.

Hutterer, R. & G. Peters. 2010. Type specimens of mammals (Mammalia) in the collections of the Zoologisches Forschungsmuseum Alexander Koenig, Bonn. Bonn Zoological Bulletin 59: 3–27.

Itaipú Binacional. 2010. Animales del zoológico de Itaipú. Dirección de Educación Ambiental, Itaipú, Hernandarias, Paraguay. 38 pp.

Kerr, R. 1792. The animal kingdom or zoological system of the celebrated Sir Charles Linnaeus. Class I. Mammalia: containing a complete systematic description, arrangement and nomenclature of all the known species and varieties of the Mammalia, or animals which give suck to their young; being a translation of that part of the Systema Naturae as lately published with great improvements by Professor Gmelin of Goettingen. Together with numerous additions from more recent zoological writers and illustrated with copperplates. A. Strahan, T. Cadell & W. Creech, Edinburgh, Scotland.

Kerr, J.G. 1901. On the birds observed during a second zoological expedition to the Gran Chaco. Ibis 8: 215–236. https://doi.org/10.1111/j.1474-919X.1901.tb00465.x

Linnaeus, C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species cum characteribus, diferentiis, synonymis, locis. editio decima. Laurentii Salvii, Holmiae, Sweden.

Lönnberg, E. 1928. Notes on some South American edentates. Arkiv för Zoologi 20A: 17–25.

Lowen, J.C., L. Bartrina, R.P. Clay & J.A. Tobias. 1996. Biological surveys and conservation priorities in eastern Paraguay. CSB Conservation Publications, Cambridge, UK. 190 pp.

Masi Pallarés, R. 2011. Vertebrados del Paraguay. Descripción y hábitos con las denominaciones en Guaraní. Smart C3, Asunción, Paraguay.

Masi Pallarés, R. & C.A. Benítez Usher. 1982. De la distribución de *Ixodina* (Van der Hammen, 1968) en el Paraguay. Revista Paraguaya de Microbiología 17: 49–52.

McDonough, C.M. & W.J. Loughry. 2018. Family Dasypodidae (long-nosed armadillos). Pp. 30–47 in: Handbook of the mammals of the world – volume 8: insectivores, sloths and colugos (D.E. Wilson & R.A. Mittermeier, eds.). Lynx Edicions, Barcelona.

Mereles, F. 2013. Acerca de las extensiones de Cerrados y Cerradones en el Paraguay. Paraquaria Natural 1: 35–38.

Meritt, D.A. Jr. 1973. Observations on the status of the giant armadillo, *Priodontes giganteus*, in Paraguay. Zoologica 58: 103.

Meritt, D.A. Jr. 2008. Xenarthrans of the Paraguayan Chaco. Pp. 294–299 in: The biology of the Xenarthra (S.F. Vizcaíno & W.J. Loughry, eds.). University Press of Florida, Gainesville.

Mertens, R. 1925. Verzeichnis der Säugetier-Typen des Senckenbergischen Museums. Senckenbergiana 7: 18–37.

Morales, M. 2007. Diversidad de mamíferos en Paraguay. Pp. 133–150 in: Biodiversidad del Paraguay: una aproximación a sus realidades (D.A. Salas-Dueñas & J.F. Facetti, eds.). Fundación Moisés Bertoni, Asunción, Paraguay.

Myers, P. & R.M. Wetzel. 1979. New records of mammals from Paraguay. Journal of Mammalogy 60: 638–641. https://doi.org/10.2307/1380113

Nava, S. *et al.* 2007. The ticks (Acari: Ixodida: Argasidae, Ixodidae) of Paraguay. Annals of Tropical Medicine and Parasitology 101: 255–270. https://doi.org/10.1179/136485907X176319

Neris, N. & F. Colman. 2001. Mamíferos. Pp. 127–247 in: Especies silvestres del Paraguay. Guía de identificación de especies con importancia económica. Secretaría Nacional del Medio Ambiente-Prodechaco-Guyra Paraguay, Asunción, Paraguay.

Neris, N., F. Colman, E. Ovelar, N. Sukigara & N. Ishii. 2002. Guía de mamíferos medianos y grandes del Paraguay: distribución, tendencia poblacional y utilización. SEAM, Asunción, Paraguay. 165 pp.

Neris, N. & E.G. Franco Rivarola. 2005. Mamíferos. Pp. 153–193 in: Guía ilustrada de anfibios, reptiles, aves y mamíferos del Paraguay (N. Neris, ed.). Natura Vita – Jica, Asunción, Paraguay.

Olson, D.M. *et al.* 2001. Terrestrial ecoregions of the world: a new map of life on Earth. BioScience 51: 933–938. https://doi.org/10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2

Quijada, B. 1910. Catálogo de los vertebrados vivientes conservados en el Museo Nacional de Chile. Boletín del Museo Nacional de Chile 1: 89–132.

Ramírez Pinto, F. & M.C. Velázquez. 2010. Mamíferos. Pp. 23–25 in: La naturaleza y riqueza del río Pilcomayo (L. Villalba, ed.). Iniciativa Chaco Trinacional y Fundación Moisés Bertoni, Asunción, Paraguay. 35 pp.

Redford, K.H. 1985. Food habits of armadillos (Xenarthra: Dasypodidae). Pp. 429–427 in: The evolution and ecology of armadillos, sloths and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington D.C.

Rengger, J.R. 1830. Naturgeschichte der Saeugethiere von Paraguay. Schweighausersche Buchhandlung, Basel, Switzerland. 394 pp. https://doi.org/10.5962/bhl.title.49975

Roguin, L. de. 1986. Les mammifères du Paraguay dans les collections du Muséum de Genève. Revue Suisse de Zoologie 93: 1009–1022. https://doi.org/10.5962/bhl.part.79525

Saldívar, S. *et al*. 2017. Los mamíferos amenazados del Paraguay. Pp. 25–32 in: Libro Rojo de mamíferos del Paraguay (S. Saldívar, V. Rojas & D. Giménez, eds.). Asociación Paraguaya de Mastozoología y Secretaría del Ambiente, Asunción, Paraguay.

Sanborn, C.C. 1930. Distribution and habits of the three-banded armadillo *Tolypeutes*. Journal of Mammalogy 11: 61–68. https://doi.org/10.2307/1373787

Sánchez Labrador, J. 1910. El Paraguay católico. Homenaje de la Universidad Nacional de La Plata al XVII Congreso Internacional de los Americanistas en su reunión de Buenos Aires, en mayo 16 a 21 de 1910. Buenos Aires, Argentina.

Schinz, H.R. 1825. Das Thierreich eingetheilt nach dem Bau der Thiere als Grundlage ihrer Naturgeschichte und der vergleichenden Anatomie. Vol. 4. J.G. Cotta, Stuttgart and Tübingen, Germany.

Schmidt, G.D. & R.L. Martin. 1978. Tapeworms of Chaco Boreal, Paraguay, with two new species. Journal of Helminthology 52: 205–209. https://doi.org/10.1017/S0022149X00005381

Seelwische, J. 1980. Diccionario Nivacle–Castellano. Vol. 1. Biblioteca Paraguaya de Antropología, Mariscal Estigarribia. 378 pp.

Servicio Forestal Nacional. 1982. Guía de algunos vertebrados del Parque Nacional Ybycuí. Ministerio de Agricultura y Ganadería, Asunción, Paraguay. 47 pp.

Smales, L.R. 2007. Oligacanthorhynchidae (Acanthocephala) from mammals from Paraguay with the description of a new species of *Neoncicola*. Comparative Parasitology 74: 237–243. https://doi.org/10.1654/4271.1

Smith, P. 2007a. Giant anteater *Myrmecophaga tridactyla*. FAUNA Paraguay Handbook of the mammals of Paraguay 2: 1–18. Update April 2012. http://www.faunaparaguay.com/mamm2Myrmecophagatridactyla.pdf

Smith, P. 2007b. Giant armadillo *Priodontes maximus*. FAUNA Paraguay Handbook of the mammals of Paraguay 6: 1–11. Update April 2012. http://www.faunaparaguay.com/mamm6Priodontesmaximus.pdf

Smith, P. 2007c. Nine-banded armadillo *Dasypus novemcinctus*. FAUNA Paraguay Handbook of the mammals of Paraguay 8: 1–30. Update April 2012. http://www.faunaparaguay.com/mamm8Dasypusnovemcinctus.pdf

Smith, P. 2007d. Six-banded armadillo *Euphractus sexcinctus*. FAUNA Paraguay Handbook of the mammals of Paraguay 5: 1–16. Update April 2012. http://www.faunaparaguay.com/mamm5Euphractussexcinctus.pdf

Smith, P. 2007e. Southern tamandua *Tamandua tetradactyla*. FAUNA Paraguay Handbook of the mammals of Paraguay 3: 1–15. Update April 2012. http://www.faunaparaguay.com/mamm3Tamanduatetradactyla.pdf

Smith, P. 2007f. Southern three-banded armadillo *Tolypeutes matacus*. FAUNA Paraguay Handbook of the mammals of Paraguay 7: 1–12. Update April 2012. http://www.faunaparaguay.com/mamm7Tolypeutesmatacus.pdf

Smith, P. 2008a. Chaco fairy armadillo *Calyptophractus retusus*. FAUNA Paraguay Handbook of the mammals of Paraguay 20: 1–5. http://www.faunaparaguay.com/mamm20Calyptophractusretusus.pdf

Smith, P. 2008b. Greater hairy armadillo *Chaetophractus villosus*. FAUNA Paraguay Handbook of the mammals of Paraguay 11: 1–15. Update April 2012. http://www.faunaparaguay.com/mamm11Chaetophractusvillosus.pdf

Smith, P. 2008c. Greater naked-tailed armadillo *Cabassous tatouay*. FAUNA Paraguay Handbook of the mammals of Paraguay 13: 1–9. Update April 2012. http://www.faunaparaguay.com/mamm13Cabassoustatouay.pdf

Smith, P. 2008d. Lesser hairy armadillo *Chaetophractus vellerosus*. FAUNA Paraguay Handbook of the mammals of Paraguay 12: 1–9. Update February 2011. http://www.faunaparaguay.com/mamm12Chaetophractusvellerosus.pdf

Smith, P. 2008e. Seven-banded armadillo *Dasypus septemcinctus*. FAUNA Paraguay Handbook of the mammals of Paraguay 14: 1–7. Update February 2011. http://www.faunaparaguay.com/mamm14Dasypusseptemcinctus.pdf

Smith, P. 2008f. Southern long-nosed armadillo *Dasypus hybridus*. FAUNA Paraguay Handbook of the mammals of Paraguay 15: 1–10. Update February 2011. http://www.faunaparaguay.com/mamm15Dasypushybridus.pdf

Smith, P. 2009. Chaco naked-tailed armadillo *Cabassous chacoensis*. FAUNA Paraguay Handbook of the mammals of Paraguay 25: 1–7. Update April 2012. http://www.faunaparaguay.com/mamm25Cabassouschacoensis.pdf

Smith, P. 2011. Southern naked-tailed armadillo *Cabassous unicinctus*. FAUNA Paraguay Handbook of the mammals of Paraguay 40: 1–10. Update April 2012. http://www.faunaparaguay.com/mamm40Cabassousunicinctus.pdf

Smith, P. 2012. Assessing the assessment, the relevance of the 2006 Paraguayan mammal Red List to the reality of Xenarthra conservation in 2012. Edentata 13: 18–28. https://doi.org/10.5537/020.013.0101

Smith, P. & R.D. Owen. 2017. *Calyptophractus retusus* (Cingulata: Dasypodidae). Mammalian Species 49(947): 57–62. https://doi.org/10.1093/mspecies/sex005

Smith, P., R.D. Owen, K. Atkinson, H. del Castillo & E. Northcote-Smith. 2011. First records of the southern naked-tailed armadillo *Cabassous unicinctus* (Linnaeus, 1758) (Xenarthra: Dasypodidae) in Paraguay. Edentata 12: 53–57. https://doi.org/10.5537/020.013.0101

Superina, M. & A.M. Abba. 2018. Family Chlamyphoridae (Chlamyphorid armadillos). Pp. 48–73 in: Handbook of the mammals of the world – volume 8: insectivores, sloths and colugos (D.E. Wilson & R.A. Mittermeier, eds.). Lynx Edicions, Barcelona.

Superina, M., T. Plese, N. Moraes-Barros & A.M. Abba. 2010. The 2010 sloth Red List assessment. Edentata 11: 115–134.

Thomas, O. 1907. On Neotropical mammals of the genera *Callicebus*, *Reithrodontomys*, *Ctenomys*, *Dasypus* and *Marmosa*. Annals and Magazine of Natural History Series 7 20: 161–168. https://doi.org/10.1080/00222930709487318

Thomas, O. 1911. The mammals of the tenth edition of Linnaeus; an attempt to fix the types of the genera and the exact bases and localities of the species. Proceedings of the Zoological Society of London 79: 120–158.

Unruh, E. & H. Kalisch. 1997. Moya'ansaeclha' Nengelpayvaam Nengeltomha Enlhet. Biblioteca Paraguaya de Antropología, Vol. 27. Centro de Estudios Antropológicos de la Universidad Católica (CEADUC), Asunción. 903 pp.

Velázquez, M. & F. Ramírez Pinto. 2014. Guía de los mamíferos de la Reserva Natural Tapytá. Fundación Moisés Bertoni, Asunción, Paraguay. 127 pp.

Villalba R. & A. Yanosky. 2000. Guía de huellas y señales: fauna paraguaya. Fundación Moisés Bertoni, Asunción, Paraguay. 112 pp.

Vinke, T. & S. Vinke. 2008. El maravilloso Chaco Paraguayo. Dauri-Verlag, Bergheim, Germany. 96 pp.

Vinke, T. & S. Vinke. 2014. El pichiciego mayor, una rareza poco conocida de la tierra chaqueña *Chlamyphorus retusus*. Paraguay Salvaje 2: 8–11.

Weiler, A. & K. Nuñez. 2012. Desafíos para la conservación del tatú carreta (*Priodontes maximus*) en el Chaco Paraguayo. Reportes Científicos de la FACEN 3: 5–13.

Wetmore, A. 1926. Observations on the birds of Argentina, Paraguay, Uruguay and Chile. Bulletin of the United States National Museum 133: 1–448. https://doi.org/10.5479/si.03629236.133.i

Wetzel, R.M. 1977. The Chacoan peccary *Catagonus wagneri* (Rusconi). Bulletin of the Carnegie Museum of Natural History 3: 1–36.

Wetzel, R.M. 1980. Revision of the naked-tailed armadillos, genus *Cabassous* McMurtrie. Annals of the Carnegie Museum of Natural History 49: 323–357.

Wetzel, R. 1985a. Taxonomy and distribution of armadillos. Pp. 23–46 in: The evolution and ecology of armadillos, sloths and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington D.C.

Wetzel, R. 1985b. The identification and distribution of recent Xenarthra (= Edentata). Pp. 5–22 in: The evolution and ecology of armadillos, sloths and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington D.C.

Wetzel, R.M. & J.W. Lovett. 1974. A collection of mammals from the Chaco of Paraguay. The University of Connecticut Occasional Papers: Biological Science, Series 2: 203–216.

Wetzel, R.M. & E. Mondolfi. 1979. The subgenera and species of long-nosed armadillos, Genus *Dasypus* L. Pp. 43–63 in: Vertebrate ecology in the northern Neotropics (J.F. Eisenberg, ed.). Smithsonian Institution Press, Washington D.C.

Wetzel, R.M., A.L. Gardner, K.H. Redford & J.F. Eisenberg. 2008. Order Cingulata. Pp. 128–156 in: Mammals of South America, Volume 1: marsupials, xenarthrans, shrews and bats (A.L. Gardner, ed.). The University of Chicago Press, Chicago.

Wilson D.E. & D.M. Reeder. 2005. Mammal species of the world. A taxonomic and geographic reference (3rd ed.). The Johns Hopkins University Press, Baltimore. 2142 pp.

Yahnke C.J., I. Gamarra de Fox & F. Colman. 1998. Mammalian species richness in Paraguay: the effectiveness of national parks in preserving biodiversity. Biological Conservation 84: 263–268. https://doi.org/10.1016/S0006-3207(97)00113-4

Yeo, M. *et al.* 2005. Origins of Chagas disease: *Didelphis* species are natural hosts of *Trypanosoma cruzi* I and armadillos hosts of *Trypanosoma cruzi* II, including hybrids. International Journal for Parasitology 35: 225–233. https://doi.org/10.1016/j.ijpara.2004.10.024

Yepes, J. 1928. Los «Edentata» argentinos. Sistemática y distribución. Revista de la Universidad de Buenos Aires Serie 2a 1: 461–515.

Yepes, J. 1933. Una especie nueva de «mulita» (Dasipodinae) para el norte argentino. Physis 11: 22–232.

Yepes, J. 1935. Las especies argentinas del género *Cabassous* (Dasypodidae). Physis 11: 438–444.

Yepes, J. 1939. Una nueva subespecie de pichi ciego mayor (Chlamyphorinae) y su probable distribución geográfica. Physis 16: 35–39.

Ziegler, T., J. Unger, A. Feiler & E. Lehr. 2002. The first Gran Chaco expedition of the Museum für Tierkunde Dresden: records of amphibians, reptiles and mammals from the Dry Chaco of Paraguay (Amphibia, Reptilia, Mammalia). Faunistische Abhandlungen Staatliches Museum für Tierkunde Dresden 23: 219–238.

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FIELD NOTE

Stepping stones facilitate river crossings by *Myrmecophaga tridactyla* in the north-eastern Brazilian Amazon

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Abstract The ability of giant anteaters (*Myrmecophaga tridactyla*) to swim has been documented in the literature, but observations in the wild are scarce. Here, we document an observation recorded on 26 September 2017 when an adult *M. tridactyla* was seen crossing a 150 m wide river in the north-eastern Amazon, Brazil. The individual successfully crossed the river using a combination of swimming and walking over large rocks that were exposed during the dry season. It appears likely that the individual chose the river section with large rocks to help it to cross the river. We discuss that rocks may play a role in the facilitation of river crossings by giant anteaters and other mammals, especially during the dry season when the river level is lower, thus creating more rapids and more exposed rocks that can be utilized.

Keywords: Amazonia, behavior, giant anteater, mammal, swimming

Uso de pedras para facilitar o cruzamento de rios por *Myrmecophaga tridactyla* no nordeste da Amazônia Brasileira

Resumo A capacidade de nadar em tamanduás-bandeira (*Myrmecophaga tridactyla*) já foi reportada na literatura, mas observações em campo são escassas. Nós documentamos uma observação registrada em 26 de setembro de 2017, quando um *M. tridactyla* adulto foi visto atravessando 150 m de um rio largo no nordeste da Amazônia, Brasil. O indivíduo cruzou o rio usando uma combinação de natação e caminhada sobre grandes pedras que ficam expostas durante a época da seca. Aparentemente o individuo escolheu a seção de rio com grandes pedras para facilitar o cruzamento. Nós discutimos que pedras desempenham um papel importante, facilitando cruzamentos dos rios para tamanduás-bandeira e outros mamíferos, especialmente durante a estação seca, quando o nível do rio é menor criando mais corredeiras e mais pedras expostas que podem ser utilizadas.

Palavras-chave: Amazônia, comportamento, mamífero, natação, tamanduá-bandeira

The giant anteater (*Myrmecophaga tridactyla* Linnaeus, 1758) is a large insectivorous mammal from the family Myrmecophagidae and is classified within the order Pilosa (Wilson & Reeder, 2005). It is a terrestrial species found in a range of habitat types from tropical forest to the xeric Chaco within South and Central America (Eisenberg & Redford, 1999; Miranda *et al.*, 2014). Giant anteaters are locally uncommon to rare, especially in Central America and the southern parts of their range (Miranda *et al.*, 2014). In fact, the giant anteater is recorded as the most threatened mammal in Central America due to the extirpation of populations from many countries (Miranda *et al.*, 2014). It is also found in low numbers in South America and has been classified as Vulnerable (VU A2c) by the IUCN (Miranda *et al.*, 2014) and in Brazil (MMA, 2008). Within Brazil the giant anteater is Regionally Extinct in the states of Santa Catarina (Cherem *et al.*, 2004), Rio de Janeiro (Bergallo, 2000), and Espírito Santo (Chiarello *et al.*, 2007). It is classified as Critically Endangered in Paraná (Mikich & Bernils, 2004) and in Rio Grande do Sul (Fontana *et al.*, 2003), but is likely to be categorized as Regionally Extinct in the next update of this latter state's Red List (Miranda *et al.*, 2014).

Due to the low densities of the giant anteater within its distribution range, coupled with its solitary habits (Eisenberg & Redford, 1999), the literature on the ecology and behavior of this species in the wild is still scarce, with observations mostly obtained from open areas, such as grasslands and savannahs (Shaw *et al.*, 1985; Young *et al.*, 2003; Mourão & Medri, 2007; Braga *et al.*, 2010). While *M. tridactyla* is a terrestrial species, it is considered a relatively strong swimmer (Miranda *et al.*, 2015), capable of crossing wide rivers (Nowak, 1999). However, swimming records for this species in the field are scarce.

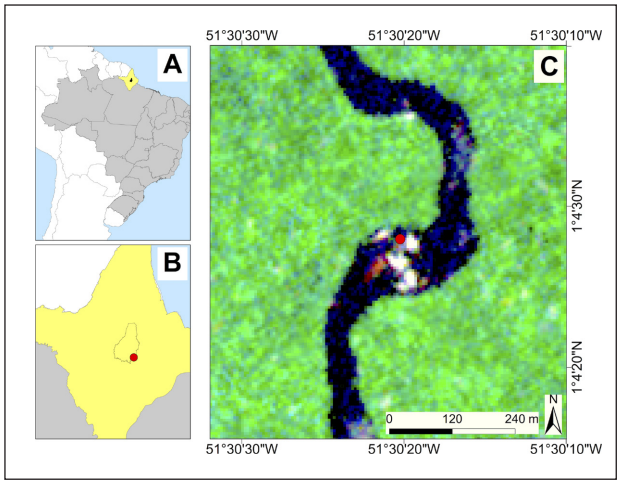

FIGURE 1. Location of the study region in the Floresta Nacional do Amapá (FLONA), Amapá state, eastern Brazilian Amazon. **A.** Amapá State in Brazil; **B.** FLONA (black polygon) in Amapá State; **C.** RapidEye image (Tile ID 2239512, 10 September 2015) showing where *Myrmecophaga tridactyla* (red circle) was observed crossing the Falsino River. Green, blue, and white areas represent forest, open-water, and rocks, respectively.

In this study, we present information on an observation of an adult giant anteater crossing a river, using a combination of swimming and stepping stones in a continuous forest area in northern Amazonia. We also discuss the use of rocks, exposed along waterways during the dry season, in facilitating river crossings.

The study was conducted on the border of the Floresta Nacional do Amapá (FLONA), a sustainable use protected area of approximately 412,000 ha, located in the center of the state of Amapá in north-eastern Brazilian Amazonia (0°55'29"N, 51°35'45"W; **FIG. 1**). FLONA is adjacent to continuous undisturbed forests and maintains the full community of mid-sized and large-bodied vertebrates (Michalski *et al.*, 2015). This protected area experiences low levels of anthropogenic perturbations, in part because only a few families live on the reserve border (Michalski *et al.*, 2012), and the nearest city, Porto Grande, is located 46 km downstream. Within the protected area, the Falsino river is the most undisturbed section of river upstream from Porto Grande, with the lowest number of houses and boats (Oliveira *et al.*, 2015).

We used a motorboat and followed a standardized boat census protocol in order to conduct long-term surveys of mid- to large-bodied vertebrates along waterways within FLONA (Pitman *et al.*, 2011; Laufer *et al.*, 2012; Oliveira *et al.*, 2015). During one of these surveys we observed an adult *M. tridactyla* crossing the Falsino river. The observation of the giant anteater at the Falsino river (1°04'28"N, 51°30'20"W) was recorded by a team of five observers at 10:40 hr on 26 September 2017. The giant anteater crossed the river at one of the widest sections, which differed from neighboring narrower stretches of river by the presence of a number of large and exposed rocks (**FIG. 1C**). The individual was observed climbing out of the water onto a large rock, and making its way across the rock (**FIG. 2A**). The *M. tridactyla* was an adult and clambered out of the water as we approached; it appeared to have already crossed approximately 110 m from the south-east bank to the rock. As we approached it on the rock it returned to the water (**FIG. 2B**), proceeded to swim 56 m across the river to the north-west river bank, calmly rose out of the water, scaled the sloping river bank, and disappeared into the forest (**FIG. 2C–F**). The giant anteater swam strongly, with its head and snout held out of the water (**FIG. 2F**). While the *M. tridactyla* swam well it did not seem to swim easily, perhaps due to the low river level at this time of year and the formation of strong rapids within the river, making it more difficult to cross.

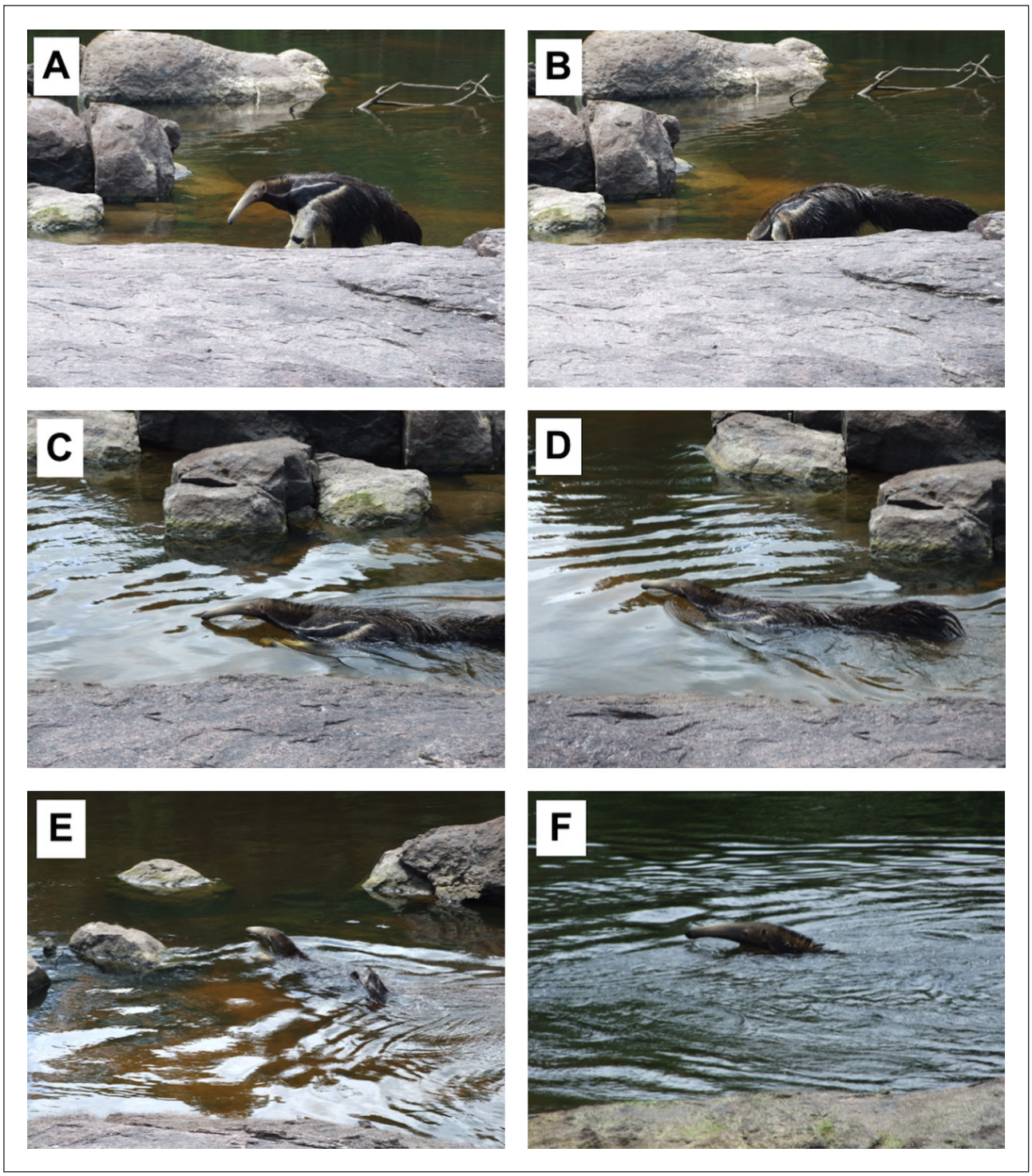

FIGURE 2. A sequence of photos **(A–F)** to show the movement and swimming of the giant anteater (*Myrmecophaga tridactyla*) observed along the Falsino River on the border of FLONA, eastern Brazilian Amazon. It started on the rock after climbing out of the water **(A)** then began to make its way across the rock before turning and retreating into the water to swim across the rest of the river **(F)**.

When it was first spotted the giant anteater was on the rock, perhaps using it as a resting place. It could therefore be suggested that these rocks may facilitate the movement of giant anteaters across the river. This could especially be true for the drier months such as September when the river water levels are particularly low, thus exposing more rock surfaces. On average in September the mean water level is normally about 4.05 m, which is lower than the wet season average of 7.00–8.00 m from February to May (data from 1981–2006; ANA, 2017).

Due to the rarity and low densities of *M. tridactyla* it is difficult to observe the behavior of this

species in the wild, especially in forested habitats. Indeed, the giant anteater was one of the species of mid-sized and large-bodied vertebrates with the lowest number of detections recorded during a camera trap study conducted in the same area (Michalski *et al.,* 2015). Some reports regarding its swimming habits exist (Nowak, 1999; Miranda *et al.,* 2015) although they are scarce and not detailed. This sighting could perhaps open up further research to address questions related to the swimming behavior of the giant anteater, as well as the use of rocks to facilitate river crossings. For example, there are sections of the Falsino river that have less or no exposed rocks. Thus, it is possible that giant anteaters may have some knowledge of the river sections with higher exposure of rocks. A similar proposal was made by Esser *et al.* (2010) based on an observation of swimming by a Northern tamandua (*Tamandua mexicana*). To test this hypothesis parts of the river with and without exposed rocks could be monitored by camera-traps during the dry season.

Giant anteaters may not be the only species to exploit stepping stones in order to cross rivers. One obvious benefit of doing so would be to increase gene flow and reduce population isolation.

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References

ANA – Agência Nacional de Águas. 2017. Sistema de monitoramento hidrológico (Hydrological monitoring system). Agência Nacional de Águas [[nl]] National Water Agency. <http://www.snirh.gov.br/hidroweb/>. Downloaded on 19 October 2017.

Bergallo, H.G. 2000. A fauna ameaçada de extinção do Estado do Rio de Janeiro. Editora da Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil. 166 pp.

Braga, F.G., R.E.F. Santos & A.C. Batista, 2010. Marking behavior of the giant anteater *Myrmecophaga tridactyla* (Mammalia: Myrmecophagidae) in southern Brazil. Zoologia 27: 7–12. http://dx.doi.org/10.1590/S1984-46702010000100002

Cherem, J.J., P.C. Simões-Lopes, S. Althoff & M.E. Graipel. 2004. Lista dos mamíferos do Estado de Santa Catarina, sul do Brasil. Mastozoología Neotropical 11: 151–184.

Chiarello, A.G., L.P. Costa, Y.L.R. Leite, M. Passamani, S. Siciliano & M. Zortéa. 2007. Os mamíferos ameaçados de extinção no Estado do Espírito Santo. Pp. 29–45 in: Espécies da fauna ameaçadas de extinção no Estado do Espírito Santo (M. Passamani & S.L. Mendes, eds.). Instituto de Pesquisas da Mata Atlântica, Vitória, Brazil.

Eisenberg, J.F. & K.H. Redford. 1999. Mammals of the Neotropics, volume 3. The Central Neotropics: Ecuador, Peru, Bolivia, Brazil. The University of Chicago Press, Chicago. 609 pp.

Esser, H., D. Brown & Y. Liefting. 2010. Swimming in the northern tamandua (*Tamandua mexicana*) in Panama. Edentata 11: 70–72. https://doi.org/10.1896/020.011.0112

Fontana, C.S., G.A. Bencke & R.E. Reis. 2003. Livro Vermelho da fauna ameaçada de extinção no Rio Grande do Sul. EDIPUCRS, Porto Alegre, Brazil. 632 pp.

Laufer, J., J.A. Amador, P.C. Conceição, D. Norris & F. Michalski. 2012. Use of boat surveys to provide complementary data on the ecology of *Bradypus tridactylus* (Pilosa: Bradypodidae) from northern Amazonia. Edentata 13: 56–60. https://doi.org/10.5537/020.013.0115

Michalski, F., P.C. Conceição, J.A. Amador, J. Laufer & D. Norris. 2012. Local perceptions and implications for giant otter (*Pteronura brasiliensis*) conservation around protected areas in the eastern Brazilian Amazon. IUCN Otter Specialist Group Bulletin 29: 34–45.

Michalski, L.J., D. Norris, T.G. Oliveira & F. Michalski. 2015. Ecological relationships of meso-scale distribution in 25 Neotropical vertebrate species. PLOS ONE 10: e0126114. https://doi.org/10.1371/journal.pone.0126114

Mikich, S.B. & R.S. Bernils. 2004. Livro Vermelho da fauna ameaçada no Estado do Paraná. Instituto Ambiental do Paraná, Curitiba, Brazil. 763 pp.

Miranda, F., A. Bertassoni & A.M. Abba. 2014. *Myrmecophaga tridactyla*. The IUCN Red List of Threatened Species 2014: e.T14224A47441961. <http://dx.doi.

org/10.2305/IUCN.UK.2014-1.RLTS.T14224A47441961.en>. Downloaded on 15 October 2017.

Miranda, F.R. *et al.* 2015. Avaliação do risco de extinção de *Myrmecophaga tridactyla* Linnaeus, 1758 no Brasil. Processo de avaliação do risco de extinção da fauna brasileira. ICMBio. <http://www.icmbio.gov.br/portal/biodiversidade/fauna-brasileira/lista-de-especies/7049-mamiferos-myrmecophaga-tridactyla-tamandua-bandeira.html> Downloaded on 18 October 2017.

MMA – Ministério do Meio Ambiente do Brasil. 2008. Livro Vermelho da fauna brasileira ameaçada de extinção. 2 Volumes. Fundação Biodiversitas, Belo Horizonte. 1420 pp.

Mourão, G. & I.M. Medri. 2007. Activity of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) in the Pantanal of Brazil. Journal of Zoology 271: 187–192. http://dx.doi.org/10.1111/j.1469-7998.2006.00198.x

Nowak, R.M. 1999. Walker's mammals of the world. The Johns Hopkins University Press, Baltimore and London. 1921 pp.

Oliveira, I.A.P., D. Norris & F. Michalski. 2015. Anthropogenic and seasonal determinants of giant otter sightings along waterways in the northern Brazilian Amazon. Mammalian Biology 80: 39–46. https://doi.org/10.1016/j.mambio.2014.07.006

Pitman, N.C.A. *et al.* 2011. Four years of vertebrate monitoring on an upper Amazonian river. Biodiversity and Conservation 20: 827–849. https://doi.org/10.1007/s10531-010-9982-y

Shaw, J.H., T.S. Carter & J. Machado-Neto. 1985. Ecology of the giant anteater *Myrmecophaga tridactyla* in Serra da Canastra, Minas Gerais, Brazil: a pilot study. Pp. 379–384 in: The evolution and ecology of armadillos, sloths, and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington and London.

Wilson, D.E. & D.M. Reeder. 2005. Mammal species of the world: a taxonomic and geographic reference. The Johns Hopkins University Press, Baltimore. 2142 pp.

Young, R.J., C.M. Coelho & D.R.A. Wieloch. 2003. A note on the climbing abilities of giant anteaters, *Myrmecophaga tridactyla* (Xenarthra, Myrmecophagidae). Boletim do Museu de Biologia Mello Leitão, Nova Série 15: 41–46.

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IUCN/SSC Anteater, Sloth & Armadillo Specialist Group

SHORT COMMUNICATION

First reports of giant anteater (*Myrmecophaga tridactyla*) and greater naked-tailed armadillo (*Cabassous tatouay*) for the Iguaçu National Park, Paraná, Brazil, with notes on all xenarthran occurrences

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Abstract Four Xenarthra species appear on the list of mammals whose presence has been documented in the Iguaçu National Park (INP). We conducted the first long-term camera trap monitoring in the Iguaçu region, encompassing the park and its buffer zone. We confirmed the presence of the four Xenarthra species known to occur in the park, with the first photographic records of giant anteaters (*Myrmecophaga tridactyla*). We also detected the presence of the greater naked-tailed armadillo (*Cabassous tatouay*), which had not previously been reported for the park. Giant anteater sightings are described, and habits are discussed. Our data provide important additions to the existing knowledge on giant anteaters inhabiting INP, a key wildlife refuge in southern Brazil.

Keywords: armadillos, Atlantic forest, distribution, habitat preferences, photographic records

Primeiros registros documentados de *Myrmecophaga tridactyla* e *Cabassous tatouay* e notas sobre a ocorrência de xenartros do Parque Nacional do Iguaçu, Paraná, Brasil

Resumo Quatro espécies de xenartros constam na lista oficial de mamíferos cuja presença foi documentada no Parque Nacional do Iguaçu (PNI). Realizamos o primeiro monitoramento por armadilhas fotográficas de longo prazo na região Iguaçu, abrangendo o parque e sua zona de amortecimento. Confirmamos a presença das quatro espécies de xenartros que ocorrem no parque, com os primeiros registros fotográficos de tamanduá-bandeira (*Myrmecophaga tridactyla*). Detectamos também a presença do tatu-de-rabo-mole grande (*Cabassous tatouay*), que não constava na lista do parque. Os registros obtidos de tamanduá-bandeira são descritos e hábitos são discutidos. Nossos dados fornecem complementos importantes ao conhecimento existente sobre o tamanduá-bandeira ocorrendo no PNI, um importante refúgio silvestre do sudoeste do Brasil.

***Palavras-chave*:** distribuição, mata Atlântica, preferências de hábitat, registros fotográficos, tatus

The official list of non-flying mammal species for the Iguaçu National Park (INP) in southwestern Brazil includes 48 species, of which four are xenarthrans: the yellow armadillo (*Euphractus sexcinctus*), the nine-banded armadillo (*Dasypus novemcinctus*), the lesser anteater (*Tamandua tetradactyla*), and the giant anteater (*Myrmecophaga tridactyla*; Medri & Mourão, 2008). Species presence was confirmed by sightings, road kills, or through trichology (*i.e.*, big cats' scat content analysis; MMA, 1999). Regarding the latter, in the absence of other forms of evidence, microscopic hair analysis has been used as an identification technique, but its reliability has been questioned many times. Nowadays, microscopic

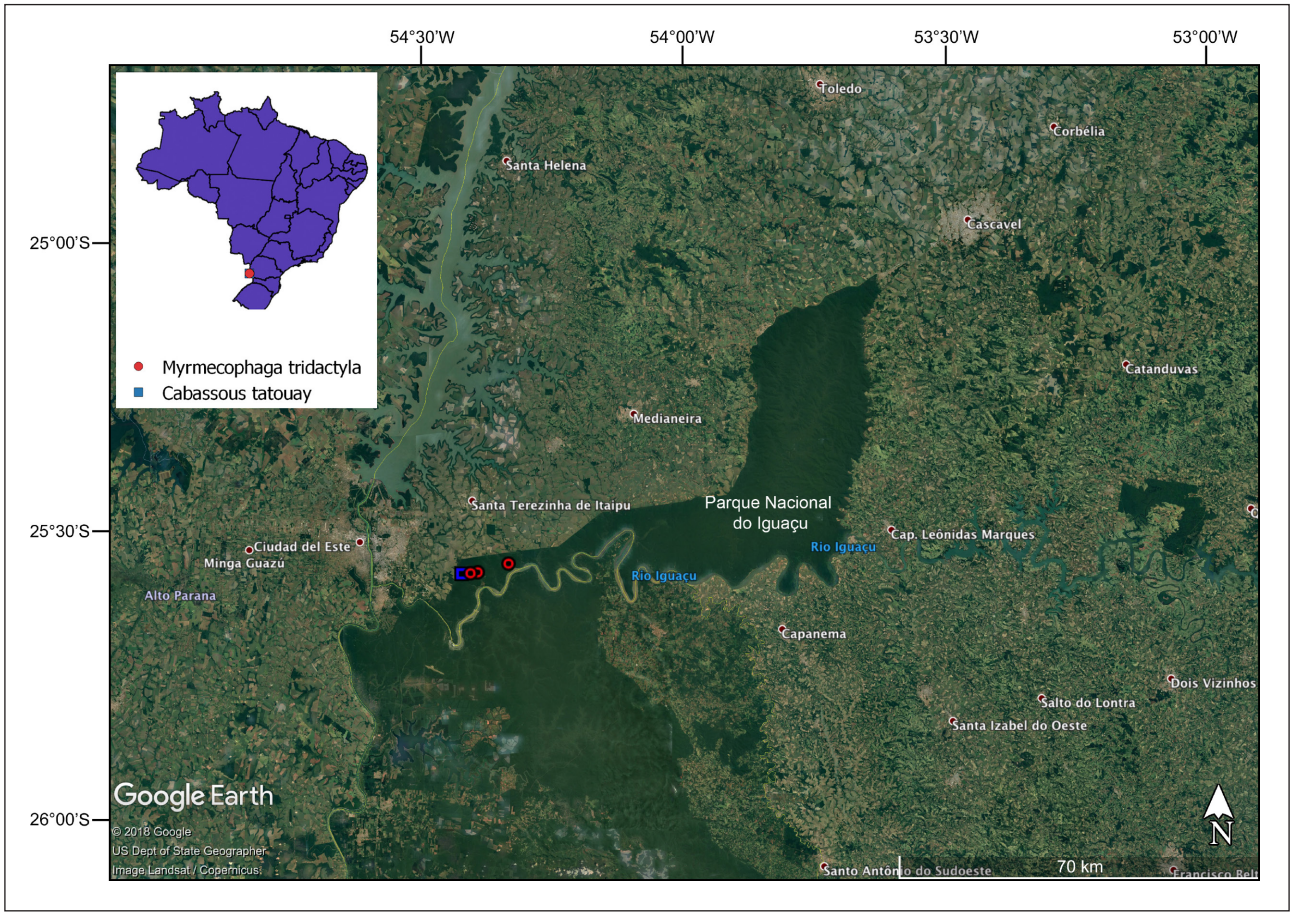

FIGURE 1. Locations of confirmed occurrence for two Xenarthra species, *Cabassous tatouay* (N=1, blue) and *Myrmecophaga tridactyla* (N=3, red), at Iguaçu National Park, Paraná, Brazil.

hair identification is not considered definitive when compared to DNA or photographic evidence (Foran *et al.*, 1997; Farrel *et al.*, 2000; Sahajpal *et al.*, 2009). Of course, DNA can be extracted from hair material and would help tremendously to turn a microscopic identification into conclusive evidence (Bertrand *et al.*, 2006).

All of the xenarthrans at INP, except the giant anteater, are listed as Least Concern in the IUCN Red List of Threatened Species (IUCN, 2017). However, much remains unknown regarding species dynamics, ecology, distribution, and trends (Abba *et al.*, 2014; Anacleto *et al.*, 2014; Loughry *et al.*, 2014; Miranda *et al.*, 2014a). The giant anteater is listed as Vulnerable based on local extinctions, road kills (Cáceres *et al.*, 2010), and habitat loss due to fire (Prada & Marinho-Filho, 2004) and human-oriented soil use (Miranda *et al.*, 2014b). In fact, it is listed in a threatened category everywhere it is known to occur (Miranda *et al.*, 2014b).

This short communication presents findings on xenarthrans extracted from a broader mammal inventory conducted in the INP region between September 2012 and October 2014. We used camera-traps to record over 30 different non-flying species of mammals. Here we provide the first photographic evidence confirming the presence of the giant anteater in INP, and also report the first record of the greater naked-tailed armadillo (*Cabassous tatouay*), which was not previously listed for the park. Finally, we discuss our findings on *M. tridactyla* and *C. tatouay*, provide brief notes on other recorded xenarthran species, and mention some important conservation issues.

Sixteen motion-triggered cameras were used to conduct a broad mammal survey in the region of the INP. We randomly placed the cameras within the INP as well as in its 5-km surrounding buffer zone. At each sampling station, we recorded latitude and longitude coordinates, as well as habitat type, microhabitat, canopy closure, and soil type. Habitat type and microhabitat were identified *in loco*, canopy closure was calculated using a quadrant, and soil type was identified using existing classification map (Ricobom & Skiba, 2001). Rapidfire PC900™ cameras (Reconyx, Holmen, WI, USA) automatically recorded air temperature, date, and time while taking 15 pictures in near-video sequences. Cameras were set in bursting mode, taking one photograph per second until the animal left the detection zone.

Sampling effort consisted of 6,190 sampling days in 193 different locations, covering 80 km² of the westernmost section of the INP (N=84 sampling stations) and its buffer zone (N=109), from São Miguel do Iguaçu to Foz do Iguaçu (**Fig. 1**). This is the first long-term monitoring in the region, covering 755 consecutive days, and totaling 247,693 photographic records. Each sampling location was monitored for 33 days on average. Three of our 16 cameras were stolen, and possibly destroyed, by fishermen and poachers, who represent one of the main pressures on giant anteater populations (Miranda *et al.*, 2014b; Quiroga *et al.*, 2016).

Of 7,681 individual animal records, 540 (7.0%) were of xenarthrans, accounting for 6.3% of INP records (N=216) and 14.9% in the buffer zone (N=324). With 97.4% of all xenarthran records (N=526), the nine-banded armadillo was the species most commonly observed; it was found equally often inside and outside the INP (Bertrand, 2016). In order to fully characterize the habitat gradient offered by the Iguaçu region, we installed our cameras in the widest variety of natural habitats. Thus, the predominance of the nine-banded armadillo is likely due to the fact that it is the most common armadillo species locally, rather than an artifact of a selective sampling procedure. The lesser anteater (1.1%, N=6) was found more times in unprotected forest remnants than inside the INP (Bertrand, 2016). Our remaining records consisted of four yellow armadillos, three giant anteaters (0.56%; **Fig. 2**), and one greater naked-tailed armadillo (**Fig. 3**). These last two species were solely found within the INP boundaries, whereas the yellow armadillo was only found in the forest thickets of the park buffer zone, suggesting that habitat differences may dictate species distribution, which in turn may reflect sensitivity to habitat alterations (Abba & Superina, 2010). **Table 1** presents a detailed description, including date, time, weather, soil type, and habitat features, of the records obtained for giant and lesser anteaters, yellow armadillos, and the greater naked-tailed armadillo. The time of day when the three giant anteater photographs were taken is consistent with the timing of activity cycles reported by Shaw *et al.* (1987).

Confusion over the taxonomic identification of the greater naked-tailed armadillo has made its conservation status and distribution uncertain (González & Abba, 2014). Currently, this species is listed as Least Concern by the IUCN, primarily because it is thought to have a wide distribution and to be relatively tolerant of habitat modification, being found in agricultural lands and secondary forests. In this study, the animal we observed was found on the edge of an illegal salt lick within the park boundary, where human-related pressures abound. Nationally, *C. tatouay* is known to occur in the southern and eastern portions of Brazil (Abba & Superina, 2010), which includes our study site. As we only collected one record, our intention here is merely to report the presence of the species in one of the most important conservation areas in southwestern Brazil, rather than extrapolate about its potential habitat preferences or distribution. Nonetheless, habitat information is provided for this record in **Table 1**.

Scientists have shown considerable interest in charismatic giant anteaters; hence, there are more data available on this species as compared with many other xenarthrans (Miranda *et al.*, 2014a). They appear to select different habitat types according to temperature; such thermoregulatory sensitivity may be linked with the fact that they feed exclusively on low-caloric foods (*i.e.*, ants and termites; McNab, 2000). During colder days, giant anteaters can be seen sun bathing in open areas, whereas they rest in forest shade on hotter days (Medri, 2002; Sampaio *et al.*, 2006). They also have

Figure 2. Near-sequence video of one of the three photographic records of a giant anteater (*Myrmecophaga tridactyla*) in the Iguaçu National Park, Paraná, Brazil, on 31 March 2014.

been observed bathing in ponds in order to regulate their body temperature (and/or avoid bothersome flies) on hot days in Bolivia (Emmons *et al.*, 2004). In one of our three photographic records, the animal was indeed on the edge of a river within the INP early at night on a hot day (**Table 1**). While this corroborates what Sampaio *et al.* (2006) found based on the monitoring of 11 individuals in the Brazilian Pantanal, the bathing habits of giant anteaters still puzzle ecologists. For example, Emmons *et al.* (2004) reported individuals also bathing in the middle of cool nights, and during the dry season, a time when they are unlikely to be bothered by flies. Unfortunately, our data do not allow any insights on the matter.

In Venezuela and Argentina, giant anteaters were exclusively nocturnal during the hot season (Shaw *et al.*, 1987; Di Blanco *et al.*, 2015). In the Brazilian Cerrado, all xenarthrans except the yellow armadillo usually display nocturnal habits (Zimbres *et al.*, 2013). While nearly all of our records of xenarthrans were indeed made between 19:00 hr and 03:00 hr, two of the three giant anteater records occurred during the day (**Table 1**). Diurnal activity has been reported by others (Shaw *et al.*, 1987; Sampaio *et al.*, 2006), with activity occurring during the day when temperatures are mild, and later in the evening on hotter days.

Habitat preferences remain unclear as giant anteaters use open and forested lands in unknown proportions (*e.g.*, Medri & Mourão, 2005). Sampaio *et al.* (2006) demonstrated that, while active, habitat choice by giant anteaters is mainly related to food/prey availability. In a study conducted in Serra da Canastra in the Brazilian Cerrado (Minas Gerais; Shaw *et al.*, 1987), individuals preferred scrublands over other habitat types. However, some individuals had none of this common habitat type in their home range. Giant anteaters also favored riparian forests, which may be rich in termites and ants (Reis & Cancello, 2007; Brown *et al.*, 2009). In our study, all three records were in forest and riparian habitats (**Table 1**).

The limits of giant anteaters' distribution range in South America are also periodically altered by

Figure 3. Photographic record of a greater naked-tailed armadillo (*Cabassous tatouay*) on 3 May 2014 in the Iguaçu National Park, Paraná, Brazil.

TABLE 1. Detailed description of the photographic records of Xenarthra species obtained at Iguaçu National Park and its surrounding buffer zone, with the exception of nine-banded armadillos. **C.T.:** *Cabassous tatouay*; **E.S.:** *Euphractus sexcinctus*; **M.T.:** *Myrmecophaga tridactyla*; **T.T.:** *Tamandua tetradactyla*; **R.H:** relative humidity; soil types: **NVEF2:** rhodic paleudalf; **LVEF1:** typic haplorthox; **GX1:** epiaquic haplustult; **LOC:** location; **P:** park; **B:** buffer zone.

Species	Coordinates	Date	Time	Habitat	Microhabitat	Canopy (%)	Soil type	Precipitation (mm)	Temperature (°C)	R.H.	Loc
C.t.	25°34'11"S, 54°25'11"W	03/05/2014	02:08	Subtropical rainforest	Alluvial	80	NVef2	0.0	26.3	74.6	P
M.t.	25°33'08"S, 54°19'49"W	04/06/2013	16:22	Subtropical rainforest	Palm trees	80	NVef2	0.0	17.4	90.5	P
M.t.	25°34'02"S, 54°23'21"W	31/03/2014	18:50	Tropical rainforest	Riparian	95	LVef1	29.6	23.8	87.6	P
M.t.	25°34'08"S, 54°24'10"W	24/04/2014	11:20	Tropical rainforest	Palm trees	90	LVef1	0.0	19.5	85.0	P
T.t.	25°37'09"S, 54°29'18"W	07/06/2013	05:56	Subtropical rainforest	Alluvial	90	NVef2	0.0	18.3	91.8	B
T.t.	25°31'35"S, 54°20'05"W	03/07/2013	1:29	Subtropical rainforest	Alluvial	95	GX1	0.0	18.6	82.8	B
T.t.	25°29'25"S, 54°21'26"W	01/11/2013	0:44	Subtropical rainforest	Bamboo	100	NVef2	0.0	26.9	64.9	B
T.t.	25°37'07"S, 54°29'24"W	24/01/2014	0:31	Subtropical rainforest	Riparian	90	NVef2	0.0	29.4	70.4	B
T.t.	25°35'07"S, 54°25'05"W	10/06/2014	2:58	Tropical rainforest	Palm trees	85	LVef1	0.0	17.7	89.0	P
T.t.	25°38'00"S, 54°26'41"W	03/09/2014	23:23	Tropical rainforest	Alluvial	100	LVef1	0.0	25.4	71.9	P
E.s.	25°31'32"S, 54°20'01"W	08/06/2013	22:29	Subtropical rainforest	Alluvial	95	GX1	0.0	18.7	82.9	B
E.s.	25°31'32"S, 54°20'01"W	29/06/2013	1:41	Subtropical rainforest	Alluvial	95	GX1	8.2	21.0	91.2	B
E.s.	25°29'24"S, 54°21'20"W	05/12/2013	0:14	Subtropical rainforest	*Dicksonia* ferns	95	NVef2	23.0	18.2	78.1	B
E.s.	25°33'25"S, 54°24'46"W	09/04/2014	2:05	Subtropical rainforest	Alluvial	70	NVef2	65.4	23.5	91.2	B

sporadic sightings or roadkills. In Honduras, the species was thought to be extirpated in the 1990s but few sightings have recently been reported (McCain, 2001; Reyes *et al.*, 2010). One sighting was also reported in Costa Rica in 1989 (Timm *et al.*, 1989), and another individual was killed by a hunter in Nicaragua (Koster, 2008), all suggesting extension or maintenance of their current distribution.

Much still needs to be understood about the behavior of giant anteaters but recent studies indicate that this species can show a high capacity to respond to habitat disturbance. In the Brazilian state of Paraná they are able to inhabit pine plantations, where they feed on leaf-cutter ants (Braga *et al.*, 2014). In the Cerrado, they have shown resilience to human-caused habitat alterations, such as fire and habitat loss (Shaw *et al.*, 1987), and remained present even when most natural habitat had been converted to soy crops (Klink & Moreira, 2002). Additionally, a high survival rate was observed during a reintroduction project in the Iberá Nature Reserve, Corrientes province, Argentina. Between 2007 and 2013, 31 giant anteaters were released and 18 were radiotracked, providing information on habitat selection and indicating factors that could hamper long-term survival (Di Blanco *et al.*, 2015). The animals preferred forest habitats where they almost exclusively rested. Deforestation and cattle management seemed to be the main threats to their survival. Only time will tell whether human-caused landscape transformation indeed negatively impacts giant anteaters (Superina *et al.*, 2010). Regardless, the species has proved able to cope in unexpected ways with human-imposed pressures and contexts (Young *et al.*, 2003; Braga *et al.*, 2014).

Our photographic confirmation of giant anteaters in the INP is an important addition to the existing knowledge on the species. The INP is the only wildlife refuge in the entire region and is therefore of invaluable worth in terms of biodiversity and conservation (Tabarelli *et al.*, 2005). Considering the conservation significance of the species and the lack of information about it in such an important part of its range, more research would help in piecing together recent occurrence reports and behavioral descriptions from different locations in South and Central America (Koster, 2008; Pérez Jimeno & Amaya, 2009; Hack & Krüger, 2013; Braga *et al.*, 2014). Consequently, the most important goal of this paper is to inform the scientific community

about the presence of both the giant anteater and the greater naked-tailed armadillo in this part of their range, and thus serve as an invitation for further research.

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References

Abba, A.M. & M. Superina. 2010. The 2009–2010 armadillo Red List assessment. Edentata 11: 135–184. https://doi.org/10.5537/020.011.0203

Abba, A.M., E. Lima & M. Superina. 2014. *Euphractus sexcinctus*. The IUCN Red List of Threatened Species 2014: e.T8306A47441708. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T8306A47441708.en>. Downloaded on 17 April 2015.

Anacleto, T.C.S., P. Smith, A.M. Abba & M. Superina. 2014. *Dasypus septemcinctus*. The IUCN Red List of Threatened Species 2014: e.T6293A47441509. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T6293A47441509.en>. Downloaded on 17 April 2015.

Bertrand, A.-S. 2016. Characterization and conservation of the Iguaçu National Park, Paraná, Brazil. PhD Thesis, University of Aveiro, Aveiro. 167 pp.

Bertrand, A.-S., S. Kenn, D. Gallant, E. Tremblay, L. Vasseur & R. Wissink. 2006. MtDNA analyses on hair samples confirm cougar, *Puma concolor*, presence in Southern New Brunswick, Eastern Canada. Canadian Field Naturalist 120: 438–442. http://dx.doi.org/10.22621/cfn.v120i4.352

Braga, F.G., N.J. Souza, A.C. Batista & P.P.S. de Lima. 2014. Consumo de formigas cortadeiras por tamanduá-bandeira *Myrmecophaga tridactyla* (Linnaeus, 1758) em plantios de *Pinus* spp. no Paraná, Brasil. Edentata 15: 1–8. https://doi.org/10.5537/020.015.0101

Brown, G.G., W. Maschio & L.C.M. Froufe. 2009. Macrofauna do solo em sistemas agroflorestais e Mata Atlântica em regeneração nos municípios de Barra do Turvo, SP, e Adrianópolis, PR. Embrapa Florestas, Colombo. 51 pp.

Cáceres, N.C., W. Hannibal, D.R. Freitas, E.L. Silva, C. Roman & J. Casella. 2010. Mammal occurrence and roadkill in two adjacent ecoregions (Atlantic Forest and Cerrado) in southwestern Brazil. Zoologia 27: 709–717. http://dx.doi.org/10.1590/S1984-46702010000500007

Di Blanco, Y.E., I.J. Pérez & M.S. Di Bitetti. 2015. Habitat selection in reintroduced giant anteaters: the critical role of conservation areas. Journal of Mammalogy 96: 1024–1035. https://doi.org/10.1093/jmammal/gyv107

Emmons, L.H., R.P. Flores, S.A. Alpirre & M.J. Swarner. 2004. Bathing behavior of giant anteaters (*Myrmecophaga tridactyla*). Edentata 6: 41–43. https://doi.org/10.1896/1413-4411.6.1.41

Farrel, L.E., J. Roman & M.E. Sunquist. 2000. Dietary separation of sympatric carnivores identified by molecular analysis of scats. Molecular Ecology 9: 1583–1590. http://dx.doi.org/10.1046/j.1365-294x.2000.01037.x

Foran, D.R., S.C. Minta & K.S. Heinemeyer. 1997. DNA-based analysis of hair to identify species and individuals for population research and monitoring. Wildlife Society Bulletin 25: 840–847.

González, E. & A.M. Abba. 2014. *Cabassous tatouay*. The IUCN Red List of Threatened Species 2014: e.T3414A47437737. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T3414A47437737.en>. Downloaded on 17 April 2015.

Hack, R.O.E. & F.A. Krüger. 2013. Novos registros de *Myrmecophaga tridactyla* (Mammalia: Xenarthra) no estado do Paraná, Brasil. Edentata 14: 70–73. https://doi.org/10.5537/020.014.0109

IUCN, 2017. The IUCN Red List of Threatened Species. Version 2017-3. <http://www.iucnredlist.org>. Downloaded on 5 December 2017.

Klink, C.A. & A.G. Moreira. 2002. Past and current human occupation and land use. Pp. 69–90 in: The Cerrados of Brazil: ecology and natural history of a Neotropical savanna (P.S. Oliveira & R.J. Marquis, eds.). Columbia University Press, New York. http://dx.doi.org/10.7312/oliv12042

Koster, J.M. 2008. Giant anteaters (*Myrmecophaga tridactyla*) killed by hunters with dogs in the Bosawas biosphere reserve, Nicaragua. The Southwestern Naturalist 53: 414–416. https://doi.org/10.1894/PS-38.1

Loughry, W.J., C.M. McDonough & A.M. Abba. 2014. *Dasypus novemcinctus*. The IUCN Red List of Threatened Species 2014: e.T6290A47440785. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T6290A47440785.en>. Downloaded on 17 April 2015.

McCain, C.M. 2001. First evidence of the giant anteater (*Myrmecophaga tridactyla*) in Honduras. Southwestern Naturalist 46: 252–254. http://dx.doi.org/10.2307/3672542

McNab, B.K. 2000. Metabolic scaling: energy constraints on carnivore diet. Nature 407: 584. http://dx.doi.org/10.1038/35036695

Medri, I.M. 2002. Área de vida e uso de hábitat de tamanduá-bandeira – *Myrmecophaga tridactyla* Linnaeus, 1758 – nas Fazendas Nhumirim e Porto Alegre, Pantanal da Nhecolândia, MS. MSc thesis, Universidade Federal de Mato Grosso do Sul, Campo Grande.

Medri, I.M. & G. Mourão. 2005. Home range of giant anteaters (*Myrmecophaga tridactyla*) in the Pantanal wetland, Brazil. Journal of Zoology 266: 365–375. http://dx.doi.org/10.1017/S0952836905007004

Medri, I.M. & G. Mourão. 2008. *Myrmecophaga tridactyla* Linnaeus, 1758. Pp. 711–713 in: Livro Vermelho da fauna brasileira ameaçada de extinção. Vol. II

(A.B.M. Machado, G.M. Drummond & A.P. Paglia, eds.). Ministério do Meio Ambiente, Brasília. 1420 pp.

Miranda, F., A. Fallabrino, M.C. Arteaga, D.G. Tirira, D.A. Meritt & M. Superina. 2014a. *Tamandua tetradactyla*. The IUCN Red List of Threatened Species 2014: e.T21350A47442916. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T21350A47442916.en>. Downloaded on 17 April 2015.

Miranda, F., A. Bertassoni & A.M. Abba. 2014b. *Myrmecophaga tridactyla*. The IUCN Red List of Threatened Species 2014: e.T14224A47441961. <http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T14224A47441961.en>. Downloaded on 17 April 2015.

MMA – Ministério do Meio Ambiente do Brasil. 1999. Plano de Manejo. Parque Nacional do Iguaçu. <http://www.cataratasdoiguacu.com.br/parque-nacional-do-iguacu/plano-de-manejo>. Downloaded on 15 September 2016.

Pérez Jimeno, G. & L.L. Amaya. 2009. Contribución al conocimiento de la distribución del oso hormiguero gigante (*Myrmecophaga tridactyla*) en Argentina. Edentata 8–10: 8–12. https://doi.org/10.1896/020.010.0106

Prada, M. & J. Marinho-Filho. 2004. Effects of fire on the abundance of Xenarthrans in Mato Grosso, Brazil. Austral Ecology 29: 568–573. http://dx.doi.org/10.1111/j.1442-9993.2004.01391.x

Quiroga, V.A., A.J. Noss, G.I. Boaglio & M.S. Di Bitetti. 2016. Local and continental determinants of giant anteater (*Myrmecophaga tridactyla*) abundance: biome, human and jaguar roles in population regulation. Mammalian Biology 81: 274–280. http://dx.doi.org/10.1016/j.mambio.2016.03.002

Reis, Y.T. & E.M. Cancello. 2007. Riqueza de cupins (Insecta, Isoptera) em áreas de Mata Atlântica primária e secundária do sudeste da Bahia. Iheringia 97: 229–234. http://dx.doi.org/10.1590/S0073-47212007000300001

Reyes, H.O.P., W.A. Matamoros & S.L. Glowinski. Distribution and conservation status of the giant anteater (*Myrmecophaga tridactyla*) in Honduras. The Southwestern Naturalist 55: 119–121. https://doi.org/10.1894/CLG-25.1

Ricobom, A.E. & M.M. Skiba. 2001. Mapa das classes de solos do Parque Nacional do Iguaçu e entorno. P. 130 in: O parque do Iguaçu como unidade de conservação da natureza no âmbito do Mercosul: os problemas decorrentes da degradação ambiental (A.E. Ricobom, ed.). MSc thesis, Federal University of Paraná, Curitiba. 226 pp.

Sahajpal, V., S.P. Goyal, K. Singh & V. Thakur. 2009. Dealing wildlife offences in India: role of the hair as physical evidence. International Journal of Trichology 1: 18–26. http://dx.doi.org/10.4103/0974-7753.51928

Sampaio, C.C., P. Camilo-Alves & G.M. Mourão. 2006. Responses of a specialized insectivorous mammal (*Myrmecophaga tridactyla*) to variation in ambient temperature. Biotropica 38: 52–56. http://dx.doi.org/10.1111/j.1744-7429.2006.00106.x

Shaw, J.H., J. Machado-Neto & T.C. Carter. 1987. Behavior of free-living giant anteaters (*Myrmecophaga tridactyla*). Biotropica 19: 255–259. http://dx.doi.org/10.2307/2388344

Superina, M., F.R. Miranda & A.M. Abba. 2010. The 2010 anteater Red List assessment. Edentata 11: 96–114. https://doi.org/10.5537/020.011.0201

Tabarelli, M., L.P. Pinto, J.M.C. Silva, M.M. Hirota & L.C. Bedê. 2005. Desafios e oportunidades para a conservação da biodiversidade na Mata Atlântica brasileira. Megadiversidade 1: 132–138.

Timm, R.M., D.E. Wilson, B.L. Clauson, R.K. La Val & C.S. Vaughan. 1989. Mammals of the La Selva-Braulio Carrillo complex, Costa Rica. North American Fauna 75: 1–62. https://doi.org/10.3996/nafa.75.0001

Young, R.J., C.M. Coelho & D.R. Wieloch. 2003. A note on the climbing abilities of giant anteaters, *Myrmecophaga tridactyla* (Xenarthra, Myrmecophaga). Boletim do Museo de Biologia Mello Leitão 15: 41–43.

Zimbres, B. *et al.* 2013. The impact of habitat fragmentation on the ecology of xenarthrans (Mammalia) in the Brazilian Cerrado. Landscape Ecology 28: 259–269. http://dx.doi.org/10.1007/s10980-012-9832-2

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SHORT COMMUNICATION

Agonistic interactions in the brown-throated three-toed sloth, *Bradypus variegatus* (Pilosa: Bradypodidae), in an urban environment in Rio Tinto, Paraíba, Brazil

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Abstract We report agonistic interactions in a group of 17 brown-throated three-toed sloths inhabiting an urban environment aiming to understand the factors involved. Most of the interactions were observed between adult males (86%), reflecting the greater number of males, and included an event in which two males started the interaction while one of them was copulating. Agonistic interactions between adult females involved a mother that supposedly abandoned its young to participate in the interaction. Agonistic interactions between males could be due to competition for females whereas the female interactions appear to be related to competition for space.

Keywords: competition, food resource, offspring, reproduction

Interações agonísticas em preguiça de três dedos, *Bradypus variegatus* (Pilosa: Bradypodidae), em ambiente urbano em Rio Tinto, Paraíba, Brasil

Resumo Relatamos aqui as interações agonísticas observadas num grupo de 17 preguiças-comuns habitantes de uma área urbana, visando entender os possíveis fatores envolvidos. A maioria das interações agonísticas foram registradas entre machos adultos (86%), refletindo o maior número de machos, e incluído um evento no qual um dos machos encontrava-se em atividade de cópula. As interações agonísticas entre fêmeas adultas envolveram uma preguiça que supostamente abandonou o seu filhote para participar da interação. As interações agonísticas entre machos poderiam ocorrer devido à competição por fêmeas, enquanto que as interações entre fêmeas parecem estar relacionadas à competição por espaço.

***Palavras-chave*:** competição, prole, recurso alimentar, reprodução

The brown-throated three-toed sloth *Bradypus variegatus*, Schinz, 1985 is an arboreal mammal with a solitary social structure (Eisenberg, 1981). The interactions between individuals of this species occur generally during mating and parental care periods (Carvalho, 1960; Montgomery & Sunquist, 1974; Soares & Carneiro, 2002; Bezerra *et al.*, 2008; Pinheiro, 2008). The interactions between sloths are more frequent in places with higher densities of individuals (Lara-Ruiz & Srbek-Araujo, 2006; Silva *et al.*, 2013).

While agonistic interactions have been previously documented in brown-throated three-toed

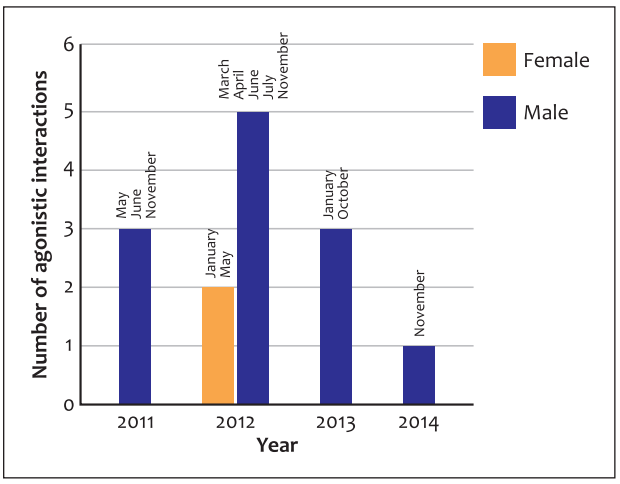

FIGURE 1. Annual records of the agonistic interactions in the brown-throated sloth in João Pessoa square, Rio Tinto, Paraíba.

sloths, the motivational basis for such interactions remains poorly understood (Beebe, 1926; Ballesteros *et al.*, 2009; Greene, 1989). Beebe (1926) reported agonistic interactions in the genus *Bradypus* living in semi-captivity and considered such interactions as casual events. On the other hand, Greene (1989) described agonistic interactions between two males of brown-throated three-toed sloths in La Selva Biological Station, in Costa Rica, suggesting that such behavior is related to competition for females, food or some other resource. Ballesteros *et al.* (2009) studied males in Viento Solar Natural Reserve in Colombia and associated agonistic interactions between them with territorial defense.

This study aimed to understand the factors involved with agonistic interactions between brown-throated three-toed sloths in an urban environment. We observed agonistic interactions between sloths in João Pessoa Square, in the city of Rio Tinto, on the northern coast of Paraíba, Brazil (6°48'30.29"S, 35°4'38.87"W). João Pessoa square has streets, a church, bars, restaurants, and houses, and is the main place for festivals and celebrations. In this place, 17 sloths (14 males and three females) inhabit a group of eight fig trees (Moraceae: *Ficus microcarpa* Linnaeus 1781) with connecting canopies, occupying an area of 0.26 ha surrounded by an urbanized landscape (Pedrosa & Castro, 2014).

The observations for recording agonistic interactions covered the period from April 2011 to December 2014. These observations were conducted in the morning (from 8:00 hr to 12:00 hr) and afternoon (from 13:00 hr to 17:00 hr) and also occurred occasionally outside these times. The agonistic interactions were recorded by the method of observation "All Occurrences" (Altmann, 1974). This method consists in recording the behaviors at the moment they occur, identifying the individuals involved and the postures adopted during the interactions. These interactions were more common between males compared to females, reflecting the greater number of males occupying the fig trees (**FIG. 1**).

In the period from April 2011 to December 2012, 672 hours of sampling effort were carried out. During this period, we recorded 10 episodes (three in 2011 and seven in 2012) of agonistic interactions. Two episodes were registered between adult females (20%) and eight between adult males (80%). The episodes of agonistic interactions between females occurred in the months of January and May 2012. Those between males occurred in the months of May, June, and November 2011, as well as March, April, June, July, and November 2012. In a second observation period (from May 2013 to December 2014), 640 hours of sampling effort were carried out. We recorded four episodes of agonistic interactions (three in 2013 and one in 2014), all of them between adult males, in January (1 episode) and October (2 episodes) 2013, and in November 2014 (**FIG. 1**).

In all recordings of agonistic interactions, claws were used to assault the individual and, in some cases, vocalizations were emitted by the individual that was being assaulted. Two sloths showed their claws when they were close to each other preceding physical contact, which involved slaps and tugs, using the forelimb claws on the body or limbs of the other individual, causing loss of balance and often resulting in its fall (**FIG. 2–3**).

The vocalizations during agonistic interactions are high-pitched with very short duration between one and the other, not more than five seconds. In some cases, in the interactions between males, the individuals showed behaviors of harassment on the part of the aggressor, and of flight on the part of the one assaulted.

We recorded in detail the agonistic interactions between two adult males that occurred on November 9, 2014. We designated them male A and male B for identification during the interaction. Early in the morning, male A embraced a female from behind, similar to the posture described by Bezerra *et al.* (2008) for the copulation behavior. The male A realized the presence and approximation of the male B. Male A left the female and moved towards the male B. The two males stood in front of each other displaying their claws. Male A vocalized while male B displayed right claw. The two males simultaneously displayed the claws of the upper limbs. Male A approached and pushed male B down. Soon after, they split and displayed their claws. Male A displayed its claws again and finally it moved towards the female.

A new episode of agonistic interaction occurred the following day (15 hours after the last episode

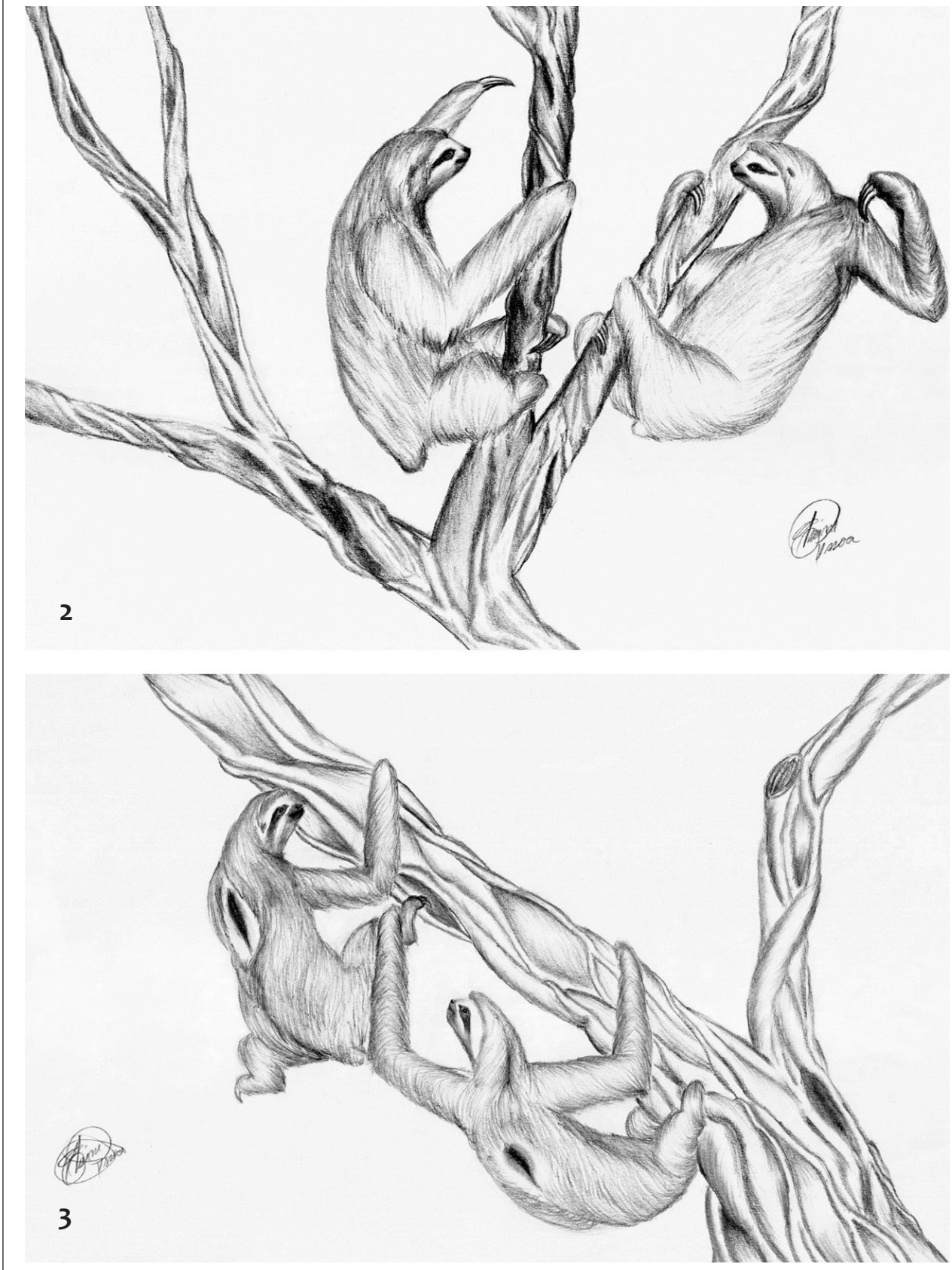

Figure 2–3. Agonistic interactions between male brown-throated three-toed sloths in João Pessoa square, Rio Tinto, Paraíba: **2.** Display of claws preceding physical aggression and **3.** Physical aggression with tugs on hind limb (Sketches: Elaine Pessoa Pedrosa).

described above). Male B approached male A, who was close to the female. Male A came towards male B, and the two remained still facing each other, displaying their claws, engaging in one more physical contact and emitting vocalizations. Two minutes after the males separated, male B moved to another fig tree. Male A remained still for 1 min, displayed its claws, and after male B moved out of view, male A moved towards the female and spent the entire morning at her side. The whole event lasted 42 min, beginning at 7:40 hr and ending at 8:22 hr. On the next day, there were no agonistic interactions, only the emission of vocalizations, but it was not possible to identify the sloth that emitted them. Vocalizations continued until the fourth day of consecutive observations, but there were no agonistic interactions.

During one of the episodes involving females, which occurred on 1 January 2012, it was possible to observe agonistic interactions between a mother (female C) and another female (D). Before we observed the agonistic interaction, a young sloth (with the umbilical cord still attached) had fallen on the floor next to the same fig tree. The young sloth vocalized, but the mother (female C) did not come down from the fig tree to rescue it.

Physical attacks between females C and D lasted about 10 min and were followed by the display of claws by both females. A third female (E) approached and hit the mother (female C) with its claws of the forelimb. Female D moved away, and the female E stayed and exchanged attacks to the mother (female C) for about 2 min. The mother (female C) moved quickly among the branches of the fig trees, went to the canopy of the next fig tree, and female E went in the opposite direction.

The staff of Área de Proteção Ambiental da Barra do Rio Mamanguape (APA) tried to return the young sloth to its mother for three consecutive days, but all attempts failed. The staff of APA took the young sloth to the Centro de Triagem de Animais Silvestres (CETAS/IBAMA).

The urban environment of João Pessoa square isolated sloths to the eight fig trees, making it nearly impossible for them to migrate to nearby forest fragments, and thus resulting in a high density of individuals at this site. Lara-Ruiz & Srbek-Araujo (2006) and Silva *et al.* (2013) observed that interactions between individuals were more frequent in conditions of high densities. Pedrosa & Castro (2014) studied the behavior of brown-throated three-toed sloths in natural (at Biological Reserve Guaribas) and urban (João Pessoa square) environments and observed that agonistic interactions, although less frequent than other behaviors, were recorded just in the urban environment. The environment of João Pessoa square could promote a higher frequency of encounters and agonistic interactions between them.

The observed interactions between adult males in João Pessoa square suggest that agonistic behaviors could involve competition for mates. As already proposed by Greene (1989), agonistic interactions between two males of brown-throated three-toed sloths can be due to, among other factors, competition for females. The months in which agonistic interactions between males were mostly recorded correspond to the portion of the year (March to October and November) in which males of *B. variegatus* are seen to be sexually active, according to studies performed in north-eastern Brazil (Gilmore *et al.*, 1994; Gilmore & Costa, 1995; Bezerra *et al.*, 2008). However, considering that our sampling effort was not similar for all months during the four years of study, we cannot discard the possibility that interactions among males occur throughout the year.

In the natural environment, home range sizes recorded for *B. variegatus* ranged from 0.9 to 1.4 ha (Chiarello, 2008), while in João Pessoa square the home range size does not exceed 0.2 ha (Pedrosa, 2013). Little is still known about the agonistic interactions between female sloths, but in João Pessoa square such interactions could occur due to competition for space. Female brown-throated three-toed sloths provide parental care to their young for approximately six months (Montgomery & Sunquist, 1974). After this period, sloth mothers use other parts of the home range to avoid competition with their offspring (Montgomery & Sunquist, 1978). At João Pessoa square, mothers are hindered from migrating to nearby forest fragments and there are no trees for their offspring to leave following separation. These conditions of the urban environment could also lead to the abandonment of young sloths. This is consistent with Pedrosa (2013) who found that all offspring were rejected by the mothers before the end of the period of parental care. The abandonment of young sloths appears to be a strategy of the mothers to allocate energy for the next reproductive cycle, as the physiological cost during the reproductive period can influence survival and future reproduction (Hussel, 1972; Moreno, 1989). The mating and parental care periods can influence a host of attributes, such as territory extent and spacing (von Hardenberg *et al.*, 2000), the level of aggression or affiliative behaviors (Cavigelli & Pereira, 2000).

In our study, agonistic interactions seemed to be influenced by different factors in male and female sloths. Agonistic interactions between males occurred mainly during mating periods, and these interactions appeared to be due to competition for mates. On the other hand, agonistic interactions between females occurred in periods in which there

were females with young sloths and were apparently due to dispute for space. Nevertheless, considering our sampling effort, we cannot exclude other variants, which could be associated to agonistic behaviors in both male and female brown-throated three-toed sloths.

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References

Altmann, J. 1974. Observational study of behavior: sampling methods. Behavior 49: 227–267. https://doi.org/10.1163/156853974X00534

Ballesteros, J., K. Reyes & J. Racero. 2009. Estructura poblacional y etología de *Bradypus variegatus* en fragmento de bosque seco tropical, Córdoba – Colombia. Revista MVZ Córdoba 3: 1812–1819. https://doi.org/10.21897/rmvz.341

Beebe, W. 1926. The three-toed sloth *Bradypus cuculliger cuculliger*. Zoologica 7: 1–67.

Bezerra, B.M., A.S. Souto, L.G. Halsey & N. Schiel. 2008. Observation of brown-throated three-toed sloths: mating behaviour and the simultaneous nurturing of two young. Journal of Ethology 26: 175–178. https://doi.org/10.1007/s10164-007-0038-z

Carvalho, C.T. 1960. Notes on the three-toed sloth, *Bradypus tridactylus*. Mammalia 24: 155–156. https://doi.org/10.1515/mamm.1960.24.1.152

Cavigelli, S.A. & M.E. Pereira. 2000. Mating season aggression and fecal testosterone levels in male ring-tailed lemurs (*Lemur catta*). Hormones and Behavior 37: 246–255. https://doi.org/10.1006/hbeh.2000.1585

Chiarello, A.G. 2008. Sloth ecology: an overview of field studies. Pp. 269–280 in: The biology of the Xenarthra (S.F. Vizcaíno & W.J. Loughry, eds.). University Press of Florida, Gainesville.

Eisenberg, J.F. 1981. The mammalian radiations: an analysis of trends in evolution, adaptation, and behavior. The University of Chicago Press, Chicago. 610 pp.

Gilmore, D.P., C.P. Costa, A. Cabral, D.P.F. Duarte, I. Montgomery & C.A. Wilson. 1994. Further studies on reproductive function in three-toed sloth *Bradypus tridactylus*. Medical Science Research 22: 255–256.

Gilmore, D.P. & C.P. Costa. 1995. The three-toed sloth in biomedical research: an update on the reproductive and endocrine systems. Medical Science Research 23: 579–581.

Greene, H.W. 1989. Agonistic behavior by three-toed sloths, *Bradypus variegatus*. Biotropica 21: 369–372. https://doi.org/10.2307/2388289

Hussel, D.T.J. 1972. Factors affecting clutch size in arctic passerines. Ecological Monographs 42: 317–364. https://doi.org/10.2307/1942213

Lara-Ruiz, P. & A. Srbek-Araujo. 2006. Comportamento potencialmente reprodutivo da preguiça-comum, *Bradypus variegatus* (Xenarthra, Bradypodidae): observações de campo. Edentata 7: 44–46. https://doi.org/10.1896/1413-4411.7.1.44

Moreno, J. 1989. Variation in daily energy expenditure in nesting northern wheatears (*Oenanthe oenanthe*). The Auk 106: 118–125. https://doi.org/10.2307/4087752

Montgomery, G. & M. Sunquist. 1974. Contact-distress calls of young sloths. Journal of Mammalogy 55: 211–213. https://doi.org/10.2307/1379274

Montgomery, G. & M. Sunquist. 1978. Habitat selection and use by two-toed and three-toed sloths. Pp. 329–359 in: The ecology of arboreal folivores (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington.

Pedrosa, E.P. 2013. Padrão comportamental, área de vida e estrutura populacional da preguiça-comum (*Bradypus variegatus*) em ambiente natural e urbano na cidade de Rio Tinto, Paraíba. Monografia, Universidade Federal da Paraíba, Paraíba. 32 pp.

Pedrosa, E.P & C.S.S. Castro. 2014. Behavior patterns of the common sloth (*Bradypus variegatus* Schinz, 1825) in urban and natural environments in Rio Tinto, Paraíba State, Brazil. Brazilian Journal of Ecology 1–2: 114–122.

Pinheiro, S.D. 2008. Comportamento alimentar da preguiça comum *Bradypus variegatus* (Schinz, 1825) (Xenarthra, Bradipodidae) no parque centenário de Barra Mansa, RJ. Dissertação de Mestrado, Universidade Federal de Juiz de Fora, Juiz de Fora. 122 pp.

Silva, S.M., C.L. Clozato, N. Moraes-Barros & J.S. Morgante. 2013. Towards a standard framework to describe behaviours in the common-sloth (*Bradypus variegatus* Schinz, 1825): novel interactions data observed in distinct fragments of the Atlantic forest, Brazil. Brazilian Journal of Biology 73: 527–531. https://doi.org/10.1590/S1519-69842013000300010

Soares, C. & R. Carneiro. 2002. Social behavior between mothers × young of sloths *Bradypus variegatus* Schinz, 1825 (Xenarthra: Bradypodidade). Brazilian Journal of Biology 62: 249–252. https://doi.org/10.1590/S1519-69842002000200008

von Hardenberg, A., P. Bassano, A. Peracino & S. Lovari. 2000. Male alpine chamois occupy territories at hotspots before the mating season. Ethology 106: 617–630. https://doi.org/10.1046/j.1439-0310.2000.00579.x

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SHORT COMMUNICATION

Notes on giant armadillo *Priodontes maximus* (Cingulata: Chlamyphoridae) distribution and ecology in *Eucalyptus* plantation landscapes in eastern Mato Grosso do Sul State, Brazil

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Abstract Despite its wide distribution in South America, ranging from northern Venezuela and the Guianas south to Paraguay and northern Argentina, the vulnerable giant armadillo (*Priodontes maximus*) occurs at low densities and is little studied due to its elusive habits. In Brazil species' records have been collected from the Pantanal and central Cerrado but little information is known from the eastern border of Mato Grosso do Sul. Here we report 97 records of giant armadillo in this region from areas of private lands using camera-traps and signs of presence in Cerrado and Atlantic Forest biomes.

Keywords: Atlantic Forest, camera-trap, Cerrado, forestry plantation, private lands

Notas sobre a distribuição e a ecologia do tatu-canastra *Priodontes maximus* (Cingulata: Chlamyphoridae) em paisagens de plantação de eucaliptos no leste do estado de Mato Grosso do Sul, Brasil

Resumo Apesar de sua ampla distribuição na América do Sul, que vai do norte da Venezuela e das Guianas ao sul do Paraguai e ao norte da Argentina, o vulnerável tatu-canastra (*Priodontes maximus*) ocorre em baixas densidades e é pouco estudado devido aos seus hábitos crípticos. No Brasil, os registros da espécie têm sido coletados no Pantanal e Cerrado central, mas há pouca informação na fronteira leste do Mato Grosso do Sul. Neste estudo são relatados 97 registros de tatu-canastra nessa região, coletados por meio de armadilhas fotográficas e vestígios nos biomas Cerrado e Mata Atlântica.

Palavras-chave: armadilha fotográfica, Cerrado, Mata Atlântica, propriedades particulares, silvicultura

Easily recognized by its size, the giant armadillo *Priodontes maximus* (Kerr, 1792) is the largest among the 20 species of living armadillos (Abba & Superina, 2010; Gibb *et al.*, 2016), with adult weights averaging around 30 kg (Carter *et al.*, 2016). Despite its wide distribution in South America, the species tends to occur at low population densities (Aguiar & Fonseca, 2008) and it is classified as Vulnerable by the International Union for the Conservation of Nature (IUCN, 2017) and the Brazilian National List of Endangered Species (Brasil, 2014). Major threats to the species include poaching and habitat loss (Abba & Superina, 2010; Desbiez & Kluyber, 2013).

In Brazil, the giant armadillo is found in Cerrado, Pantanal, Amazon, and Atlantic Forest biomes (Chiarello *et al.*, 2015). It is considered extinct in the state of Paraná and restricted to a few localities in the southeastern part of the country (Chiarello *et al.*, 2008; Srbek-Araujo *et al.*, 2009).

The species feeds mainly on ants and termites, destroying anthills and termite mounds during foraging (Anacleto & Marinho-Filho, 2001; Chiarello

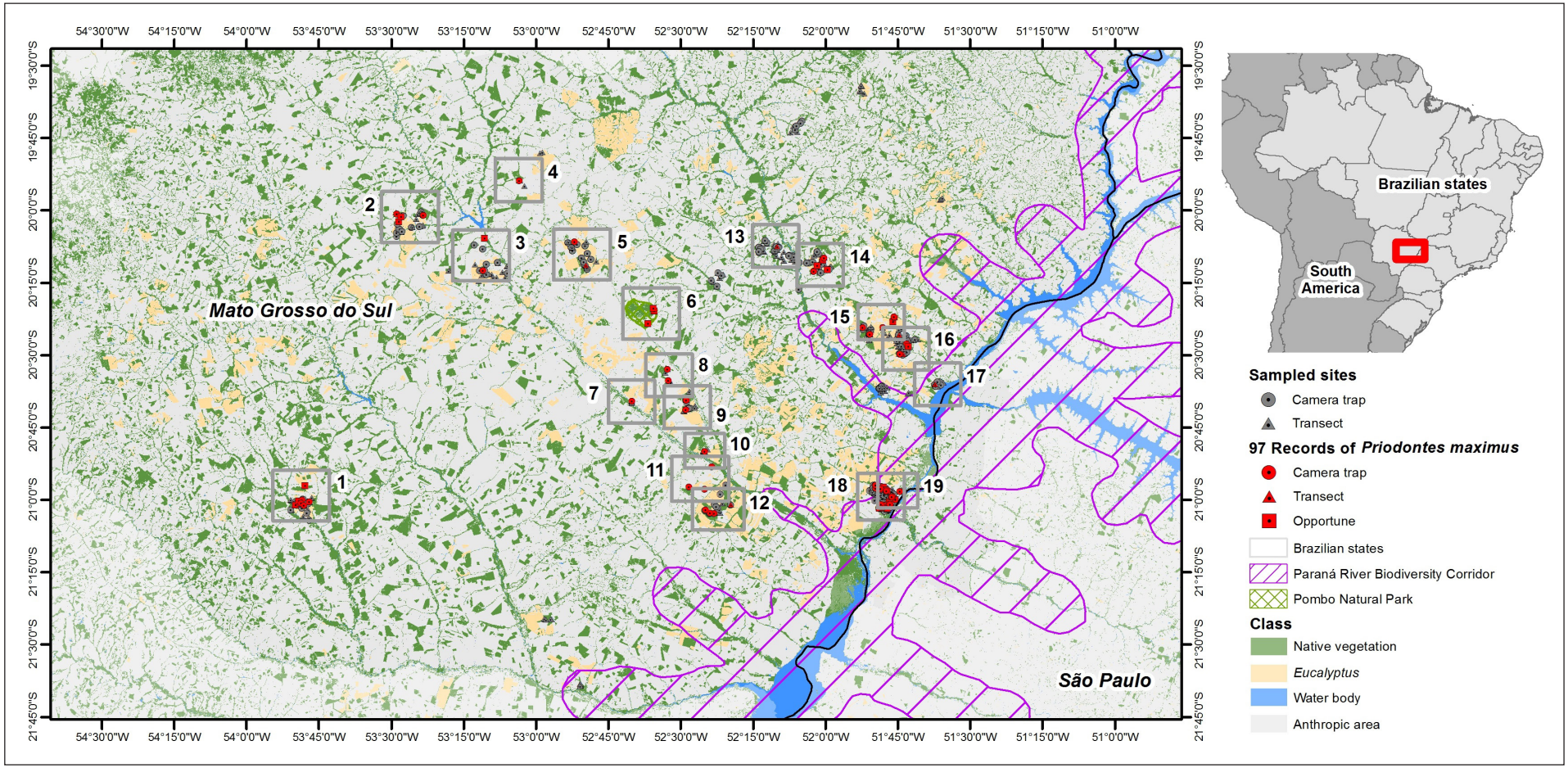

FIGURE 1. Location of the study areas, which comprised 29 private farms of *Eucalyptus* plantation and one protected area in eastern Mato Grosso do Sul, Brazil. The numbered panels show the 18 farms and the protected area with *Priodontes maximus* records. The basis for this map was made available by the Brazilian Foundation for Sustainable Development (FBDS) using Rapid Eye images (5 meters of spatial resolution), base year 2013. A supervised classification and vectorization of four classes of interest with subsequent evaluation of the quality of the mapping was performed. Verification was done in a 1: 10,000 scale using checkpoints randomly distributed in the scenes of Rapid Eye images (100 points per scene) and the result reached the minimum percentage of 95% hits in all scenes.

et al., 2008). While foraging, the giant armadillo uses its powerful front claws, long vermiform tongue, large salivary glands, and small teeth to capture and consume prey (Redford, 1985). *Priodontes maximus* can also eat other invertebrates such as spiders, worms, small snakes, and even carrion (Carter *et al.*, 2016). Recently, the giant armadillo was recognized as an ecosystem engineer because its excavations for burrows can create new habitat for other species (Leite-Pitman *et al.*, 2004; Desbiez & Kluyber, 2013; Aya-Cuero *et al.*, 2017; Massocato & Desbiez, 2017).

Due to its fossorial and nocturnal habits, as well as the fact that individuals can remain inside the burrow for several days and are rarely seen (Eisenberg & Redford, 1999; Noss *et al.*, 2004), few studies have been conducted in nature and little information about the ecology and behavior of the giant armadillo is known. What data are available mostly have been obtained by indirect signs, occasional visual contacts or dead specimens (Silveira *et al.*, 2009). However, the increasing use of camera-trapping in recent years has broadened knowledge of the giant armadillo, including in the Cerrado of central Brazil (Anacleto & Marinho-Filho, 2001; Santos-Filho & Silva, 2002; Silveira *et al.*, 2009; Zimbres *et al.*, 2013), Atlantic Forest (Srbek-Araujo *et al.*, 2009), and Pantanal (Trolle, 2003; Trolle & Kéry, 2005; Porfirio *et al.*, 2012).

Brazil has strong environmental laws concerning conservation of natural ecosystems, including the Forest Code (Federal Law No. 12.651/2012), which requires rural landowners to maintain at least 20% of their properties as native vegetation and to restore the area along streams and rivers. Nearly 85% of Cerrado and Atlantic Forest remnants are located on private properties (Oliveira *et al.*, 2010; Sparovek *et al.*, 2011), which thus assume an important role in the conservation of biodiversity. Although some sectors of Brazilian agriculture do not fulfill their legal obligations, the forestry sector, due to certification requirements, has a satisfactory record regarding restoration of degraded areas and habitat conservation (Silva *et al.*, 2007; Egeskog *et al.*, 2016).

In Brazil and many other countries, plantation forests are the focus of controversial opinions, with arguments that afforestation with commercial monocultures may or may not be suitable as habitat for certain species (Brockerhoff *et al.*, 2008). This debate can involve costs and benefits at different scales, for example, global environmental benefits are obtained at the expense of local impacts or, conversely, the benefits of local economic development collide with global needs for nature protection (Buongiorno & Zhu, 2014; Hemström *et al.*, 2014; Andersson *et al.*, 2016).

With the growth of the forest-based industry in Mato Grosso do Sul, mainly in the eastern region of the state (IBA, 2016), the substitution of livestock pastures by forestry plantations has been increasing over the years (Kudlavicz, 2011). This modification of the regional landscape has profound consequences for biodiversity conservation because the conversion of pastures to forestry can reduce the edge effects of forest fragments (Antongiovanni & Metzger, 2005) and be suitable for forest dwelling species. On the other hand, the replacement of natural grassland (a common and endangered habitat in the Cerrado; Klink & Machado, 2005) with

FIGURE 2. Direct and indirect signs of presence of *Priodontes maximus*: **A.** photo from a camera-trap; **B.** burrow; **C.** track.

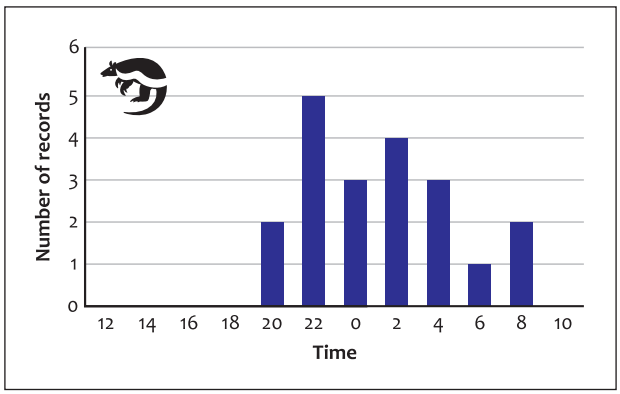

FIGURE 3. Activity pattern of the giant armadillo based on camera-trap and visual records.

commercial tree plantations may be detrimental to wildlife that inhabit open areas. Protecting the diverse suite of open and forested habitats of the Brazilian Cerrado is crucial, although the current Brazilian Forest Code fails to take into account this habitat variety, only mentioning "forests and other forms of native vegetation" throughout its entire text.

Given this scenario, this study aimed to fill information gaps about the occurrence of the giant armadillo with data collected in eastern Mato Grosso do Sul state, in landscapes with a predominance of forestry and *cerradão* phytophysiognomies—the latter a native forest of the Cerrado biome. We report the first records of the giant armadillo on private lands of this region (in Cerrado and Atlantic Forest Biomes) using camera-trapping and signs of presence data.

The study area comprised 29 private farms of *Eucalyptus* commercial plantation (properties of Fibria-MS Celulose Sul Mato Grossense Ltd., Eldorado Brasil Celulose S/A, Niobe Florestal S/A, and Frigg Florestal S/A) and one protected area, Parque Natural Municipal do Pombo (**FIG. 1**). As part of a mammal species monitoring program on *Eucalyptus* farms, transects and camera trapping surveys were carried out from August 2007 until September 2017 in areas of native vegetation and commercial forestry. A total of 173 camera traps were installed at fixed stations along dirt roads or in the forests and programmed to operate continuously (24 h/day) taking pictures (see **FIG. 2A**) or shooting video (minimum interval of 30 s). Recorded observations were considered independent for photos and videos obtained at each camera trap station every 24 h (1 day).

In addition to camera traps, 187 transects of different lengths (ranging from 500 m to 2 km) were sampled along dirt roads in order to identify traces of presence, such as scats, tracks, and burrows (**FIG. 2**). On average, 32 transects per year were carried out. Some trails were sampled only once

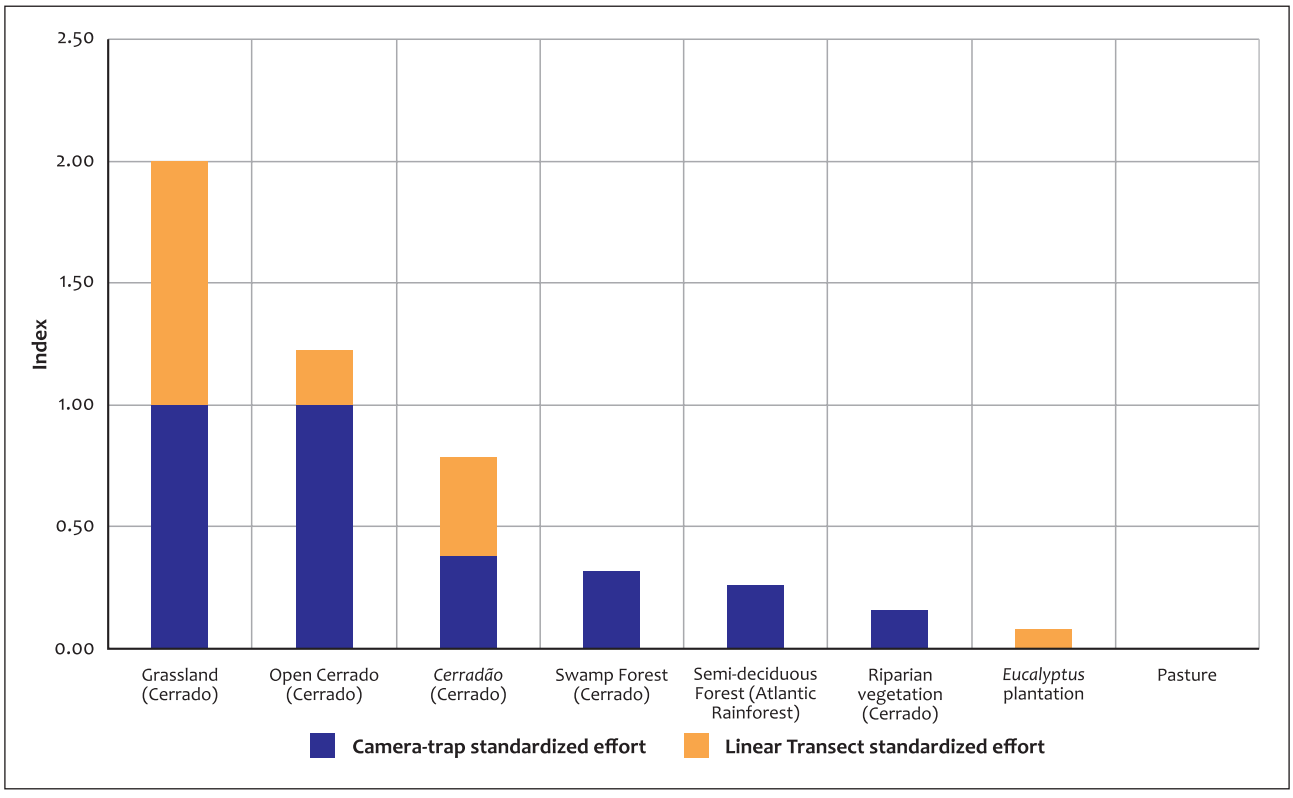

FIGURE 4. Habitat use index based on standardized sampling effort and records of giant armadillo in eastern Mato Grosso do Sul, Brazil.

TABLE 1. Description of records, sampling effort, and habitat use index for giant armadillo in eastern Mato Grosso do Sul, Brazil.

CTO: Camera-trap occurrences

LTO: Linear transect occurrences

OO: Opportune occurrences

TO: Total occurrences = CTO + LTO + OO

CTE: Camera-trap effort

LTE: Linear transect effort

CTOR: Camera-trap occurrences ratio = (CTO/CTE) × 100

LTOR: Linear transect occurrences ratio = LTO/LTE

SCTO: Standardized camera-trap occurrences $SCTO_i = \frac{CTOR_{MAX} - CTOR_i}{CTOR_{MAX} - CTOR_{MIN}}$, where i = habitat type, $CTOR_{MAX}$: Maximum CTOR value among habitat types, and $CTOR_{MIN}$: Minimum CTOR value among habitat types

SLTO: Standardized linear transect occurrences $SLTO_i = \frac{LTOR_{MAX} - LTOR_i}{LTOR_{MAX} - LTOR_{MIN}}$, where i = habitat type, $LTOR_{MAX}$: Maximum LTOR value among habitat types, and $LTOR_{MIN}$: Minimum LTOR value among habitat types

THUI: Total habitat use index = SCTO + SLTO

Species	CTO	LTO	OO	TO	CTE (days)	LTE (km)	CTOR	LTOR	SCTO	SLTO	THUI
Grassland (Cerrado)	1	2	1	4	59	6.5	1.70	30.77	0.99	1.00	1.99
Open Cerrado (Cerrado)	2	1	2	5	117	14.5	1.71	6.90	1.00	0.22	1.22
Cerradão (Cerrado)	9	42	18	69	1390	336.7	0.65	12.47	0.38	0.41	0.78
Swamp Forest (Cerrado)	3	1	0	4	555	0	0.54	0.00	0.32	0.00	0.32
Semi-deciduous Forest (Atlantic Rainforest)	1	0	1	2	224	0	0.45	0.00	0.26	0.00	0.26
Riparian vegetation (Cerrado)	1	0	1	2	367	3.5	0.27	0.00	0.16	0.00	0.16
Eucalyptus plantation	0	7	4	11	245	290	0.00	2.41	0.00	0.08	0.08
Pasture	0	0	0	0	73	28	0.00	0.00	0.00	0.00	0.00
Total	17	53	27	97	3029	679	0.56	7.80			

(eucalypt farms with rapid fauna inventory) and others up to 20 times (eucalypt farms with long-term monitoring, usually conducted seasonally). Opportune detections (outside of the survey period) of species traces during monitoring campaigns were also considered. The location of cameras and signs of presence were georeferenced with a GPS navigator and then exported to ArcGis 10 software (Environmental Systems Research Institute, Redlands, CA, USA).

A total of 70 point localities of the giant armadillo were obtained on 18 private farms from transects (7.8 records/100 km) and camera traps (0.56 pictures/100 camera-trap days), totaling an effort of 679.2 km and 3,029 trap-days. Opportune detections such as tracks, burrows, and sightings accounted for an additional 27 records, thus generating 97 total records for the species.

Camera-trap and visual records combined (n=20) indicated that giant armadillos were nocturnally active (*i.e.*, outside their burrows), specifically between 20:13 hr and 08:41 hr, and more active from 22:00 hr to 04:00 hr (**FIG. 3**). Despite the low number of records, this corresponds quite well with the pattern obtained by Noss *et al.* (2004), Silveira *et al.* (2009), and Aya-Cuero *et al.* (2017).

For landscape description of the giant armadillo's occurrence, we used a land cover map to determine the percentage of various habitat types within a 1.8 km radius of each animal's point location (**APPENDIX 1**). The mapping was done manually through the ArcMap extension of ArcGis, based on images available in Google Earth®. The 1.8 km radius was chosen to represent the approximate home range of the giant armadillo, based on Silveira *et al.* (2009).

Collectively, the location points encompassed, on average, 43% of *Eucalyptus* plantations, 35% of native vegetation and 15% of pasture (**APPENDIX 2**). Considering the surroundings of just the occurrence points on 18 private farms, there was substantial variation in how much commercial forest (eucalypts) was encompassed, from 2% to 89%, and also of native vegetation, from 5% to 85%.

Rather than looking at the larger scale habitat associations with each occurrence point, we next examined the specific type of habitat in which each point was obtained. Our records of the giant armadillo were collected in different Cerrado and Atlantic Forest physiognomies, including areas of swamp forests, natural grassland, semi-deciduous rainforest, open Cerrado (woodland), *cerradão* (tall woodland), riparian vegetation, and also in sites of *Eucalyptus* plantation. Most of the occurrence points were in native vegetation (89%), followed by 11% in *Eucalyptus* plantation and no records in pasture. **FIGURE 4** shows the standardized effort (camera-trap and linear transect) related to the occurrence of *P. maximus* in each habitat type sampled. Standardization was performed using the range

method, in which data range from 0 to 1 (**Table 1**). First, a ratio of the number of occurrences and sampling effort was calculated for each habitat type and each sampling method (occurrences/camera-trap day and occurrences/km, respectively). Then, the ratio obtained between the different habitats was standardized, where the maximum value for each method represents "1" and the minimum "0". In this case, "0" represents the places where the species was not registered. Finally, the habitat use index was calculated by adding the standardized occurrences for each type of method (index ranges from 0 to 2), with the highest values representing preferred habitats.

Although the reported habitat preference of *P. maximus* is for open areas (Santos-Filho & Silva, 2002; Silveira *et al.*, 2009; Abba & Superina, 2010), some authors registered the species in more closed physiognomies, such as *cerradão* (Anacleto, 1997; Anacleto & Diniz-Filho, 2008; Aya-Cuero *et al.*, 2017). The *Eucalyptus* farms surveyed in our study were predominantly surrounded by closed habitats, and we recorded the species in more forested areas (79% of records). Even so, comparing the sampling effort spent on grassland and *cerradão*, for example, the habitat use by the species shows some tendency for open areas when it is available (**Fig. 4**). The lack of conserved open habitat types on private lands may be one of the reasons why many giant armadillo occurrences are in closed Cerrado outside the limits of protected areas (Silveira *et al.*, 2009). Clearly, additional studies are needed in order to better understand the natural history, habitat preferences, and basic ecology of giant armadillos (Meritt Jr., 2006; Carter *et al.*, 2016).

Also of importance is that 38% of the giant armadillo occurrences were located in the Parana River Biodiversity Corridor (also known as the Trinational Biodiversity Corridor; ICMBio, 2008; MMA, 2016; see **Fig. 1**). Together with the data of Massocato & Desbiez (2017), our results confirm the presence of the giant armadillo in the Brazilian territory of this corridor.

The evidence of some individuals using forestry landscapes (10 tracks and 1 burrow) suggests that giant armadillos may use dirt roads within eucalypt stands as a connection between remnants of native vegetation, for food resources, or both. Despite their nomadic foraging behavior, the species is sensitive to environmental disturbance and does not tolerate intense human presence (Quiroga *et al.*, 2017). Thus, its occurrence could be considered an indicator of environmental quality (Anacleto & Diniz-Filho, 2008; Silveira *et al.*, 2009). One potential threat that *Eucalyptus* plantations may cause to giant armadillos and other species that feed mainly on ants and termites is the use of pesticides and chemicals with long residual periods. These insects are one of the main causes of economic losses for forestry plantations (Wilcken *et al.*, 2002), and the effects on wildlife of control methods need to be better assessed.

Although the Parque Natural Municipal do Pombo is included in the category of Full Protection by Federal Law No. 9.985/2000 (permission only for indirect use of its natural resources), the eastern region of Mato Grosso do Sul state lacks more protected areas. The results presented in this investigation reveal the importance that protected native vegetation areas on private lands, such as Legal Reserves and Areas of Permanent Protection (ensured by Federal legislation), may have for the conservation of giant armadillos in Cerrado and Atlantic Forest biomes. However, we believe a joint effort in the creation and maintenance of governmental and private protected areas, as well as ecological corridors capable of maintaining connectivity between them, will ultimately be vital for the conservation of the species in the region.

In regions with highly fragmented landscapes, plantation forests may be effective for the conservation of species, especially the most sensitive ones, if the understory of tree stands is retained and is connected to adjacent areas of natural habitats (Brockerhoff *et al.*, 2013; Begotti *et al.*, 2018). Although forest certification (*e.g.*, Forest Stewardship Council International – FSC) can provide the means by which producers meet rigorous sustainable forestry standards, there is no definition of priority areas needed for maintenance of the functional connectivity between plantations (Hardt *et al.*, 2015). Connectivity is important, especially in patchy landscapes permeated by an agricultural matrix, because it enables the flow of individuals from isolated populations (Uezu *et al.*, 2005).

In summary, our results provide relevant information to guide decision-making, whether for the conservation of the species, subsidizing the future National Action Plan for the conservation of the giant armadillo, to fill information gaps for improvement in conservation strategies, to determine how lands are used and occupied, or to support the creation of protected areas in the region.

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References

Abba, A.M. & M. Superina. 2010. The 2009/2010 armadillo Red List assessment. Edentata 11: 135–184. https://doi.org/10.5537/020.011.0203

Aguiar, J.M. & G.A.B. Fonseca. 2008. Conservation status of the Xenarthra. Pp. 215–231 in: The biology of the Xenarthra (S.F. Vizcaíno & W.J. Loughry, eds.). University Press of Florida, Gainesville.

Anacleto, T.C.S. 1997. Dieta e utilização de habitat do tatu-canastra (*Priodontes maximus* Kerr, 1792) numa área de cerrado do Brasil Central. Master's Thesis, Universidade de Brasília, Brasília. 64 pp.

Anacleto, T.C.S. & J. Marinho-Filho. 2001. Hábito alimentar do tatu-canastra (Xenarthra, Dasypodidae) em uma área de cerrado do Brasil Central. Revista Brasileira de Zoologia 18: 681–688. https://doi.org/10.1590/S0101-81752001000300003

Anacleto, T.C.S. & J.A.F. Diniz-Filho. 2008. Efeitos da alteração antrópica do Cerrado sobre a comunidade de tatus (Mammalia, Cingulata, Dasypodidae). Pp. 55–67 in: Ecologia de mamíferos (N.R. Reis, A.L. Peracchi & G.A.S.D. Santos, eds.). Technical Books, Londrina.

Andersson, K., D. Lawrence, J. Zavaleta & M.R. Guariguata. 2016. More trees, more poverty? The socioeconomic effects of tree plantations in Chile, 2001–2011. Environmental Management 57: 123–136. https://doi.org/10.1007/s00267-015-0594-x

Antongiovanni, M. & J.P. Metzger. 2005. Influence of matrix habitats on the occurrence of insectivorous bird species in Amazonian Forest fragments. Biological Conservation 122: 441–451. https://doi.org/10.1016/j.biocon.2004.09.005

Aya-Cuero, C., A. Rodríguez-Bolaños & M. Superina. 2017. Population density, activity patterns, and ecological importance of giant armadillos (*Priodontes maximus*) in Colombia. Journal of Mammalogy 98: 770–778. https://doi.org/10.1093/jmammal/gyx006

Begotti, R.A., E.S. Pacífico, S.F.B. Ferraz & M. Galetti. 2018. Landscape context of plantation forests in the conservation of tropical mammals. Journal for Nature Conservation 41: 97–105. https://doi.org/10.1016/j.jnc.2017.11.009

Brasil. 2014. Portaria N–444, Diário Oficial da União Nº 245, quinta-feira, 18 de dezembro de 2014. 21 pp. <http://www.icmbio.gov.br/portal/faunabrasileira?id=6706:portarias-fauna-ameacada> Downloaded on 17 May 2017.

Brockerhoff, E.G., H. Jactel, J.A. Parrotta & S.F.B. Ferraz. 2013. Role of eucalypt and other planted forests in biodiversity conservation and the provision of biodiversity-related ecosystem services. Forest Ecology and Management 301: 43–50. https://doi.org/10.1016/j.foreco.2012.09.018

Brockerhoff, E.G., H. Jactel, J.A. Parrotta, C.P. Quine & J. Sayer. 2008. Plantation forests and biodiversity: oxymoron or opportunity? Biodiversity and Conservation 17: 925–951. https://doi.org/10.1007/s10531-008-9380-x

Buongiorno, J. & S. Zhu. 2014. Assessing the impact of planted forests on the global forest economy. New Zealand Journal of Forestry Science 44: S2. https://doi.org/10.1186/1179-5395-44-S1-S2

Carter, T.S., M. Superina & D.M. Leslie. 2016. *Priodontes maximus* (Cingulata: Chlamyphoridae). Mammalian Species 48: 21–34. https://doi.org/10.1093/mspecies/sew002

Chiarello, A.G., L.M.S. Aguiar, R. Cerqueira, F.R. Melo, F.H.G. Rodrigues & V.M. Silva. 2008. Mamíferos ameaçados de extinção no Brasil. Pp. 681–702 in: Livro Vermelho da fauna brasileira ameaçada de extinção (A.B.M. Machado, G.M. Drummond & A.P. Paglia, eds.). Ministério do Meio Ambiente and Fundação Biodiversitas, Belo Horizonte.

Chiarello, A.G. *et al.* 2015. Avaliação do risco de extinção de *Priodontes maximus* (Kerr, 1792) no Brasil. Pp. 209–222 in: Avaliação do risco de extinção dos xenartros Brasileiros (ICMBio, ed.). Ministério do Meio Ambiente, Brasília.

Desbiez, A.L.J. & D. Kluyber. 2013. The role of giant armadillos (*Priodontes maximus*) as physical ecosystem engineers. Biotropica 45: 537–540. https://doi.org/10.1111/btp.12052

Egeskog, A. *et al.* 2016. Actions and opinions of Brazilian farmers who shift to sugarcane—an interview-based assessment with discussion of implications for land-use change. Land Use Policy 57: 594–604. https://doi.org/10.1016/j.landusepol.2016.2016.06.022

Eisenberg, J.F. & K.H. Redford. 1999. Mammals of the Neotropics. Volume 1. The Northern Neotropics: Panama, Colombia, Venezuela, Guyana, Suriname, French Guyana. The University of Chicago Press, Chicago. 609 pp.

Gibb, G.C. *et al.* 2016. Shotgun mitogenomics provides a reference phylogenetic framework and timescale for living xenarthrans. Molecular Biology and Evolution 33: 621–642. https://doi.org/10.1093/molbev/msv250

Hardt, E., E. Borgomeo, R.F. dos Santos, L.F.G. Pinto, J.P. Metzger & G. Sparovek. 2015. Does certification improve biodiversity conservation in Brazilian coffee farms? Forest Ecology and Management 357: 181–194. https://doi.org/10.1016/j.foreco.2015.08.021

Hemström, K., K. Mahapatra & L. Gustavsson. 2014. Public perceptions and acceptance of intensive forestry in Sweden. Ambio 43: 196–206. https://doi.org/10.1007/s13280-013-0411-9

IBA – Indústria Brasileira de Árvores. 2016. Relatório anual de 2016. <http://iba.org/images/shared/Biblioteca/IBA_RelatorioAnual2016_.pdf>. Downloaded on 09 May 2017.

ICMBio – Instituto Chico Mendes de Conservação da Biodiversidade. 2008. Plano de manejo do Parque Nacional de Ilha Grande. <http://www.icmbio.gov.br/portal/images/stories/docs-planos-de-manejo/parna_ilha_grande_pm.pdf>. Downloaded on 18 May 2018.

IUCN – International Union for the Conservation of Nature and Natural Resources. 2017. The IUCN Red List of Threatened Species 2017.2. <http://www.iucnredlist.org/>. Downloaded on 15 February 2017.

Klink, C.A. & R.B. Machado. 2005. Conservation of the Brazilian Cerrado. Conservation Biology 19: 707–713. https://doi.org/10.1111/j.1523-1739.2005.00702.x

Kudlavicz, M. 2011. Dinâmica agrária e a territorialização do complexo celulose/papel na microrregião de Três Lagoas/MS. Master's thesis, Universidade Federal de Mato Grosso do Sul, Três Lagoas. 177 pp.

Leite-Pitman, R. *et al.* 2004. Habitat use and activity of the giant armadillo (*Priodontes maximus*): preliminary data from southeastern Peru. 2004 Annual Meeting of the Society for Conservation Biology, New York.

Massocato, G.F. & A.L.J. Desbiez. 2017. Presença e importância do tatu-canastra, *Priodontes maximus* (Kerr, 1792), na maior área protegida do leste do Estado de Mato Grosso do Sul, Brasil. Edentata 18: 26–33. https://www.doi.org/10.2305/IUCN.CH.2017.Edentata-18-1.4.en

Meritt Jr., D.A. 2006. Research questions on the behavior and ecology of the giant armadillo (*Priodontes maximus*). Edentata 7: 30–33. https://doi.org/10.1896/1413-4411.7.1.30

MMA – Ministério do Meio Ambiente do Brasil. 2016. Ecological corridors — Brazilian initiative and the continental perspective. Working document. Brasília. 41 pp.

Noss, A.J., P. Peña & D.I. Rumiz. 2004. Camera trapping *Priodontes maximus* in the dry forest of Santa Cruz, Bolivia. Endangered Species Update 2: 43–52.

Oliveira, V.B., A.P. Paglia, M. Fonseca & E. Guimarães. 2010. RPPN e biodiversidade: o papel das reservas particulares na proteção da biodiversidade da Mata Atlântica. Conservação Internacional/Fundação SOS Mata Atlântica/The Nature Conservancy, Belo Horizonte. 48 pp.

Porfirio, G.E.O. *et al.* 2012. New records of giant armadillo *Priodontes maximus* (Cingulata: Dasypodidae) at Serra do Amolar, Pantanal of Brazil. Edentata 13: 72–75. https://doi.org/10.5537/020.013.0110

Quiroga, V.A., Y.E. Di Blanco, A. Noss, A.J. Paviolo & M.S. Di Bitetti, 2017. The giant armadillo (*Priodontes maximus*) in the Argentine Chaco. Mastozoología Neotropical 24: 163–175.

Redford, K.H. 1985. Food habits of armadillos (Xenarthra: Dasypodidae). Pp. 429–437 in: The evolution and ecology of armadillos, sloths and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington and London.

Santos-Filho, M. & M.N.F. Silva. 2002. Uso de habitats por mamíferos em área de Cerrado do Brasil Central: um estudo com armadilhas fotográficas. Revista Brasileira de Zoociências 4: 57–73.

Silva, A.M., M.A. Nalon, F.J.N. Kronka, C.A. Alvares, P.B. Camargo & L.A. Martinelli. 2007. Historical land-cover/use in different slope and riparian buffer zones in watersheds of the state of São Paulo, Brazil. Scientia Agricola 64: 325–335. https://doi.org/10.1590/S0103-90162007000400003

Silveira, L., A.T.A. Jácomo, M.M. Furtado, N.M. Torres, R. Sollmann & C. Vynne. 2009. Ecology of the giant armadillo (*Priodontes maximus*) in the grasslands of central Brazil. Edentata 8–10: 25–34. https://doi.org/10.1896/020.010.0112

Sparovek, G., A. Barretto, I. Klug, L. Papp & J. Lino. 2011. A revisão do Código Florestal brasileiro. Novos Estudos 89: 111–135. https://doi.org/10.1590/S0101-33002011000100007

Srbek-Araujo, A.C., L.M. Scoss, A. Hirsch & A.G. Chiarello. 2009. Records of the giant armadillo *Priodontes maximus* (Cingulata: Dasypodidae) in the Atlantic Forest: are Minas Gerais and Espírito Santo the last strongholds of the species? Zoologia 26: 461–468. https://doi.org/10.1590/S1984-46702009000300010

Trolle, M. 2003. Mammal survey in the southeastern Pantanal, Brazil. Biodiversity and Conservation 12: 823–836. https://doi.org/10.1023/A:1022489426920

Trolle, M. & M. Kéry. 2005. Camera trap study of ocelot and other secretive mammals in the northern Pantanal. Mammalia 69: 409–416. https://doi.org/10.1515/mamm.2005.032

Uezu, A., J.P. Metzger & J.M. Vielliard. 2005. Effects of structural and functional connectivity and patch size on the abundance of seven Atlantic Forest bird species. Biological Conservation 123: 507–519. https://doi.org/10.1016/j.biocon.2005.01.001

Wilcken, C.F., C.G. Raetano & L.C. Forti. 2002. Termite pests in *Eucalyptus* forests of Brazil. Sociobiology 40: 179–190.

Zimbres, B. *et al.* 2013. The impact of habitat fragmentation on the ecology of xenarthrans (Mammalia) in the Brazilian Cerrado. Landscape Ecology 28: 259–269. https://doi.org/10.1007/s10980-012-9832-2

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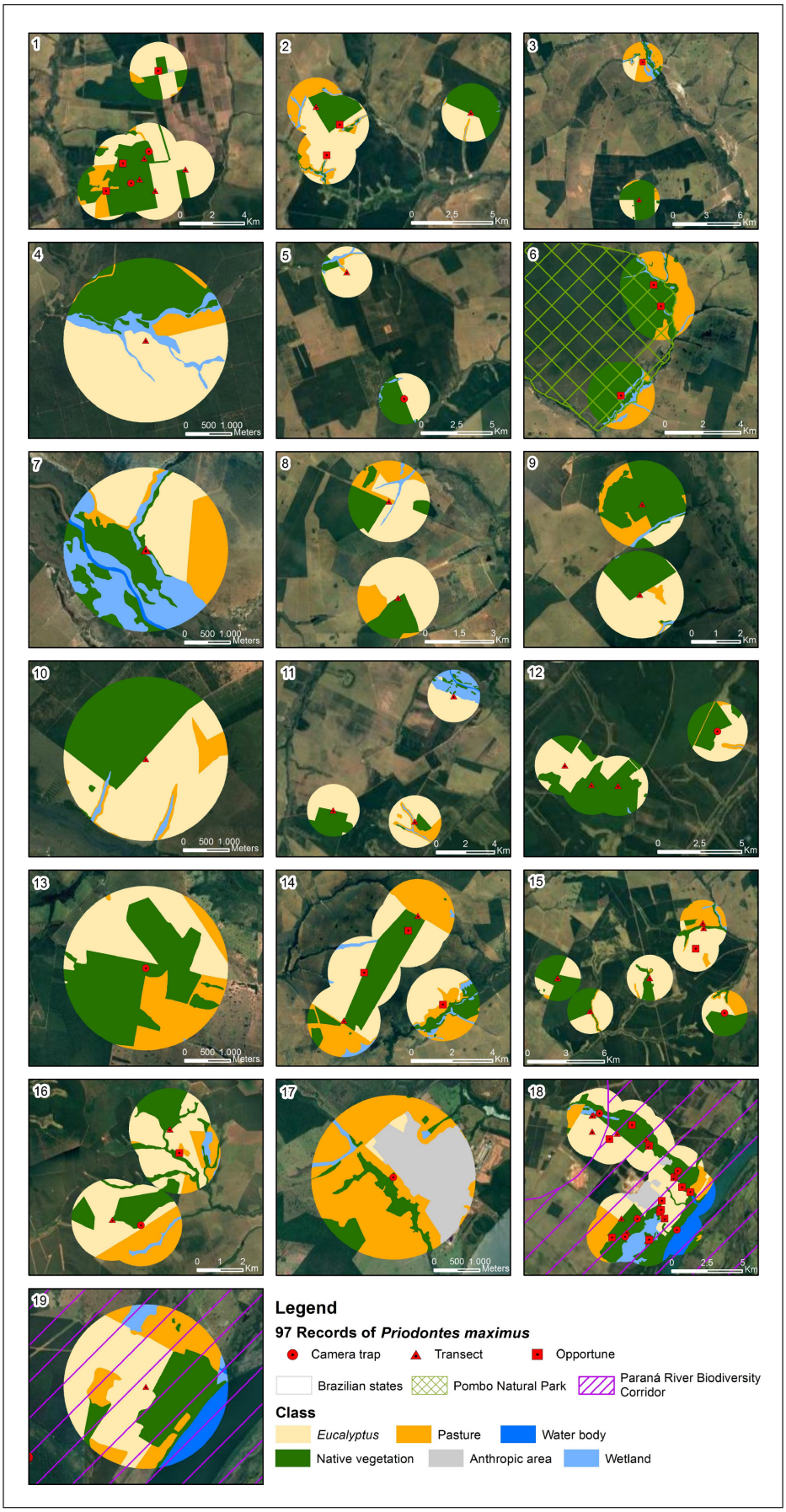
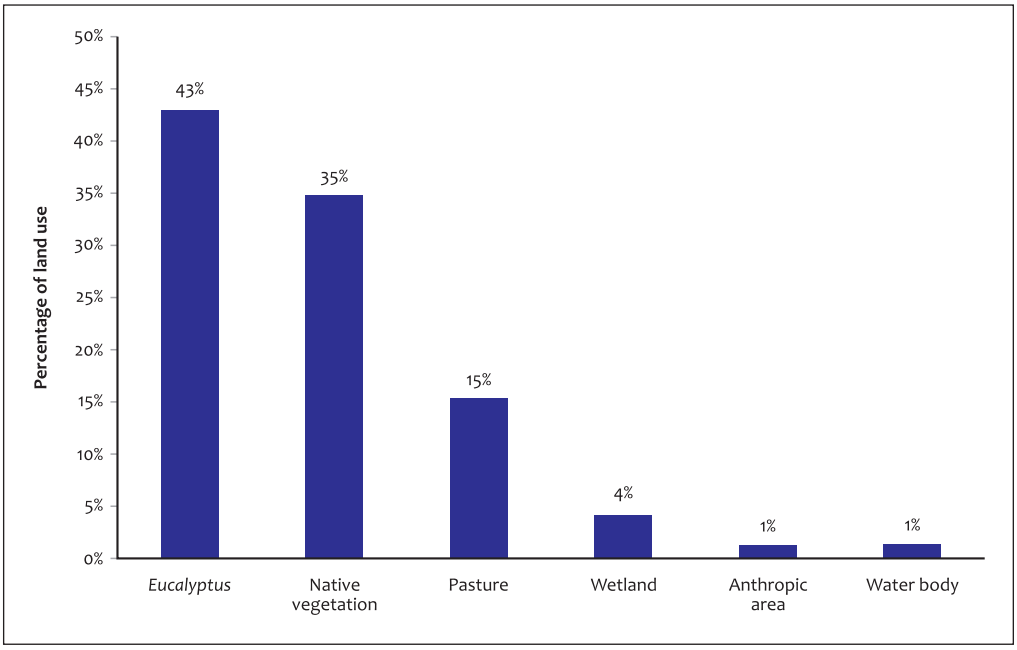
APPENDIX 1

Habitat type for each of the 97 location points of the giant armadillo on 18 private farms and Parque Natural Municipal do Pombo, eastern Mato Grosso do Sul, Brazil. Some location points overlap.



Appendix 2

Averaged percentage of land use types within a 1.8 km radius of each location point of the giant armadillo in eastern Mato Grosso do Sul, Brazil.



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COMUNICACIÓN BREVE

Registros de oso melero (*Tamandua tetradactyla*) en la provincia de San Luis, Argentina. Ampliación del límite austral de la distribución de la especie

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Resumen El oso melero, *Tamandua tetradactyla*, se distribuye ampliamente en Sudamérica, habitando en sabanas, bosques y selvas, desde Venezuela hasta el norte y centro de Argentina. En Argentina habita en las provincias de Catamarca, Chaco, Córdoba, Corrientes, Formosa, Jujuy, La Rioja, Misiones, Salta, Santa Fe, Santiago del Estero y Tucumán. Recientemente han sido registrados ejemplares fuera de los límites del área de distribución tradicional, observándose una posible ampliación hacia zonas más australes. En el presente trabajo damos a conocer los primeros registros de la especie para la provincia de San Luis, Argentina.

***Palabras clave*:** oso hormiguero menor, Pilosa, Sudamérica, tamandúa, Xenarthra

Records of collared anteaters (*Tamandua tetradactyla*) in San Luis Province, Argentina. Extension of the southern limit of the species distribution

Abstract The collared anteater, *Tamandua tetradactyla*, has a wide distribution in South America, where it inhabits savannas, forests, and rainforests from Venezuela to the north and center of Argentina. In Argentina, it occurs in the provinces of Catamarca, Chaco, Córdoba, Corrientes, Formosa, Jujuy, La Rioja, Misiones, Salta, Santa Fe, Santiago del Estero, and Tucumán. In recent years, specimens have been registered outside the traditional area of distribution, showing a possible southward expansion. In this work we present the first records of the species for the province of San Luis, Argentina.

***Keywords*:** lesser anteater, Pilosa, South America, southern tamandua, Xenarthra

Tamandua tetradactyla, comúnmente denominado oso melero, es una especie que se distribuye ampliamente en Sudamérica, habitando en sabanas, bosques y selvas, desde Venezuela hasta el norte y centro de Argentina. En Argentina habita en las provincias de Catamarca, Chaco, Córdoba, Corrientes, Formosa, Jujuy, La Rioja, Misiones, Salta, Santa Fe, Santiago del Estero y Tucumán (Juliá *et al.*, 1994; Vizcaíno *et al.*, 2006; Torres *et al.*, 2009), abarcando las ecorregiones del Chaco Árido, Chaco Húmedo, Espinal, Esteros de Iberá y Bosques de las Yungas (Abba *et al.*, 2012). La fragmentación y pérdida de hábitat representan las principales amenazas para la especie en Argentina, por lo que la misma se encuentra categorizada como Casi Amenazada (NT) a nivel nacional (Superina *et al.*, 2012). Otras amenazas reportadas para algunos sectores de su rango de distribución son la caza para alimento, el ataque

por perros domésticos, el mascotismo, los incendios y los atropellamientos en rutas (Miranda *et al.*, 2014). Algunas veces, los meleros que son encontrados en estado salvaje son donados o vendidos a zoológicos privados y quizás involucrados en el tráfico ilegal (Superina *et al.*, 2010).

En los últimos años se han registrado ejemplares de oso melero fuera de su área de distribución

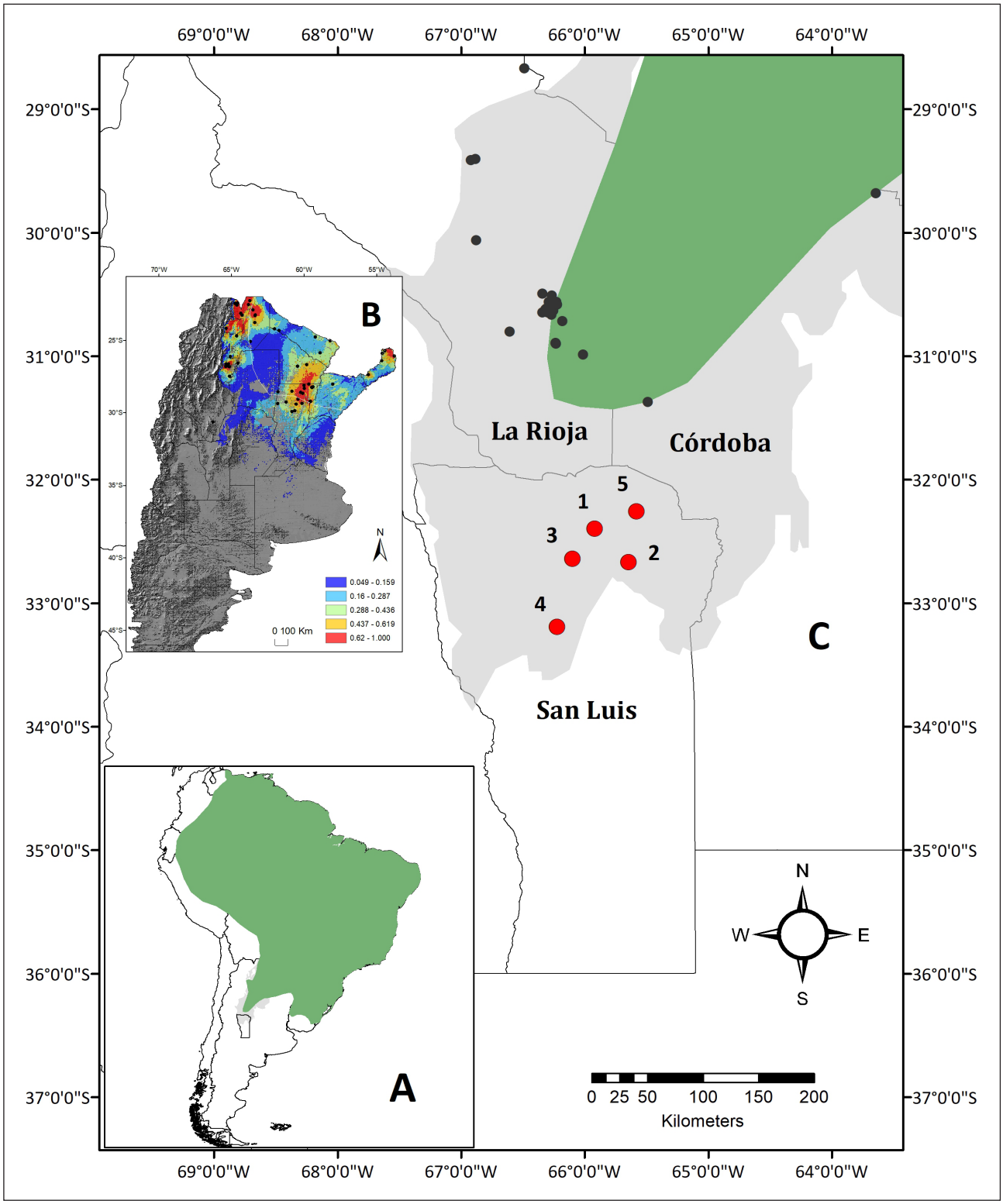

FIGURA 1. Registros de *Tamandua tetradactyla* en la Provincia de San Luis, Argentina. **A.** Área de distribución de la especie según Miranda *et al.* (2014). **B.** Mapa de distribución potencial tomado y modificado de Abba *et al.* (2012). **C.** Registros para la provincia de San Luis (puntos rojos) y para las provincias de Córdoba y La Rioja (puntos negros; Torres *et al.*, 2009; González, 2013). **SOMBREADO VERDE:** límite de distribución sur de la especie. **SOMBREADO GRIS:** límite sur de la ecorregión del Chaco Seco tomado y modificado de Burkart *et al.* (1999).

Tabla 1. Coordenadas geográficas de los registros de *Tamandua tetradactyla* en la provincia de San Luis, Argentina.

ID	Fecha	Lugar	Estado	Latitud	Longitud
1	Marzo 2009	Luján, Reserva Natural Estricta Quebrada de las Higueritas	Ejemplar vivo	32°23'43,69"S	65°55'08,37"W
2	Enero 2014	Potrerillo	Ejemplar muerto por perros domésticos	32°39'58,73"S	65°38'43,35"W
3	Septiembre 2016	San Francisco del Monte de Oro	Ejemplar vivo	32°38'19,72"S	66°05'59,71"W
4	Julio 2017	Potrero de los Funes	Ejemplar vivo	33°11'27,66"S	66°13'19,70"W
5	Febrero 2018	Talita	Ejemplar vivo	32°15'20,41"S	65°34'52,73"W

tradicional (Agüero *et al.*, 2003; Torres *et al.*, 2009; Miranda *et al.*, 2014), por lo que existen algunas dudas sobre los límites de distribución actual de la especie. Vizcaíno & Chebez (2000) señalan como las zonas más marginales de su distribución el norte de Santa Fe y el noroeste de Corrientes. Vizcaíno *et al.* (2006) mencionan distribuciones marginales en las provincias de Córdoba, Santa Fe y Entre Ríos. Durante la década de 1990 comenzaron a registrarse individuos en las provincias de Córdoba y La Rioja, las cuales actualmente son consideradas el límite austral de su distribución natural (Agüero *et al.*, 2003; Torres *et al.*, 2009; Miranda *et al.*, 2014).

Abba *et al.* (2012) elaboraron un mapa de distribución potencial para *T. tetradactyla* trabajando con 56 registros correspondientes a las provincias de Corrientes, Chaco, Formosa, Jujuy, La Rioja, Misiones, Salta, Santa Fe y Tucumán. Sus resultados indican la existencia de hábitat adecuado para la ocurrencia de la especie más al sur del patrón de distribución conocido. Según este modelo de distribución potencial, el límite austral abarcaría un sector al norte de la provincia de San Luis (**Fig. 1B**), aunque hasta el presente no había sido reportada la presencia de la especie en esta provincia.

En este trabajo se dan a conocer por primera vez registros de *T. tetradactyla* en la provincia de San Luis (Argentina) acontecidos durante el período 2009 a 2018, todos ellos consistentes en datos de animales encontrados en el medio silvestre. Durante dicho período han sido documentados cinco individuos en localidades ubicadas en ambientes de pedemonte y serranos, correspondientes a las Sierras Centrales de San Luis y coincidentes con el límite sur de la ecorregión del Chaco Seco (**Fig. 1A** y **Fig. 1C**, **Tabla 1**). Cuatro de ellos continuaron en libertad en el medio silvestre y uno fue hallado muerto. A continuación se detallan los eventos de ocurrencia en la provincia de San Luis en orden de aparición temporal:

- Luján, departamento Ayacucho. Mes de marzo de 2009. Nellar (2011) menciona la existencia de fotografías y filmaciones de un ejemplar vivo en perfectas condiciones que trepaba por los árboles dentro de la Reserva Natural Estricta Quebrada de las Higueritas. Tal registro habría sido realizado por el Sr. C. Villeco, habitante de la localidad de Quines, durante una visita al área protegida. Este dato fue confirmado por el Guardaparque del área protegida Samuel Olivieri (com. pers.), quien además aportó una imagen obtenida por el Sr. Villeco durante aquel encuentro (**Fig. 2A**).
- Potrerillo, departamento Libertador General San Martín. Mes de enero de 2014. La policía de la localidad informa al Ministerio de Medio Ambiente de la provincia sobre la aparición de un ejemplar muerto por perros. El ejemplar se encuentra taxidermizado en la colección del Área de Zoología de la Facultad de Química, Bioquímica y Farmacia de la Universidad Nacional de San Luis (**Fig. 2B**).
- San Francisco del Monte de Oro, departamento Ayacucho. Mes de septiembre de 2016. Encuentro ocasional de Gabriel Marín (com. pers.), habitante de la localidad, con un ejemplar vivo a orillas del río Gómez. El Sr. Marín toma fotografías cuando el animal adopta una postura de amenaza ante su presencia (**Fig. 2C**).
- Potrero de los Funes, departamento Juan Martín de Pueyrredón. Mes de julio de 2017. Encuentro ocasional de Analía Demarco y Federico Ruta (com. pers.) con un ejemplar vivo a orillas del arroyo Áspero durante una excursión por las sierras. Toman fotografías del encuentro (**Fig. 2D**).
- Talita, departamento Junín. Mes de febrero de 2018. Juan García (com. pers.) reporta un encuentro ocasional con un ejemplar dentro del campo de su familia y aporta fotografías tomadas por su hermano Andrés García (**Fig. 2E**).

Solo una parte de los registros aquí presentados coincide con el modelo de distribución elaborado por Abba *et al.* (2012), mientras que otros se extienden un poco más hacia al sur, pero todos los

Figura 2. Fotografías de los ejemplares de *Tamandua tetradactyla* reportados en el presente trabajo. **A.** Luján, imagen aportada por el Guardaparque Samuel Olivieri. **B.** Potrerillo (Fotografía: Noelia Fernández). **C.** San Francisco del Monte de Oro (Fotografía: Gabriel Marín). **D.** Talita (Fotografía: Andrés García). **E.** Potrero de los Funes (Fotografía: Analía Demarco y Federico Ruta).

datos coinciden con el sector más austral de la ecorregión del Chaco Seco. Esta información corrobora la presencia de la especie en la provincia de San Luis, en territorios más al sur del área de distribución clásica conocida. A partir de estos registros surge el interrogante sobre si la especie no había sido hallada con anterioridad en San Luis por falta de estudios a campo o si se está produciendo un paulatino desplazamiento de sus límites de distribución conocida hacia el sur. Teniendo en cuenta que situaciones similares se han dado en las provincias de La Rioja (González, 2013) y Córdoba (Torres *et al.*, 2009), es necesario realizar estudios más detallados para conocer su estado poblacional en San Luis y en el resto de las provincias mencionadas.

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Referencias

Abba, A.M., M.F. Tognelli, V.P. Seitz, B. Bender & S.F. Vizcaíno. 2012. Distribution of extant xenarthrans (Mammalia: Xenarthra) in Argentina using species distribution models. Mammalia 76: 123–136. https://doi.org/10.1515/mammalia-2011-0089

Agüero, J.A., J.V. Díaz & D. González. 2003. Presencia y características del hábitat asociadas a *Tamandua tetradactyla* en las Sierras de los Llanos de La Rioja, Argentina. Pp. 81 in XVIII Jornadas Argentinas de Mastozoología (SAREM, ed.), La Rioja.

Burkart, R., N. Bárbaro, R.O. Sánchez & D.A. Gómez. 1999. Ecorregiones de la Argentina. Administración de Parques Nacionales, PRODIA, Buenos Aires, Argentina. 43 pp.

González, D.S. 2013. Nuevos registros de presencia y distribución de *Tamandua tetradactyla* en la Provincia de la Rioja, Argentina. Informe inédito. Registro de Propiedad Intelectual: safecreative.org. Depósito Código: 1306025203990. Fecha: 02–jun–2013 4:52 UTC.

Juliá, J.P., E. Richard & J. Samaniego. 1994. Nota sobre la distribución geográfica del oso melero (*Tamandua tetradactyla*, Xenarthra: Myrmecophagidae) en el Noroeste Argentino. Nótulas Faunísticas 66: 1–4.

Miranda, F., A. Fallabrino, M.C. Arteaga, D.G. Tirira, D.A. Meritt & M. Superina. 2014. *Tamandua tetradactyla*. The IUCN Red List of Threatened Species 2014: e.T21350A47442916. http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T21350A47442916.en. Consultada el 11 de octubre de 2018.

Nellar, M.M. 2011. Conservación de la naturaleza en la provincia de San Luis. Especies silvestres amenazadas de extinción. Generación Digital, San Luis. 445 pp.

Superina, M., F. Miranda & A.M. Abba. 2010. The 2010 anteater Red List assessment. Edentata 11: 96–114. https://doi.org/10.5537/020.011.0201

Superina, M., A.M. Abba & S.F. Vizcaíno. 2012. Orden Pilosa. Pp. 59–60 in: Libro Rojo de los mamíferos de Argentina (R.A. Ojeda, V. Chillo & G. Díaz, eds.). Sociedad Argentina para el Estudio de los Mamíferos (SAREM), Mendoza.

Torres, R., J. Monguillot, G. Bruno, P. Michelutti & A. Ponce. 2009. Ampliación del límite austral de la distribución del oso melero (*Tamandua tetradactyla*) en la Argentina. Nótulas Faunísticas, Segunda Serie 39: 1–5.

Vizcaíno, S.F. & J.C. Chebez. 2000. *Tamandua tetradactyla*. Pp. 42–43 in: Libro Rojo de mamíferos amenazados de la Argentina (G.B. Díaz & R.A. Ojeda, eds.). Sociedad Argentina para el Estudio de los Mamíferos (SAREM), Mendoza.

Vizcaíno, S.F., A.M. Abba & C.M. García Esponda. 2006. Magnaorden Xenarthra Cope, 1889. Pp. 46–56 in: Mamíferos de Argentina. Sistemática y Distribución (R.M. Barquez, M.M. Díaz & R.A. Ojeda, eds.). Sociedad Argentina para el Estudio de los Mamíferos (SAREM), San Miguel de Tucumán.

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SHORT COMMUNICATION

Giant anteater (*Myrmecophaga tridactyla*) mothers may teach their calves what "not to eat"

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Abstract During a prey scent preference experiment with captive giant anteaters living at the Nashville Zoo (USA), two anteater mothers actively inhibited their dependent calves from investigating non-nourishing but innocuous scents. An exact binomial test showed a statistically significant tendency for the dams to ignore the scents themselves after obstructing the calves' investigation. This is the first known documentation of what appears to be "teaching" behavior in Xenarthra and a rare example of a non-human animal discouraging feeding and smelling behaviors that aren't adversely affecting its young.

Keywords: captivity, feeding behavior, maternal effects, negative reinforcement, prey choice, teaching

Las hembras de oso hormiguero gigante (*Myrmecophaga tridactyla*) pueden enseñar a sus crías lo que «no quieren que coman»

Resumen Durante una investigación de preferencia de olor de presa con osos hormigueros cautivos que viven en el Zoológico de Nashville (EE.UU.), dos hembras inhibieron activamente a sus crías de investigar los olores no nutritivos pero inocuos. Se observó una tendencia estadísticamente significativa de que las hembras ignoran los aromas después de obstruir la investigación de las crías. Esta es la primera documentación conocida de lo que parece ser un comportamiento «de enseñanza» en los xenartros y un ejemplo poco común de animales no humanos desalentando comportamientos de alimentación y olfateo que no están afectando negativamente a sus crías.

Palabras clave: cautiverio, comportamiento alimentario, efectos maternos, elección de presa, enseñanza, refuerzo negativo

The feeding behavior of giant anteaters (*Myrmecophaga tridactyla*) has been well documented (*e.g.*, Redford, 1985; Medri *et al.*, 2003; Miranda *et al.*, 2003; Rodrigues *et al.*, 2008). Individuals travel between concentrations of insect prey, usually ant or termite nests, and revisit specific foraging areas periodically (Montgomery & Lubin, 1977). The literature describes females (dams) accompanied by dependent young (calves) as they forage (*e.g.*, Cabrera & Yepes, 1960; Shaw *et al.*, 1987; Eisenberg & Redford, 1999; Figel *et al.*, 2016). As for how young anteaters develop their own foraging behavior, observations only document that calves explore their surroundings by smell and taste (Bartmann, 1983; Maia, 2002; Valle Jerez & Halloy, 2003). Over the course of experimentally testing captive giant anteaters for prey scent preferences, a novel behavior was observed. Two dams, one wild-caught and one captive-born, sometimes physically blocked their respective calves from trying to investigate and feed at the experimental apparatus, which contained non-nutritious but also non-harmful chemical scents. If dams were not actively trying to influence their calves' investigatory behavior, we would expect that a dam would be equally likely to ignore her calf's behavior as interfere with it. We hypothesize that the giant anteater mothers were intervening in an attempt to teach their offspring

TABLE 1. Behavior of two anteater dams with their calves while investigating prey scents and control scents in an experimental apparatus. Counts were compared with exact binomial goodness-of-fit tests.

	Captive-bred dam	Wild-caught dam
Number of trials analyzed	10	13
Average number of blocks per trial (excluding trials with no blocks)	2.89	2.25
Number of trials with no blocks	1	5
Maximum number of blocks in one trial	7	5
Number of blocks with investigation	6	2
Number of blocks without investigation	20	16

what not to eat, by discouraging them from smelling and tasting the apparatus.

The experiments were performed with the captive population of adult and juvenile giant anteaters at the Nashville Zoo at Grassmere (Nashville, Tennessee, USA) and were approved by the Animal Care and Use Committees at Nashville Zoo and Middle Tennessee State University. One dam was wild-caught and one dam was captive-born, but both have been living at Nashville Zoo for several years. The calves, both females, were born two months apart at the zoo in 2017. Dams and calves were always together in the same enclosure for the experiments. We filmed anteater reactions to two-choice tests between dilute prey scents and a control scent. In trials lasting approximately 3 min, the two dams and their respective calves were presented with a U-shaped plastic pipe with two open ends (**FIG. 1A, 1B**). In each open end, we placed an aluminum tea diffuser containing a cotton ball dampened with 0.5 mL of either a dilute prey scent or a control scent, diethyl phthalate (CAS#84-66-2). This chemical was also used as the solvent (carrier) for the following prey scent dilutions: 0.05% dimethyl disulfide (CAS#624-92-0), a 0.1% 1:1 blend of limonene (CAS#138-86-3) and α-pinene (CAS#80-56-8), a 0.1% 1:1 blend of β-pinene (CAS#127-91-3) and γ-terpinene (CAS#99-85-4), 0.05% cyclohexane (CAS#110-82-7), 0.05% isovaleric acid (CAS#503-74-2), and 0.05% 2-ethyl-3(5,6)-dimethyl pyrazine (CAS#27043-05-6). The experimental chemicals were chosen because they are volatile scent odors of potential giant anteater prey genera (*Nasutitermes* termites: Himuro *et al.*, 2011; Paulino de Mello *et al.*, 2016; *Solenopsis* ants: Vander Meer *et al.*, 2010). At no time could the anteaters actually taste the chemical scents with their tongues because the scented cotton balls were completely enclosed in the aluminum tea diffuser for safety (**FIG. 1A**). The experiments relied on the anteaters' perception of the volatile odors, which are described (by human noses) as follows: sulphurous (dimethyl disulfide); pine/citrus-like (limonene, pinenes, and terpinene); petroleum-like (cyclohexane); sweaty feet/cheese-like (isovaleric acid); and musty/moldy (pyrazine). Because most of these prey chemicals do not readily dissolve in water, we chose a solvent that was relatively safe, stable, and as odorless as possible, but also would allow the volatile prey odors to escape. Diethyl phthalate is an organic solvent and a common additive to cosmetics and plastics; although it has a bitter taste, it is described as "without significant odor" and was safely used as a solvent and control in scent preference experiments with captive carnivores (Nilsson *et al.*, 2014). While this chemical may be perceived differently by giant anteaters, who have an acute sense of smell (McAdam & Way 1967), approximately the same amount of diethyl phthalate (0.5 mL) was applied both as the control and as the carrier for experimental scents that were at concentrations of 0.1% or less.

Trials were run on average once per week between March and August 2018, when calves were 3–9 months old. Dams and calves were always together in the same enclosure for the experiments. Scents were presented in random order, and over the course of the experiment each prey scent was offered in three separate trials. We used plastic gloves when applying scents and handling the pipe apparatus to reduce the influence of human odors on anteater behavior. The apparatuses were thoroughly washed and dried between animals to minimize the transfer of anteater scents and saliva between individuals. Trials were filmed with a GoPro© Hero5 Session camera (GoPro, San Mateo, USA) placed approximately 1.5 m above the apparatus. At the start of each trial, the openings at each end of the tube were set to face the anteaters and the apparatus was secured to the cage door with plastic ties.

The wild-caught dam and her calf were presented with the apparatus in 18 trials. The captive-born dam and her calf were presented with the apparatus in 20 trials. Of 38 trials total, 15 trials were discarded because the calf was either outside of the video frame or stayed on the dam's back and did not interact with the apparatus during the video.

The remaining 23 trial videos where both dam and calf interacted with the apparatus were scored by each author independently for whether and how many times the dam interfered with the calf while it attempted to place its nose into an open end of the apparatus. Dams might ignore their calf's behavior at the apparatus (no blocks during the 3-min trial), or interrupt the calf from licking or smelling at an open end by using their nose, forepaw, or whole body to move the calf's head away (**Fig. 1B–1D**). Counts of blocks were divided into two categories: either the dam blocked the calf and subsequently investigated the apparatus herself (by placing her own nose into an open end), or she blocked the calf and did not subsequently investigate the apparatus.

We measured between-observer reliability by calculating a Pearson's correlation coefficient for the number of blocks counted across the 23 trials (Kaufman & Rosenthal, 2009). We used an exact binomial goodness-of-fit test to compare observed counts in each category (McDonald, 2014).

The inter-observer score correlation coefficient was 0.80. Dams ignored their calf's behavior at the apparatus and permitted them to lick and smell it without any interference in 6 of 23 trials, which is a significantly different proportion from what would be expected by chance under the null hypothesis, which predicts equal amounts of blocking and non-blocking behaviors (**Table 1**; binomial test

Figure 1. **A.** The tea diffuser containing a cotton ball shown as it would appear to the anteaters in one open end of the experimental apparatus; **B.** an anteater dam and her calf ignoring each other and investigating the experimental apparatus together; the green tape indicates the side with the experimental scent; **C–D.** video stills captured anteater dams blocking their calves from investigating the apparatus with the nose [**C**] and the forepaw [**D**].

p-value = 0.0023). When dams interfered with their calves' exploration, they were significantly more likely to block without investigation than block with investigation (binomial test p-value = 2.5 X 10^{-5}). This clearly indicates dams did not interrupt their calves' exploration (tasting and smelling) simply to lick and smell the scents themselves. Taken together, these data support our idea that mothers' behaviors were an effort to teach their offspring what "not to" taste and smell. Although full results are beyond the scope of this short communication, adult anteaters, including dams, were significantly more likely to spend more time investigating the various prey scent dilutions than the control scent (8 anteaters, 74 trials; 1-tailed sign test p-value = 0.013). By contrast, in 16 trials, the two calves tended to spend more time investigating the control scent (10 trials *vs.* 6 trials where they spent more time with the prey scents), but the difference was not statistically significant (1-tailed sign test p-value > 0.2). Over the course of our experiments, the calves grew more exploratory, and the pair would occasionally interact with the apparatus together (**Fig. 1B**). Nonetheless, the dams generally spent much less time than the full trial duration investigating the tube openings, whereas the calves persisted in trying to lick and sniff one or both sides until their mothers intervened and/or the apparatus was removed from the enclosure. Anecdotally, we also observed that dams investigated the apparatus less and less as the experimental period went on, which suggests that they learned it contained no actual food. Blocking behavior was similar in frequency, if not form, between the two mothers (**Table 1**). The captive-bred dam more often used her rostrum instead of her forepaw to move her calf's head away, and sometimes she would lick at the calf's mouth (**Fig. 1C**). The wild-caught dam more often cuffed her calf on the nose with her forepaw (**Fig. 1D**). During several trials, the anteaters seemed to be anticipating their afternoon meal by repeatedly returning to the front of the enclosure and sticking their rostrums out and occasionally licking/smelling the bottom or sides of the door. Neither dam was observed blocking her calf during that type of exploration, even if the calf was "in the way".

Young giant anteaters accompany their mothers on foraging trips for many months during the period of dependency (Eisenberg & Redford, 1999; Valle Jerez & Halloy, 2003; Rodrigues *et al.*, 2008). Presumably, calves may obtain information about the prey the mother selects without much effort on her part, both by imitating her behavior at foraging sites and by passive exposure to prey chemical cues in a manner that is similar to what occurs between mothers and offspring across taxa (*e.g.*, Jaeggi *et al.*, 2008; Vitale *et al.*, 2018). By contrast, active maternal intervention to discourage what is effectively non-profitable behavior is unexpected in this relic species. Since anteaters and most other xenarthrans are described as solitary (Eisenberg & Redford, 1999), there would not seem to be selection pressure for social learning. Only one other study in the superorder Xenarthra describes anything comparable to what we report here: female sloths (*Bradypus variegatus*) supply particular leaves to their infants, who consume those exclusively, while orphan sloths choose poisonous or otherwise inappropriate food items (Soares & Carneiro, 2002).

Active "teaching" by non-human animals in the sense of Caro & Hauser (1992) is generally uncommon although examples continue to emerge from a widening range of taxa. Cetaceans demonstrate feeding/hunting strategies and give younger animals the opportunity to practice by scaring or herding fish and then not pursuing them (Boran & Heimlich, 1999). Chimpanzees (*Pan troglodytes*) demonstrate how to manipulate tools to obtain specific food stuffs such as nuts (Boesch, 1991). Chimpanzees and gorillas (*Gorilla beringei*) will remove non-food, poisonous or otherwise hard-to-process items from their infants (reviewed by Byrne, 1999). Vervet (*Cercopithecus aethiops*) mothers will sometimes bite or slap their young when they give an inappropriate alarm call (reviewed in Caro & Hauser, 1992). When under attack by predators, muskoxen (*Ovibos moschatus*) reportedly head butt calves and may even hook them with their horns when they move too slowly into the protective circle made by adults (reviewed in Klein, 1999). In some felids, mothers hiss at or slap at their kittens to force them to hide when predators appear (reviewed in Kitchener, 1999). In our experiments, captive anteater dams modified their behavior at the experimental apparatus when their calves were present by blocking their calves from continuing to investigate while ignoring the stimuli themselves. We consider below three alternative explanations of the mothers' behavior that does not involve teaching their calves about potential food.

1) *Dams perceived the apparatus or the control diethyl phthalate as a dangerous novel object/smell.* The giant anteaters at Nashville Zoo are presented with novel toys, botanical scents, and puzzle feeders on a regular basis as part of their environmental enrichment. They have experience with a similar pipe apparatus from an enrichment study DDB conducted in 2014 (unpublished data). If anteaters had perceived the chemical odors or apparatus as a threat, they would be expected to consistently block the calves from approaching the apparatus and/or avoid it themselves. Some of the other adult anteaters in this experiment did avoid approaching the apparatus for the first several trials, but the wild-caught dam permitted her calf to explore the apparatus on the very first trial, although she did eventually interfere in that exploration. Dams' behavior differed across trials and between the two

sides of the apparatus so we feel confident in assuming they did not consider the apparatus or volatile odors of diethyl phthalate as threatening (although we also assumed it would not be considered as potential food).

2) *The blocking behaviors were related to normal grooming and play behaviors stimulated by close contact at the apparatus.* While giant anteater mothers do groom their calves and play with them by body wrestling and grasping or swiping at them with their claws (Maia, 2002), dams would most often walk back into the video frame from elsewhere in the enclosure to block the young. Also, our counts of blocks do not include any maternal contact unrelated to the calves' attempts at feeding/smelling the apparatus.

3) *Dams simply interfered when calves spent too much time "obsessing" over the apparatus.* In other words, the observed behavior wasn't about discouraging feeding/smelling behavior but is related to the habit of anteaters to move quickly from site to site rather than lingering (Montgomery & Lubin, 1977). Nevertheless, blocks did not happen at a consistent point in the trials. Blocks also did not necessarily happen when calves persisted in licking the control tea diffuser, the outside of the apparatus, the floor, the door, or other non-food items. Finally, a different dam-calf pair was observed in 2014 with avocado (a preferred treat) hidden inside a similar pipe apparatus. In two trials lasting a total of 20 min, both the dam and the calf spent the majority of the trial exploring the apparatus and all five observed blocks by the dam were followed by investigation, indicating that she was attempting to get the avocado herself. She was not observed blocking the calf from investigating any other part of the apparatus or the floor (DDB, unpublished data).

The differences between the wild-caught and captive-bred dams' behavior are slight, but may also reflect differences in the behavioral tendencies of the calves. Both calves seemed to have a preference for the control stimulus and the zoo staff suggested that regular handling of the calves from birth with plastic gloves might have primed them to prefer the smell and taste of diethyl phthalate. The current dataset does not allow us to determine whether the mothers' efforts changed their calf's exploration behavior over the long term. Furthermore, we are limited in our ability to extrapolate these behaviors observed in captivity to anteaters living in the wild. However, we believe these results show the mother anteaters actively discouraging their calves from expending energy investigating something that may have smelled interesting to the young anteaters, but was actually non-nutritious, even if innocuous. This report remains one of a very few where an animal appears to correct an exploratory behavior that isn't adversely affecting its young.

Supplementary information

Readers may see examples on YouTube© of a trial from each dam at the links that follow.

Praim 29 June 2018
(https://youtu.be/CyCxmxWptRU)

Description: Wild-born adult female giant anteater and 8-month old female calf living in a U.S. zoo. They are investigating an experimental apparatus with a 0.05% solution of isovaleric acid in diethyl phthalate on one end (with green tape) and only diethyl phthalate on the other end. The anteaters cannot taste the chemicals, only smell them. The mother interferes twice with the calf's investigation of the apparatus over the course of the trial.

Consuela 22 June 2018
(https://youtu.be/GQHj2iovKOs)

Description: Captive-born adult female giant anteater and 6-month old female calf living in a U.S. zoo. They are investigating an experimental apparatus with a 0.10% solution of 1:1 β-pinene and γ-terpinene in diethyl phthalate on one end (with green tape) and only diethyl phthalate on the other end. The anteaters cannot taste the chemicals, only smell them. The mother interferes twice with the calf's investigation of the apparatus over the course of the trial.

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References

Bartmann, W. 1983. Haltung und Zucht von Grossen Ameisenbären, *Myrmecophaga tridactyla*, im Dortmunder Tierpark. Zoologischer Garten Neue Folge 53: 1–31.

Boesch, C. 1991. Teaching among wild chimpanzees. Animal Behaviour 41: 530–532. https://doi.org/10.1016/S0003-3472(05)80857-7

Boran, J.R. & S.L. Heimlich. 1999. Social learning in cetaceans: hunting, hearing and hierarchies. Pp. 282–307 in: Mammalian social learning comparative and ecological perspectives (H.O. Box & K.R. Gibson, eds.). Cambridge University Press, Cambridge.

Byrne, R.W. 1999. Cognition in great ape ecology: skill-learning ability opens up foraging opportunities. Pp. 333–350 in: Mammalian social learning comparative and ecological perspectives (H.O. Box & K.R. Gibson, Eds.). Cambridge University Press, Cambridge.

Cabrera, A. & J. Yepes. 1960. Los Edentados. Pp. 51–70 in: Mamíferos Sud Americanos. Ediar, Buenos Aires.

Caro, T.M. & M. Hauser. 1992. Is there teaching in non-human animals? The Quarterly Review of Biology 67: 151–174.

Eisenberg, J.F. & K.H. Redford. 1999. Mammals of the Neotropics, Vol. 3. The Central Neotropics: Ecuador, Bolivia, Brazil. University of Chicago Press, Chicago.

Figel, J.J., S. Botero-Cañola, J.D. Sánchez-Londoño & A. Quintero-Ángel. 2016. Unexpected documentation and inter-Andean range expansion of a vulnerable large mammal (Mammalia, Pilosa, *Myrmecophaga tridactyla*) in Colombia. Mammalia 80: 449–452. https://doi.org/10.1515/mammalia-2015-0037

Himuro, C., T. Yokoi & K. Matsuura. 2011. Queen-specific volatile in a higher termite *Nasutitermes takasagoensis* (Isoptera: Termitidae). Journal of Insect Physiology 57: 962–965. https://doi.org/10.1016/j.jinsphys.2011.04.012

Jaeggi, A.V., M.A. Van Noordwijk & C.P. Van Schaik. 2008. Begging for information: mother-offspring food sharing among wild Bornean orangutans. American Journal of Primatology 70: 533–541. https://doi.org/10.1002/ajp.20525

Kaufman, A. & R. Rosenthal. 2009. Can you believe my eyes? The importance of interobserver reliability statistics in observations of animal behaviour. Animal Behaviour 78: 1487–1491. http://psycnet.apa.org/doi/10.1016/j.anbehav.2009.09.014

Kitchener, A.C. 1999. Watch with mother: a review of social learning in the Felidae. Pp. 236–258 in: Mammalian social learning comparative and ecological perspectives (H.O. Box & K.R. Gibson, eds.). Cambridge University Press, Cambridge.

Klein, D.R. 1999. Comparative social learning among arctic herbivores: the caribou, muskox and arctic hare. Pp. 126–140 in: Mammalian social learning comparative and ecological perspectives (H.O. Box & K.R. Gibson, eds.). Cambridge University Press, Cambridge.

Maia, O.B. 2002. Maternal behavior of two captive giant anteaters *Myrmecophaga tridactyla* Linnaeus, 1758. Revista de Etologia 4: 41–47.

McAdam, D.W. & J.S. Way. 1967 Olfactory discrimination in the giant anteater. Nature 214: 316–317. https://doi.org/10.1038/214316a0

McDonald, J.H. 2014. Handbook of biological statistics (3rd ed.). Sparky House Publishing, Baltimore, Maryland.

Medri, I.M., G.M. Mourão & A.Y. Harada. 2003. Dieta de tamanduá-bandeira (*Myrmecophaga tridactyla*) no Pantanal da Nhecolândia, Brasil. Edentata 5: 28–34.

Miranda, G.H.B., F.H.G. Rodrigues, Í.M. Medri & F.V. dos Santos. 2003. Giant anteater (*Myrmecophaga tridactyla*) beehive foraging at Emas National Park, Brazil. Edentata 5: 55.

Montgomery, G.G. & Y.D. Lubin. 1977. Prey influences on movements of Neotropical anteaters. Pp. 103–131 in: Proceedings of the 1975 predator symposium, Montana Forest and Conservation experiment station (R.L. Philips & C.J. Jonkel, eds.). University of Montana Press, Missoula, Montana.

Nilsson S., J. Sjoberg, M. Amundin, C. Hartmann, A. Buettner & M. Laska. 2014. Behavioral responses to mammalian blood odor and a blood odor component in four species of large carnivores. PLoS ONE 9(11): e112694. https://doi.org/10.1371/journal.pone.0112694

Paulino de Mello, A., N.R. Azevedo, A.M. Barbosa-Silva & M.A. Bezerra-Gusmão. 2016. Chemical composition and variability of the defensive secretion in *Nasutitermes corniger* (Motschulsky, 1885) in urban area in the Brazilian semiarid region. Entomotropica 31: 82–90.

Redford, K.H. 1985. Feeding and food preference in captive and wild giant anteaters *Myrmecophaga tridactyla*. Journal of Zoology (London) 205: 559–572. https://doi.org/10.1111/j.1469-7998.1985.tb03544.x

Rodrigues, F.H.G., I.M. Medri, G.H.B. de Miranda, C. Camilo-Alves & G. Mourão. 2008. Anteater behavior and ecology. Pp. 257–268 in The biology of the Xenarthra (S.F. Vizcaíno & W.J. Loughry, eds.). University Press of Florida, Gainesville.

Shaw, J., J. Machado-Neto & T. Carter. 1987. Behavior of free-living giant anteaters (*Myrmecophaga tridactyla*). Biotropica 19: 255–259. https://doi.org/10.2307/2388344

Soares, C.A. & R.S. Carneiro. 2002. Social behavior between mothers × young of sloths *Bradypus variegatus* Schinz, 1825 (Xenarthra: Bradypodidae). Brazilian Journal of Biology 62: 249–252. http://dx.doi.org/10.1590/S1519-69842002000200008

Valle Jerez, S. & M. Halloy. 2003. El oso hormiguero, *Myrmecophaga tridactyla*: crecimiento e independización de una cría. Mastozoología Neotropical 10: 323–330.

Vander Meer, R.K., C.A. Preston & M.Y. Choi. 2010. Isolation of a pyrazine alarm pheromone component from the fire ant, *Solenopsis invicta*. Journal of Chemical Ecology 36: 163–170. https://doi.org/10.1007/s10886-010-9743-0

Vitale, A.A., S.T. McKinney & D.W. Linden. 2018. Maternal effect and interactions with philopatry in subadult female American black bear, *Ursus americanus*, den selection. Animal Behaviour 138: 131–139. https://doi.org/10.1016/j.anbehav.2018.02.008

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FIELD NOTE

Predation of a Central American coral snake (*Micrurus nigrocinctus*) by a nine-banded armadillo (*Dasypus novemcinctus*) in Santa Rosa National Park, Costa Rica

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Abstract We describe the manner in which a nine-banded armadillo (*Dasypus novemcinctus*) killed a Central American coral snake (*Micrurus nigrocinctus*) that it subsequently ate. The armadillo repeatedly ran towards, jumped, flipped over in mid-air, and landed on top of the snake with its back until the snake was dead.

Keywords: armadillo, behavior, food, predation, snake

Depredación de una serpiente de coral de América Central (*Micrurus nigrocinctus*) por un armadillo de nueve bandas (*Dasypus novemcinctus*) en el Parque Nacional Santa Rosa, Costa Rica

Resumen En esta nota describimos la manera en que un armadillo de nueve bandas (*Dasypus novemcinctus*) mató a una serpiente de coral de América Central (*Micrurus nigrocinctus*) que posteriormente comió. El armadillo corrió varias veces hacia adelante, saltó, se dio vuelta en el aire y aterrizó sobre la serpiente con la espalda hasta que la serpiente estuvo muerta.

***Palabras clave*:** armadillo, comida, comportamiento, depredación, serpiente

Nine-banded armadillos (*Dasypus novemcinctus*) feed mostly on arthropods such as beetles, termites, and ants, but also consume bird eggs and "unusual items" such as fruits, fungi, and small vertebrates (McBee & Baker, 1982; Wetzel, 1991; Carrillo *et al.*, 1999; Loughry & McDonough, 2013). Snakes have been reported in the diet of the armadillo in Louisiana, Alabama, and Florida in the U.S. (Fitch *et al.*, 1952; Breece & Dusi, 1985; Wirtz *et al.*, 1985), and in Bolivia (Salazar-Bravo *et al.*, 2010), but no observations have been reported regarding the manner in which such prey, or any other vertebrate prey, is captured (Loughry & McDonough, 2013:130). Here we describe the predation of a Central American coral snake (*Micrurus nigrocinctus*) by a nine-banded armadillo.

The ~4-kg nine-banded armadillo is distributed from the southeast and central United States to Uruguay and northern Argentina, Granada, Trinidad and Tobago, and the Margarita Islands (Loughry *et al.*, 2014). On the Caribbean and Pacific slope of Costa Rica it lives from sea level to 2,600 m asl in humid and dry forests, wooded areas, and savannas (Vaughan & Shoenfelder, 1999), and is mainly nocturnal and solitary. The ~1-m Central American coral snake is distributed from Oaxaca and Chiapas in Mexico to northwestern Colombia, is found on the Pacific Coast of Costa Rica, and is active both day and night (Solórzano, 2004).

The predation event took place around 16:00 hr on 7 December 1985 (temperature ~25 °C), at the

beginning of the dry season (December–April), in Santa Rosa National Park, Costa Rica (10°47'59.82"N, 85°38'56.52"W), a dry tropical forest (Janzen & Hallwachs, 2016). As EC walked down a forest path, he heard a noise among the leaves, and a few thuds, about 10 m away from the path. Upon entering the forest, he observed, from a distance of ~5 m, an armadillo that made unusual movements near a live coral snake ~1 m long. The armadillo moved away from the snake 1–2 m and then returned running. Perhaps 0.2 m before reaching the snake, the armadillo jumped ~0.5 m in the air, turned, and fell on the snake, landing on its armored back. The armadillo did that 6 or 7 times until the snake was dead. Then, the armadillo began to eat the snake, a process that lasted approximately 30 min; it consumed the entire snake.

Reptilian and amphibian prey of armadillos includes skinks, anoles, glass lizards, frogs, toads, and salamanders (Fitch *et al.*, 1952; Breece & Dusi, 1985; Wirtz *et al.*, 1985). Given this, it is not surprising that snakes are consumed by armadillos, as well, but it has not been documented frequently. Three small snakes (2 rough earth snakes [*Haldea striatula*, formerly *Virginia striatula*], 1 unidentifiable) were recorded in stomachs of armadillos from Louisiana (Fitch *et al.*, 1952), and another rough earth snake was recorded as armadillo food in Alabama (Breece & Dusi, 1985). In Florida, armadillo stomachs contained water snake (*Natrix* sp.) and garter snake (*Thamnophis* sp.) hatchlings (Wirtz *et al.*, 1985), and a 244-mm specimen of Boettger's ground snake (*Atractus boettgeri*) was found in the stomach of a nine-banded armadillo in Bolivia (Salazar-Bravo *et al.*, 2010). Small whole snakes (~250 mm) also have been recorded in the diet of the yellow armadillo (*Euphractus sexcinctus*) in south-central Brazil (Dalponte & Tavares-Filho, 2004). Vertebrate prey appears to be taken more often in the winter; for reptile and amphibian prey, this may be because these species are ectotherms and they may move more slowly and be more easily caught when it is cold (Loughry & McDonough, 2013:134).

The manner in which the coral snake was crushed by a 4-kg jumping armadillo in Costa Rica seems unique but, given armadillo morphology and behavior, it makes some sense. First, although the carapace may provide some protection against predators (Wetzel, 1991; Loughry & McDonough, 2013:75), it might also provide protection from bites of poisonous snakes. Armadillos are surprisingly speedy and agile, especially over short distances (Loughry & McDonough, 2013:180) and will pounce upon and rip apart larger prey such as grasshoppers (Loughry & McDonough, 2013:179). In addition, armadillos roll on their back to mud bathe (Loughry & McDonough, 2013:182), and when alarmed or about to be captured, an armadillo jumps straight up and arches its back (Talmage & Buchanan, 1954; Wetzel, 1991); in one case, this behavior was in reaction to discovering a large cottonmouth snake (*Agkistrodon piscivorus*) lying at the base of a tree (Loughry & McDonough, 2013:189). Also, during intraspecific fights, armadillos can jump and flip in the air in attempts to avoid, or deliver, blows (Loughry & McDonough, 2013:191). Thus, armadillos are physically capable of killing snakes in the way that is reported here, but until more foraging armadillos are observed for long periods of time, it is unlikely that such behavior will be confirmed.

References

Breece, G.A. & J.L. Dusi. 1985. Food habits and home ranges of the common long-nosed armadillo *Dasypus novemcinctus* in Alabama. Pp. 419–428 in: The evolution and ecology of armadillos, sloths, and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington, D.C.

Carrillo, E., G. Wong & J. Saenz. 1999. Mammals of Costa Rica. Instituto Nacional de Biodiversidad, San José, Costa Rica. 300 pp.

Dalponte, J.C. & J.A. Tavares-Filho. 2004. Diet of the yellow armadillo, *Euphractus sexcinctus*, in south-central Brazil. Edentata 6: 37–41. https://doi.org/10.1896/1413-4411.6.1.37

Fitch, H.S., P. Goodrum & C. Newman. 1952. The armadillo in the southeastern United States. Journal of Mammalogy 33: 21–37. https://doi.org/10.2307/1375638

Janzen, D.H. & W. Hallwachs. 2016. Biodiversity conservation history and future in Costa Rica: the case of Area de Conservación Guanacaste (ACG). Pp. 290–341 in: Costa Rican ecosystems (M. Kappelle, ed.). The University of Chicago Press, Chicago, Illinois. http://dx.doi.org/10.7208/chicago/9780226121642.003.0010

Loughry, W.J. & C.M. McDonough. 2013. The nine-banded armadillo — a natural history. University of Oklahoma Press, Norman, Oklahoma. 323 pp.

Loughry, W.J., C.M. McDonough & A.M. Abba. 2014. *Dasypus novemcinctus*. The IUCN Red List of Threatened Species 2014: e.T6290A47440785. http://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T6290A47440785.en

McBee, K. & R.J. Baker. 1982. *Dasypus novemcinctus*. Mammalian Species 162: 1–9. https://doi.org/10.2307/3503864

Salazar-Bravo, J., J. Vargas, A. Jimenez-Ruiz & J.M. Savage. 2010. A new record of *Atractus boettgeri* (Serpentes: Colubridae), with notes on taxonomy and natural history. Revista Mexicana de Biodiversidad 81: 925–929.

Solórzano, A. 2004. Serpientes de Costa Rica. Instituto Nacional de Biodiversidad, San José, Costa Rica. 791 pp.

Talmage, R.V. & G.D. Buchanan. 1954. The armadillo (*Dasypus novemcinctus*). A review of its natural history, ecology, anatomy and reproductive physiology.

The Rice Institute Pamphlet, Monographs in Biology 41(2): 1–135.

Vaughan, C. & S. Shoenfelder. 1999. Dry season activity, movement, habitat and den utilization of nine-banded armadillo (*Dasypus novemcinctus*) in neotropical dry forest, Costa Rica. Revista de Biología Tropical 47: 1117–1119.

Wetzel, R.M. 1991. *Dasypus novemcinctus* (Cusuco, Armadillo). Pp. 465–467 in: Costa Rican natural history (D.H. Janzen, ed.). The University of Chicago Press, Chicago, Illinois.

Wirtz, W.O., D.H. Austin & G.W. Dekle. 1985. Food habits of the common long-nosed armadillo *Dasypus novemcinctus* in Florida, 1960–1961. Pp. 439–451 in: The evolution and ecology of armadillos, sloths, and vermilinguas (G.G. Montgomery, ed.). Smithsonian Institution Press, Washington, D.C.

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IUCN/SSC Anteater, Sloth & Armadillo Specialist Group

FIELD NOTE

Tayra (*Eira barbara*) predation of a brown-throated three-toed sloth (*Bradypus variegatus*) in Costa Rica

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Abstract Being strictly arboreal, sloths become more vulnerable to predation when on the ground. Records of such predation, however, are rare. Here we present video documentation of a tayra (*Eira barbara*) preying on a juvenile brown-throated three-toed sloth (*Bradypus variegatus*) in Barbilla National Park, Costa Rica. Tayras and other ground predators, plus human activities such as habitat fragmentation, are probably major factors influencing sloth life history and permanence in the ecosystem. Predation by tayras might be more common than we think, particularly in disturbed forests.

Keywords: arboreal, Barbilla National Park, behavior, diet, prey

Depredación de perezoso de tres dedos (*Bradypus variegatus*) por tolomuco (*Eira barbara*) en Costa Rica

Resumen Al ser estrictamente arbóreos, los perezosos se vuelven más vulnerables a la depredación cuando están en el suelo. Sin embargo, los registros de dicha depredación son raros. Aquí presentamos la documentación en video de un tolomuco (*Eira barbara*) que caza un juvenil de perezoso de tres dedos (*Bradypus variegatus*) en el Parque Nacional Barbilla, Costa Rica. Tolomucos y otros depredadores terrestres, además de actividades humanas como la fragmentación del hábitat, son posiblemente los principales factores que influyen en la historia de vida de los perezosos y su permanencia en los ecosistemas. La depredación por tolomucos podría ser más común de lo que pensamos, particularmente en bosques perturbados.

***Palabras clave*:** arbóreos, comportamiento, dieta, Parque Nacional Barbilla, presa

Of the many anti-predator options available to mammals (Caro, 2005), flight (*i.e.*, "running away") is not one employed by sloths, often noted as being among the slowest of all living mammals (Britton, 1941b). Even though highly adapted for an arboreal lifestyle (Britton, 1941b), the slow movements and cryptic pelage of sloths do not fully protect them from canopy predators, whether avian (Beebe, 1926; Retting, 1978; Galetti & Carvalho, 2000; Touchton *et al.*, 2002; Voirin *et al.*, 2009; Aguiar-Silva *et al.*, 2017) or mammalian (Bezerra *et al.*, 2009; Sobroza *et al.*, 2016).

Even greater helplessness and vulnerability to predation of sloths on the ground (Mendel, 1985; Wainwright, 2002) is likely because "…progression is very slow [even for the sloth] and difficult" (Britton, 1941a:24). Beebe (1926:16) reported that "a mother sloth on the ground, speeded up by the calls of her infant, made 14 feet in one minute." It is not surprising, then, that sloths spend little time on the ground. Unintended "ground-time" may result from fights resulting in falls from trees (Ingles, 1953), but sloths also come to the ground to defecate at an average interval of 8 days, with each visit lasting

FIGURE 1. Photos (from a 30-sec video) of a tayra (*Eira barbara*) preying on a juvenile brown-throated three-toed sloth (*Bradypus variegatus*) in Barbilla National Park, Costa Rica.

just a few minutes (Montgomery & Sunquist, 1975). More importantly, sloths move on the ground to get to other trees, sometimes crossing pastures (Vaughan *et al*., 2007), roads (Britton, 1941a), and rivers (Beebe, 1926), thus exposing themselves to possible predation for longer periods of time.

The brown-throated three-toed sloth (*Bradypus variegatus*) and Hoffmann's two-toed sloth (*Choloepus hoffmanni*) have been reported as prey of several felids, including jaguars (*Panthera onca*), pumas (*Puma concolor*), and ocelots (*Leopardus pardalis*; Beebe, 1926; Garla *et al*., 2001; Moreno *et al*., 2006), and canids such as coyotes (*Canis latrans*) and domestic dogs (Vaughan *et al*., 2007; Peery & Pauli, 2014). However, these observations have come mostly from studies of stomach contents, scats, or other signs; there is just a single published report of an actual predation event, specifically by a coyote of a Hoffmann's two-toed sloth on the ground (Sibaja-Morales & Cartín Núñez, 2017). Here we report the predation of a juvenile brown-throated three-toed sloth by a tayra (*Eira barbara*), known locally as the tolomuco, as documented by a video recorded by a remote camera.

During 2009–2016, we set cameras in Barbilla National Park (9°58'19"N, 83°28'51"W), located in the northern Talamanca Mountains of Costa Rica, to document the distribution and relative abundance of jaguars and other wildlife (*cf*. Sáenz-Bolaños *et al*., 2015). At 21 locations in the park, we placed cameras (Trophy Cam models 119436, 119446, 119456, Bushnell, Overland Park, USA) on trees 0.5 m above the ground and near a human trail or animal path where we thought a jaguar might pass, and recorded either three individual photos taken 1 sec apart or a 30-sec video, with a minimum interval of 1 min between consecutive recordings.

In total, we accumulated 8,450 trap nights at the 21 camera stations. Tayras were photographed a total of 56 times at 12 (57%) of the stations; at the one station that recorded the single brown-throated three-toed sloth photographed and reported here, 14 (25%) of the tayra photos were taken. This camera trap station was located at the end of a steep

area in primary forest close to the Danta River. Forest disturbance was very low at this location; trees were big and tall with nice canopy overlap. Thus, the absence of tall trees likely was not the reason the sloth came to the ground. Moreover, the only human activity recorded in more than seven years at this station was just one video of two indigenous people with a rifle.

The video of the sloth (as best we could tell, a juvenile male) was recorded at 05:29 hr on 3 May 2013. The video begins with the tayra in the foreground walking away from the camera on a line 1 m to the left of and 2 m away from a lone sloth in the background (which the tayra is walking toward). The sloth is 0.3 m off the ground and moving down a tree perhaps 12 cm in diameter. The tayra lifts its nose, seemingly sniffing the air, walking slowly and pausing briefly. When about 1 m from the sloth, it continues sniffing but orients to the sloth (3 sec after the video begins) and then approaches it, touching it with its nose (at 8 sec; **Fig. 1**; https://youtu.be/7WhLYIhgdeU). The tayra sniffs both sides and underneath the sloth, the sloth moves slightly, then the tayra noses higher, swipes at the sloth briefly with its left front paw (at 17 sec), and then grabs it by its head (at 20 sec), bites around its neck and then, placing its right paw on the body, pulls it down from the tree (at 24 sec). It then appears to bite around the sloth's head and neck while the sloth weakly reaches its right arm toward the body of the tayra. The video ends at 29 sec; we believe that the sloth was killed. The next videos taken at this camera station were recorded 23 min later; they were of a tayra of the same size, apparently searching for something, sniffing all around and climbing the tree where the sloth had been. However, no sloth carcass subsequently could be found, nor could any evidence of blood, hair or something else related to the attack.

Tayras forage on the ground and in the trees of tropical and subtropical forests, and are considered opportunistic omnivores, consuming a variety of fruits, small vertebrates, insects, carrion, and honey (Presley, 2000). Tayra prey also includes medium-sized ground mammals such as rabbits (*Sylvilagus floridanus*, *S. brasiliensis*), opossums (*Didelphis marsupialis*), agoutis (*Dasyprocta punctata*), and pacas (*Agouti paca*; Galef *et al*., 1976; Janzen, 1983; Calouro, 2000; Wainwright, 2002), and their excellent climbing skills allow them to prey on arboreal woolly opossums (*Caluromys derbianus*; Ceballos, 2016), primates such as common marmosets (*Callithrix jacchus*; Bezerra *et al*., 2009) and red-handed howlers (*Alouatta belzebul*; Camargo & Ferrari, 2007), and sloths (Bezerra *et al*., 2009; Sobroza *et al*., 2016).

Sloths descend to the ground either when they are obliged to move to another tree that is not possible to reach via the canopy, or weekly to defecate. Being on the ground is a risky and energetically costly activity (Pauli *et al*., 2014) that exposes sloths to potentially high and population-limiting predation, the latter being particularly important given the species' long lifespan and low fecundity (Peery & Pauli, 2014). Thus, abundant predators such as tayras, but including many other mesopredators, could be major factors influencing sloth life history and permanence. In addition, human activities might increase the importance of mesopredator predation on sloths. For example, habitat fragmentation could eliminate canopy connections between trees and also remove apex predators. The former might force sloths to go to the ground more frequently, while the latter might result in an increase in mesopredator abundance (Ritchie & Johnson, 2009). If so, then predation by tayras (and other mesopredators) of sloths could be more common than is currently appreciated.

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References

Aguiar-Silva, F.H., O. Jaudoin, T.M. Sanaiotti, G.H.F. Seixas, S. Duleba & F.D. Martins. 2017. Camera trapping at harpy eagle nests: interspecies interactions under predation risk. Journal of Raptor Research 51: 72–78. https://doi.org/10.3356/JRR-15-58.1

Beebe, W. 1926. The three-toed sloth *Bradypus cuculliger* Wagler. Zoologica 7: 1–67.

Bezerra, B.M., A. Barnett, A. Souto & G. Jones. 2009. Predation by the tayra on the common marmoset and the pale-throated three-toed sloth. Journal of Ethology 27: 91–96. https://doi.org/10.1007/s10164-008-0090-3

Britton, S.W. 1941a. Form and function in the sloth. The Quarterly Review of Biology 16: 13–34. https://doi.org/10.1086/394620

Britton, S.W. 1941b. Form and function in the sloth (concluded). The Quarterly Review of Biology 16: 190–207. https://doi.org/10.1086/394628

Calouro, A.M. 2000. Attempted predation on Brazilian rabbit (*Sylvilagus brasiliensis* — Lagomorpha: Leporidae) by tayra (*Eira barbara* — Carnivora: Procyonidae). Revista de Biología Tropical 48: 267–268.

Camargo, C.C. & S.F. Ferrari. 2007. Interactions between tayras (*Eira barbara*) and red-handed howlers (*Alouatta belzebul*) in eastern Amazonia. Primates 48: 147–150. https://doi.org/10.1007/s10329-006-0009-y

Caro, T. 2005. Antipredator defenses in birds and mammals. University of Chicago Press, Chicago, Illinois, USA. 592 pp.

Ceballos, G. 2016. Observation of attempted predation of a woolly opossum (*Caluromys derbianus*) by a tayra (*Eira barbara*) during daylight in Belize. Revista Mexicana de Mastozoología Nueva Época 6: 46–49.

Galef, B.G. Jr., R.A. Mittermeier & R.C. Bailey. 1976. Predation by the tayra (*Eira barbara*). Journal of Mammalogy 57: 760–761. https://doi.org/10.2307/1379450

Galetti, M. & O. Carvalho, Jr. 2000. Sloths in the diet of a harpy eagle nestling in Eastern Amazon. The Wilson Bulletin 112: 535–536. https://doi.org/10.1676/0043-5643(2000)112[0535:SITDOA]2.0.CO;2

Garla, R.C., E.Z. Setz & N. Gobbi. 2001. Jaguar (*Panthera onca*) food habits in Atlantic rain forest of southeastern Brazil. Biotropica 33: 691–696.

Ingles, L.G. 1953. Observations on Barro Colorado Island mammals. Journal of Mammalogy 34: 266–268. https://doi.org/10.1093/jmammal/34.2.266a

Janzen, D.H. 1983. Costa Rican natural history. University of Chicago Press, Chicago, Illinois, USA. 816 pp.

Mendel, F.C. 1985. Use of hands and feet of three-toed sloths (*Bradypus variegatus*) during climbing and terrestrial locomotion. Journal of Mammalogy 66: 359–366. https://doi.org/10.2307/1381249

Montgomery, G.G.& M.E. Sunquist.1975. Impact of sloths on Neotropical forest energy flow and nutrient cycling. Pp. 69–98 in: Tropical ecological systems (F.B. Golley & E. Medina, eds.). Springer Verlag, New York. https://doi.org/10.1007/978-3-642-88533-4_7

Moreno, R.S., R.W. Kays & R. Samudio, Jr. 2006. Competitive release in diets of ocelot (*Leopardus pardalis*) and puma (*Puma concolor*) after jaguar (*Panthera onca*) decline. Journal of Mammalogy 87: 808–816. https://doi.org/10.1644/05-MAMM-A-360R2.1

Pauli, J.N., J.E. Mendoza, S.A. Steffan, C.C. Carey, P.J. Weimer & M.Z. Peery. 2014. A syndrome of mutualism reinforces the lifestyle of a sloth. Proceedings of the Royal Society B 281: 20133006. https://doi.org/10.1098/rspb.2013.3006

Peery, M.Z. & J.N. Pauli. 2014. Shade-grown cacao supports a self-sustaining population of two-toed but not three-toed sloths. Journal of Applied Ecology 51: 162–170. https://doi.org/10.1111/1365-2664.12182

Presley, S.J. 2000. *Eira barbara*. Mammalian Species 636: 1–6. https://doi.org/10.2307/0.636.1

Retting, N.L. 1978. Breeding behavior of the harpy eagle (*Harpia harpyja*). The Auk 95: 629–643.

Ritchie, E.G. & C.N. Johnson. 2009. Predator interactions, mesopredator release and biodiversity conservation. Ecology Letters 12: 982–998. https://doi.org/10.1111/j.1461-0248.2009.01347.x

Sáenz-Bolaños, C., V. Montalvo, T.K. Fuller & E. Carrillo. 2015. Records of black jaguars at Parque Nacional Barbilla. Cat News 62: 38–39.

Sibaja-Morales, K.D. & M. Cartín Núñez. 2017. Unusual predation of Hoffmann's two-toed sloth (*Choloepus hoffmanni*) by a coyote (*Canis latrans*) in Costa Rica. Edentata 18: 89–91. https://doi.org/10.2305/IUCN.CH.2017.Edentata-18-1.13.en

Sobroza, T.V., A.L. Gonçalves & L. Silva dos Santos. 2016. Predation attempt and abnormal coat coloration of the tayra (*Eira barbara*) in the Brazilian Central Amazon. Studies on Neotropical Fauna and Environment 51: 231–234. https://doi.org/10.1080/01650521.2016.1227137

Touchton, J., Y.C. Hsu & A. Palleroni. 2002. Foraging ecology of reintroduced captive-bred subadult harpy eagles (*Harpia harpyja*) on Barro Colorado Island, Panama. Ornitología Neotropical 13: 365–379.

Vaughan, C., O. Ramírez, G. Herrera & R. Guries. 2007. Spatial ecology and conservation of two sloth species in a cacao landscape in Limon, Costa Rica. Biodiversity and Conservation 16: 2293–2310. https://doi.org/10.1007/s10531-007-9191-5

Voirin, B., R. Kays, M. Lowman & M. Wikelski. 2009. Evidence of three-toed sloth (*Bradypus variegatus*) predation by spectacled owl (*Pulsatrix perspicillata*). Edentata 8–10: 15–20. https://doi.org/10.1896/020.010.0113

Wainwright, M. 2002. The natural history of Costa Rican mammals. Zona Tropical Publications, Miami, Florida, USA. 383 pp.

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News

Animal Educators and Nurtured by Nature are supporting the IUCN SSC Anteater, Sloth and Armadillo Specialist Group and the Brazilian three-banded armadillo conservation program

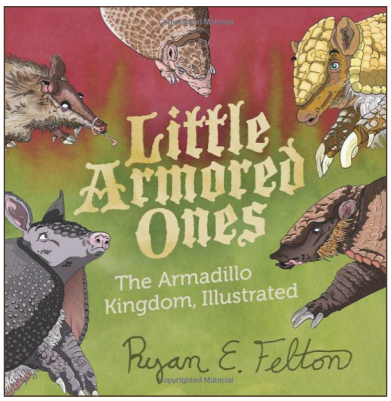
Animal Educators Inc. and its non-profit, Nurtured by Nature Inc., are organizations headquartered in Valley Center (California) that, among other things, develop, implement, and provide sustainable interactions with the wonders of nature and environmentally sustainable breeding conservation programs for several species of reptiles and mammals. Several years ago, the co-founders of these organizations, Kevin and Wendy Yates, realized that zoos were importing southern three-banded armadillos (*Tolypeutes matacus*) for their collections, and that mortality rates of these animals were up to 50%. They created a solution to the problem by establishing a southern three-banded armadillo breeding project. With over 100 offspring born over seven years, Animal Educators and Nurtured by Nature managed to significantly reduce imports of wild-caught three-banded armadillos by zoological institutions in the US.

To show their commitment to the conservation of Xenarthra, Animal Educators and Nurtured by Nature have recently established an agreement with the IUCN SSC Anteater, Sloth and Armadillo Specialist Group to help fund the Brazilian three-banded armadillo conservation program. After their initial donation, Kevin and Wendy implemented a policy whereby any zoo that purchases a three-banded armadillo from their facility must make a mandatory donation to the conservation program. In addition, they will contribute their vast knowledge on the maintenance and captive reproduction of *Tolypeutes* to the *ex situ* breeding program of both species of three-banded armadillos.

Animal Educators is part of the AZA Regional Studbook for southern three-banded armadillos. We are extremely grateful for their commitment and generous donation!

Art exhibit highlights armadillos and raises money to support the ASASG

In March of this year artist Ryan Felton hosted an exhibition of his artwork that celebrated his passion for armadillos. Ryan developed his love for armadillos despite growing up in the state of Indiana, USA, where no armadillos occur (at least until very recently, and only now in the very southern tip of the state). Despite this childhood deprivation, Ryan has become a champion for armadillos; his main mission is to raise public awareness of these little-known mammals.



The exhibit featured a painting, most on circular pieces of wood, of each species of armadillo, with an accompanying bit of text describing some of their basic features and a map showing their geographic distribution. Although somewhat fanciful with regard to facial features and expressions, the paintings were otherwise morphologically accurate; a strip of paper below each painting indicated the actual length of each species, not including the tail. The final component to the exhibit was two letters of welcome, written by Specialist Group members Mariella Superina and Jim Loughry, that

highlighted our need to know more about armadillos and, most important, how to conserve them.

In addition to the paintings, the exhibit served as a platform for Ryan to promote his book: *Little Armored Ones: The Armadillo Kingdom, Illustrated* (self published, ISBN-13: 978-1984055101; available at www.amazon.com), which featured reproductions of his paintings, as well as the accompanying text and maps from the exhibit. The target audience for both the book and exhibit is children and young adults, although adults can certainly learn many new things about each species too.

The event was well received; Ryan estimated that about 150 people attended, perhaps lured in part by the prospect of free armadillo-themed cupcakes to consume while enjoying the exhibit. There was also a special guest star: Xander, a live screaming hairy armadillo, who Ryan introduced to people and who was the center of considerable attention.

Of particular interest to Specialist Group members is that Ryan encouraged attendees to make donations to the Anteater, Sloth and Armadillo Specialist Group. The great news is that they did so, with contributions totaling about US$ 400. As we all know, every bit of funding helps, and it is gratifying to know that so many people, most of whom know very little about armadillos, are still willing to assist our efforts. Best wishes for continued success to Ryan as he continues his campaign on behalf of all things armadillo.

4TH ANNUAL MONITORING OF THE NATIONAL ACTION PLAN FOR THE CONSERVATION OF THREE-BANDED ARMADILLOS (*TOLYPEUTES* SPP.)

The Technical Advisory Group of the National Action Plan for the Conservation of Three-banded Armadillos (*Tolypeutes* spp.), representing four Brazilian institutions, met on 3–4 October 2018, in João Pessoa, Paraíba, Brazil, for its 4th annual monitoring workshop.

This meeting, sponsored by the Chico Mendes Institute for Biodiversity Conservation (ICMBio) through the National Center for Research and Conservation of Brazilian Primates (CPB) and the Directorate of Research, Assessment and Monitoring of Biodiversity (DIBIO), is one of the components

of the Action Plan for the Conservation of the Three-banded Armadillo (PAN Tatu-bola). The main goal of the action plan is to develop strategies to reduce the risk of extinction of *Tolypeutes tricinctus* to the category of "Vulnerable", and to ensure the proper evaluation of the conservation status of *T. matacus* in the country.

The activities of this PAN (started in 2014 and continuing until 2019) involve:

1. To update the areas of occurrence of both *Tolypeutes* species.
2. Assess the main threats to each species' conservation throughout their geographic distribution.
3. Raise awareness in local communities and the broader society about the importance of protecting *T. tricinctus* in the Caatinga and Cerrado.
4. Increase knowledge about both species' biology and ecology to guide conservation strategies.
5. Expand, train, and hire surveillance personnel to suppress the hunting of *T. tricinctus*.
6. Reduce the rate of habitat loss and promote connectivity among populations of *T. tricinctus*.

These activities were organized into 30 specific actions, of which 41% have already been concluded or are in progress. These involve mainly:

- Mapping of the current and potential distribution of the two species of *Tolypeutes*,
- the creation of protected areas in areas of occurrence of *T. tricinctus*,
- educating the public on the implications of three-banded armadillo hunting, and
- studies on the genetics, habitat use, activity patterns, and diets of both species.

Some actions are facing difficulties in their execution. These include those related to the development of protocols for where and how to maintain captive individuals, the establishment of protocols for environmental licensing in areas of occurrence

of *Tolypeutes* spp., training of surveillance agents to inspect and control hunting activities, and development of restoration projects to improve connectivity in areas of occurrence of *T. tricinctus*. Given this scenario, new strategies were discussed to improve the performance of participants in the PAN, and new partnerships are being established for the execution of these actions in 2019.

For additional information about the Brazilian Action Plan for the Conservation of the Three-banded Armadillo, see http://www.icmbio.gov.br/portal/faunabrasileira/plano-de-acao-nacional-lista/4808-plano-de-acao-nacional-para-conservacao-do-tatu-bola

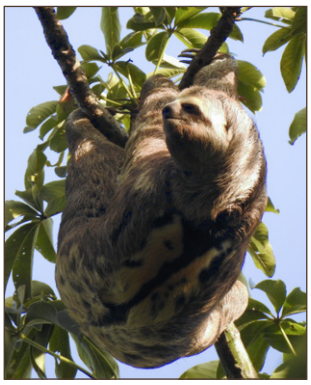
Flávia Miranda receives Honorable Mention for one of the best doctoral theses in Brazil

Specialist Group member Dr. Flávia Miranda has received recognition from the Brazilian Academy of Sciences for having produced one of the best doctoral theses in the country. Dr. Miranda won a Honorable Mention for her dissertation titled "Integrative taxonomy of the genus *Cyclopes* Gray 1821 (Xenarthra, Pilosa)". There were many criteria for the award, among which were the originality and ultimate quality of the thesis, its potential importance in the area of systematic zoology, its impact not only in the field of study but in other disciplines as well, and the number and quality of publications that could be derived from the thesis.

Congratulations to Dr. Miranda on behalf of the IUCN SSC Anteater, Sloth and Armadillo Specialist Group!

New Xenarthra rehab center in Córdoba, Colombia

The confiscation of trafficked or mistreated sloths, anteaters, and armadillos is frequent in Colombia. Fundación AIUNAU, led by Specialist Group member Tinka Plese, has been dedicated to the rescue and rehabilitation of xenarthrans, as well as other threatened species, for many years. Since 2002, this institution has received more than 1200 animals, most of them sloths, at their Rescue and Rehabilitation Center for Xenarthra (CRRX) in the department of Antioquia, Colombia. A second facility has now opened in El Alto, in the department of Córdoba, which will allow AIUNAU to take care of trafficked and injured wildlife from northern Colombia. The new facility is located within a private reserve called Betanci, which protects about 600 hectares of tropical dry forest (https://youtu.be/HN804odd2_Q). Two hectares have been allotted to the rehab center, which consists of four spacious enclosures—with plenty of space for additional ones—, a small clinic where the animals can receive treatment with traditional and non-traditional medicines, and an apartment for the three staff members who take care of the animals. In addition to helping injured wildlife, this new center will allow Fundación AIUNAU to extend its conservation efforts to another part of the country.



We wish Fundación AIUNAU lots of success with their new rehab center!

New rescue center for sloths, anteaters and armadillos in Suriname

Green Heritage Fund Suriname (GHFS), led by Specialist Group member Monique Pool, was established in 2005 to help improve the fate of animals. Their first program, dedicated to the Xenarthra, aimed at conveying a conservation message by means of creating a sustainable education product for the public. On 2 November 2018, GHFS officially opened its Rescue Center for Sloths, Anteaters and Armadillos. Affectionately known as the

"Sloth Wellness Center", this new rehab center will allow Monique and her team to provide rescued xenarthrans with the care they need before returning to their natural habitat. The ceremony to open the center was attended by many friends, volunteers, and several government representatives, including Suriname's Minister of Spatial Planning, Land and Forest Management, Roline Samsoedien. The Minister stated that the Education Department of her Nature Conservation Division was going to work together with GHFS to raise public awareness of the need to protect xenarthrans and other species.

We wish GHFS all success with their new Sloth Wellness Center!

Armadillos, anteaters and sloths in the *Handbook of the Mammals of the World*, Volume 8

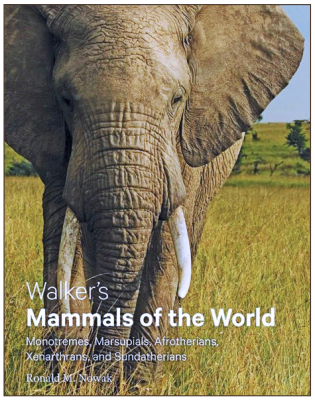
Cingulata and Pilosa are the first two orders treated in the penultimate volume of the *Handbook of the Mammals of the World*. Several chapters are authored by IUCN SSC Anteater, Sloth and Armadillo Specialist Group members including Colleen McDonough & James Loughry (Dasypodidae), Mariella Superina & Agustín Abba (Chlamyphoridae), Flávia Miranda (Cyclopedidae), and Nadia Moraes-Barros (Megalonychidae). Each of these lavishly illustrated chapters, as well as those for Myrmecophagidae (authored by Alessandra Bertassoni) and Bradypodidae (authored by Jonathan Pauli), summarizes the respective Family's systematics, morphological aspects, habitat, general habits, communication, food and feeding, breeding, movements, home range, social organization, relationship with humans, status, and conservation. In turn, individual species accounts provide common names and a distribution map together with taxonomy, subspecies and distributions, descriptive notes, as well as details on the topics treated above if available.

Specialist Group chair Mariella Superina also co-authored the Volume's special introductory chapter on Conservation Priorities and Actions, focusing on the current IUCN Red List status and risk of extinction for Cingulata and Pilosa. Although only two of 20 extant species of Cingulata are listed in a threatened Red List category, only four species have stable populations while population trends are decreasing for six and unknown for ten species. One in four extant species are so poorly known they are categorized as Data Deficient. As for Pilosa, one of the ten anteaters and two of the six sloths are listed in a threatened category. But many species in each Family lack conservation-relevant information, and research is urgently needed on their ecology, population numbers and trends, and the threats they face.

Priority species highlighted in this chapter, with details of major threats as well as current conservation efforts, are the Brazilian three-banded armadillo (*Tolypeutes tricinctus*), the giant armadillo (*Priodontes maximus*), the pygmy three-toed sloth (*Bradypus pygmaeus*), the maned three-toed sloth (*Bradypus torquatus*), and the giant anteater (*Myrmecophaga tridactyla*). Research and conservation programs should be supported by more training for students and professionals, and more technical advice to authorities.

Don E. Wilson & Russell A. Mittermeier (eds.). 2018. Handbook of the Mammals of the World, Volume 8. Insectivores, Sloths and Colugos. Lynx Edicions in association with Conservation International and IUCN, Barcelona. 710 pp. ISBN-13: 978-84-16728-08-4.

A new edition of Walker's *Mammals of the World* has been published



Updating a zoological classic, this volume covers 19 of the 31 historical and modern mammal orders, including the Cingulata and Pilosa. It represents the most sweeping modification of Walker's since publication of the first edition in 1964. Compared to corresponding sections of the 1999 edition, text length has doubled, a proportional increase far greater than in any previous revision. Every old generic account has been substantively changed, 17 accounts of newly described genera have been added, and many separate species accounts have been prepared. About 2,200 new references are cited and about 1,000 have been retained from the 1999 edition. The original illustrations, all black and white, have been almost completely replaced with more than 500 new color images, including beautiful photos of live individuals of Xenarthra, and scientifically prepared paintings of extinct genera, such as the giant ground sloth *Mylodon darwinii*. Topics covered for each genus include scientific and common name, number and distribution of species, measurements, physical description, habitat, locomotion, daily and seasonal activity, diet,

population dynamics, home range, social life, reproduction, longevity, and relationship with people. The volume discusses every species, subspecies, and population that is historically extinct or listed in a category of concern by the IUCN, CITES, and U.S. Department of the Interior.

Nowak, R.M. 2018. Walker's Mammals of the World: Monotremes, Marsupials, Afrotherians, Xenarthrans, and Sundatherians. Johns Hopkins University Press, Baltimore, Maryland, USA. 784 pp. ISBN: 9781421424675.

A special course on medicine and conservation of Xenarthra was held in Brazil

Every year, the Wildlife Research Group of Brazil (Grupo de Estudos em Animais Selvagens do Brasil, GEAS) organizes an academic event that aims at increasing knowledge about native wildlife. This year GEAS teamed up with the Tamandua Institute (formerly Projeto Tamanduá) to celebrate the Year of the Anteater, an initiative of the Association of Zoos and Aquaria of Brazil, by offering a course on medicine and conservation of Xenarthra.

The course was held from 15–18 November 2018 at the University of São Paulo's Faculty of Veterinary Medicine. The first three days consisted of talks by renowned experts, including Flávia Miranda, Rogério Zacariotti, and Karina Molina. Specialist Group Chair Mariella Superina participated by videoconference. Several mini-courses were offered on the last day; topics included the care of offspring, nutrition, and diseases of Xenarthra under human care.

Over 100 registered participants and around 20 collaborators made this event a real landmark for the conservation of anteaters, sloths, and armadillos in Brazil. Such courses are fundamental to disseminate knowledge and experience, and to train future specialists.

Re-assessment of the conservation status of Xenarthra in Argentina

In October 2017, an agreement was signed between Argentina's Secretary of Environment and Sustainable Development (SAyDS) and the Argentinean Society for the Study of Mammals (SAREM) to re-assess the conservation status of the 408 mammal species of Argentina. The re-assessment follows IUCN's Guidelines for application of IUCN Red List criteria at regional and national levels. More than 450 specialists are participating in this process, which includes the development of a database with species descriptions and updated range maps. The compiled information will be made available through an online system.

The re-assessment of the Xenarthra is being coordinated by our Red List Authority Agustín M. Abba and our Chair Mariella Superina. Thirty mammalogists are participating in the assessment of 17 species: *Bradypus variegatus*, *Myrmecophaga tridactyla*, *Tamandua tetradactyla*, *Tolypeutes matacus*, *Cabassous chacoensis*, *Ca. tatouay*, *Priodontes maximus*, *Chaetophractus vellerosus*, *Cha. villosus*, *Zaedyus pichiy*, *Euphractus sexcinctus*, *Calyptophractus retusus*, *Chlamyphorus truncatus*, *Dasypus hybridus*, *D. novemcinctus*, *D. septemcinctus*, and *D. mazzai*.

The re-assessment process is expected to conclude by mid-2019. It will be used to update the official list of threatened mammals of Argentina within the framework of the Law on Wildlife Conservation No. 22421.

Re-assessment of the conservation status of the Xenarthra and development of national action plans for *Myrmecophaga tridactyla* and *Priodontes maximus* in Brazil

The Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), an institution of the Federal Government of Brazil, recently dedicated an entire week to hold two extremely important workshops that focused on the conservation of Brazilian species of Xenarthra.

Between 26 and 30 November 2018, more than 15 experts met in João Pessoa, Paraíba, to carry out the second Assessment of the conservation status of the Xenarthra of Brazil. A total of 21 species were assessed during this workshop, including four recently described *Cyclopes* species (*C. xinguensis*, *C. ida*, *C. thomasi*, and *C. rufus*). Based on new information, *Dasypus hybridus* and *Cabassous chacoensis* were removed from the list of xenarthrans native to Brazil, and their conservation status was therefore not evaluated.

The assessment workshop was followed by a second workshop to develop the National Action Plans for the conservation of giant anteaters (*Myrmecophaga tridactyla*) and giant armadillos (*Priodontes maximus*). Eight specific objectives and 31 actions were identified, which will be implemented over a period of five years.

The Brazilian Government will publish the results of both workshops in 2019. These are important steps to ensure the long-term persistence of the Xenarthra in Brazil.

2018: "Raise this Flag", The Year of the Anteater

Every year, the Association of Zoos and Aquaria of Brazil (AZAB) teams up with a research and conservation institution to hold a campaign of environmental education and awareness about a Brazilian animal species. This year's campaign was dedicated to anteaters, and the collaborating institution was the Instituto Tamanduá (formerly Projeto Tamanduá).

Many institutions, zoos, and aquaria from several continents participated in the campaign "Raise this Flag"—a wordplay referring to the Portuguese name of the giant anteater, tamanduá-bandeira, with "bandeira" meaning "flag". They organized a variety of environmental education activities to disseminate knowledge about the different anteater species, awaken curiosity and affection by the public for these fascinating species, and raise awareness about protecting the ecosystems they inhabit. A total of 27 institutions—22 of them from Brazil, 1 from Peru, 3 from Asia, and 2 from Europe—have participated in the activities, which reached over 50,000 people from all age groups and a variety of social, cultural, and economic levels. Thanks to all these participants, the Year of the Anteater is the largest campaign ever undertaken by AZAB and a research institution.

An environmental education booklet, the first of its kind to focus exclusively on anteaters, was developed within the framework of the Year of the Anteater. It is available in three languages (Portuguese, English, and Spanish) and includes environmental education activities, comics, and games. It is available for download on the official campaign website.

The Year of the Anteater is supported by the IUCN SSC Anteater, Sloth and Armadillo Specialist Group, the World Association of Zoos and Aquariums (WAZA), the Latin American Zoo and Aquarium Association (ALPZA), and the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) of the Ministry of Environment of the Federal Government of Brazil.

For more information, please visit the official website:
http://www.anodotamandua.wix.com/campanha2018

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NOTES TO CONTRIBUTORS

Edentata is the official, peer-reviewed, annual publication of the IUCN/SSC Anteater, Sloth and Armadillo Specialist Group. It aims to publish information that contributes to the conservation of xenarthrans.

A broad range of topics is welcomed and encouraged but only manuscripts that make substantial contributions to the conservation of xenarthrans will be accepted. These topics include taxonomy, systematics, genetics, biogeography, ecology, conservation, behavior, and health. Manuscripts must describe original research findings that have not been published or submitted simultaneously to other journals. Any overlap of contents with already published papers should be minimal. ***Edentata*** also encourages submission of short communications, field notes, thesis abstracts, news items, recent events, book reviews, congress announcements, and the like.

Manuscripts may be written in English, Portuguese or Spanish. Authors whose first language is not English should please have their texts *carefully reviewed* by a native English speaker.

Once the manuscript has been received, the editors will perform a first evaluation. Manuscripts not satisfying the editorial instructions will be returned to the authors without review. Manuscripts judged appropriate by the editors are subjected to peer review. The formal review process is performed by at least two reviewers per manuscript who are not members of the editorial committee.

Detailed instructions to authors are available on the Specialist Group's website <http://www.xenarthrans.org/newsletter>.

PAUTAS PARA LOS COLABORADORES

Edentata es la publicación oficial, anual y revisada por pares del Grupo de Especialistas en Osos Hormigueros, Perezosos y Armadillos de la IUCN/SSC (IUCN/SSC Anteater, Sloth and Armadillo Specialist Group). Está dedicada a la difusión de información que contribuya a la conservación de los xenartros.

Se aceptan manuscritos que se encuentren dentro de una amplia variedad de temáticas, pero que hagan sustanciales aportes a la conservación, incluyendo: taxonomía, sistemática, genética, biogeografía, ecología, conservación, comportamiento y salud. Los manuscritos deben ser trabajos originales y no haber sido publicados ni enviados simultáneamente a otros medios de publicación. La superposición de contenidos con artículos relacionados ya publicados debe ser mínima. También se alienta el envío de comunicaciones breves, notas de campo, resúmenes de tesis, noticias, información sobre eventos, revisiones de libros, avisos de congresos, etc.

Los manuscritos pueden estar redactados en inglés, portugués o español. En el caso de autores cuya lengua materna no sea el inglés y envíen manuscritos en ese idioma, deberán someter el texto a una *revisión detallada* por una persona angloparlante nativa o traductor profesional.

Los manuscritos que no cumplan con las normas establecidas serán devueltos a los autores sin pasar al proceso de revisión por pares. Todos los manuscritos que son considerados apropiados por los editores son sometidos a revisión externa. El sistema de arbitraje recurre a al menos dos evaluadores por manuscrito que no pertenecen al comité editorial.

Las normas editoriales detalladas se pueden bajar de la página <http://www.xenarthrans.org/newsletter?lang=es>.

INSTRUÇÕES AOS COLABORADORES

Edentata é a publicação oficial, anual e com arbitragem científica do Grupo de Especialistas em Tamanduás, Preguiças e Tatus da IUCN/SSC (IUCN/SSC Anteater, Sloth and Armadillo Specialist Group). Tem como finalidade a difusão de informações que contribuam para a conservação dos xenartros.

Incentiva-se a submissão de manuscritos dentro de uma ampla variedade de tópicos, mas só são aceitos trabalhos que apresentem contribuições significativas à conservação dos xenartros. O tópicos incluem taxonomia, sistemática, genética, biogeografia, ecologia, conservação, comportamento e saúde. Os manuscritos devem ser trabalhos originais, que não foram publicados ou submetidos simultaneamente a outros periódicos. Qualquer sobreposição de conteúdo com artigos já publicados deve ser mínima. ***Edentata*** incentiva também a submissão de comunicações breves, notas de campo, resumos de teses, informações sobre eventos, revisões de livros, avisos de congressos, entre outros.

Os manuscritos podem ser redigidos em inglês, português ou espanhol. Aos autores cuja língua materna não seja o inglês, e que optem por enviar manuscritos nesse idioma, solicita-se uma *revisão detalhada* por pessoa nativa ou tradutor profissional. Assim que os manuscritos são recebidos, os editores fazem uma primeira avaliação.

Os manuscritos que não estejam de acordo com as normas editoriais são devolvidos aos autores, sem revisão. Os manuscritos considerados apropriados pelos editores são submetidos à revisão por pares. O processo de revisão de cada manuscrito envolve a avaliação de pelo menos dois revisores, que não podem ser membros do comitê editorial.

As normas editoriais detalhadas estão disponíveis na página do grupo de especialistas <http://www.xenarthrans.org/newsletter?lang=pt>.


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