

Distribution, ecology, and conservation of *Xenarthra* in Bolivia — update to 2021

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Abstract We present an update on the taxonomy, distribution, ecology, threats, and conservation status of Bolivian *Xenarthra* (orders Cingulata and Pilosa) based on articles published between 2010 and 2021. The Andean hairy armadillo *Chaetophractus nationi* has been synonymized with the less threatened *C. vellerosus*. *Cabassous squamicaudis* has been revalidated for Bolivia. *Dasypus kappleri* has been divided into three species; *D. beniensis* is the species present in Bolivia. *Cyclopes didactylus* was divided into seven species; *C. catellus* is the species in Bolivia. *Chlamyphorus* was divided into two genera; *Calyptophractus retusus* is the species in Bolivia. Recent camera trap and biodiversity surveys extend records of *Xenarthra* into the dry forests of the central and southern Andes of Bolivia. No comprehensive population assessment or basic ecological studies were undertaken for any *Xenarthra* species in the country during the period. However, indirectly, armadillos and anteaters have been included in recent studies using camera traps to evaluate effects of forest management, forest fragmentation, agriculture, and hunting on terrestrial mammals. Deforestation is the major threat to *Xenarthra*, exacerbated by economic pressures, policy changes, and frequent extensive fires in the past decade. The majority of xenarthrans are affected by hunting for subsistence consumption, meat sales, and/or cultural purposes. Overall, the conservation status of *Xenarthra* species in Bolivia is thought to be relatively stable, with vast protected areas, indigenous territories, and certified forestry concessions where deforestation and hunting are limited. However, outside of protected areas, threats are increasing. Direct research on Bolivian *Xenarthra* is needed, especially studies on long-term population trends, habitat preferences, and distribution in less-studied and threatened ecosystems such as the Chiquitano Dry Forest and the Bolivian-Tucumán Forest.

Keywords: Anteaters, armadillos, sloths, taxonomy, threats

Resumen Presentamos una actualización sobre la taxonomía, distribución, ecología, amenazas y estado de conservación de los Xenarthra (órdenes Cingulata and Pilosa) en Bolivia, con base en publicaciones entre 2010 y 2021. El armadillo peludo andino (quirquincho) *Chaetophractus nationi* ha sido sinonimizado con la especie menos amenazada *C. vellerosus*. *Cabassous squamicaudis* ha sido revalidado para Bolivia. *Dasyopus kappleri* fue dividido en tres especies; *D. beniensis* es la especie en Bolivia. *Cyclopes didactylus* fue dividido en siete especies; *C. catellus* es la especie en Bolivia. *Chlamyphorus* fue dividido en dos géneros; *Calyptophractus retusus* es la especie en Bolivia. Estudios recientes con cámaras trampa y evaluaciones de biodiversidad han extendido la distribución de los Xenarthra a los bosques secos de los Andes centrales y meridionales de Bolivia. No existen evaluaciones poblacionales o estudios ecológicos para ninguna especie de Xenarthra. Indirectamente, los armadillos y osos hormigueros han sido incluidos en recientes estudios con cámaras trampa que evaluaron los efectos del manejo forestal, la fragmentación forestal, la agricultura y la caza de los mamíferos terrestres. La deforestación es la mayor amenaza para las especies de Xenarthra, agravada por la presión económica, los cambios de políticas y los extensos y frecuentes incendios de la última década. La mayoría de las especies están afectadas por la cacería de subsistencia, venta de carne y/o fines culturales. En general, se piensa que el estado de conservación de los Xenarthra en Bolivia es relativamente estable, debido a las vastas áreas protegidas, territorios indígenas y concesiones forestales certificadas donde la deforestación y la caza son aún limitadas. Fuera de las áreas protegidas las amenazas aumentan. Se requiere investigación dirigida hacia los Xenarthra, especialmente evaluaciones de sus tendencias poblacionales, preferencia de hábitat y distribución en ecosistemas menos estudiados y amenazados como los bosques de la Chiquitania y el bosque Boliviano-Tucumano.

Palabras clave: Amenazas, armadillos, osos hormigueros, perezosos, taxonomía

INTRODUCTION

In Bolivia, the supraorder Xenarthra is one of the least-studied mammal groups. This group consists of two orders, Pilosa and Cingulata, with 16 species recognized in Bolivia: eleven armadillos, two sloths, and three anteaters (Aguirre *et al.*, 2019; Feijó & Anacleto, 2021; **TABLE 1**). Noss *et al.* (2010a, 2010b) published an exhaustive review of the distribution, ecology, and conservation of xenarthrans. Here, we present an update of the research on Xenarthra in Bolivia with focus on their taxonomy, distribution, ecology, threats, and conservation status. We evaluated references published between 2010 and 2021 using the bibliography for armadillos (between 2011 and 2019) on the IUCN SSC Ant-eater, Sloth & Armadillo Specialist Group website <https://www.xenarthrans.org/armadillo-bibliography/> and all other publications on Bolivian Xenarthra known to the authors.

TAXONOMY

Although the taxonomy of Cingulata and Pilosa has been stable above the family level, recent analyses using molecular techniques have reorganized the taxonomy of several genera of Bolivian armadillos (Aguirre *et al.*, 2019). The most notable change is the synonymization of the Andean hairy armadillo *Chaetophractus nationi* (locally called a *quirquincho*) with the more common screaming hairy armadillo, *Chaetophractus vellerosus*, based on morphological and molecular analyses of animals from Oruro Department (Abba *et al.*, 2015). Further molecular analyses suggested that *C. nationi*

is a disjunct series of populations of *C. vellerosus* (Poljak *et al.*, 2018). However, we question the synonymization of *C. nationi* because quirquinchos live exclusively in sand dunes at 4,000 m asl, whereas *C. vellerosus* are habitat generalists living at lower altitudes, and the two distributions are disjunct.

Analyses for the genus *Dasyopus* by Feijó & Cordeiro-Estrela (2016) and Feijó *et al.* (2018, 2019) suggested that the greater long-nosed armadillo *D. kappleri* was a complex of three species with allopatric distributions, with the Beni greater long-nosed armadillo *D. beniensis* being the species that occurs in Bolivia. The genus *Cabassous* was reviewed by Feijó & Anacleto (2021), and based on complementary morphological approaches they revalidated the Cerrado naked-tailed armadillo *Cabassous squamicaudis* which occurs in southern Bolivia. Finally, the genus *Chlamyphorus* was divided into two genera by Delsuc *et al.* (2012) and Smith & Owen (2017), with the genus *Calyptophractus* replacing *Chlamyphorus* for the Chacoan fairy armadillo *Calyptophractus retusus*.

TABLE 1 presents an updated list of the armadillos of Bolivia, with eleven species in six of the eight recognized genera. Only the genera *Chlamyphorus* and *Zaedyus* have not been recorded for Bolivia (Aguirre *et al.*, 2019).

In Bolivia, the Order Pilosa includes three species of anteaters: two representatives of the family Myrmecophagidae (the giant anteater *Myrmecophaga tridactyla* and the southern tamandua *Tamandua tetradactyla*) and one representative of the family Cyclopedidae (the Amboro silky anteater *Cyclopes*

TABLE 1. Current recognized species of Xenarthra in Bolivia following Aguirre *et al.* (2019) with the exception of *Cabassous squamicaudis* following Feijó & Anacleto (2021). Levels of threat follow the IUCN categorization (**EN** = Endangered; **LC** = Least Concern; **NT** = Near Threatened; **VU** = Vulnerable; **DD** = Data Deficient), and the Red List for Bolivia (MMAyA, 2009). *Cabassous squamicaudis* has not yet been evaluated for level of threat.

Family-subfamily	Species recognized in Bolivia	Synonym	IUCN	Bolivia Red List
Dasypodidae / Dasypodinae	<i>Dasypus beniensis</i>	<i>Dasypus kappleri beniensis</i>	LC	NT
	<i>Dasypus novemcinctus</i>	<i>Dasypus novemcinctus novemcinctus</i>	LC	LC
	<i>Dasypus septemcinctus</i>		LC	LC
Chlamyphoridae / Euphractinae	<i>Chaetophractus vellerosus</i>	Including former <i>Chaetophractus nationi</i>	LC	<i>C. vellerosus</i> and <i>C. nationi</i> are included in the Bolivia Red List as NT and EN, respectively
	<i>Chaetophractus villosus</i>		LC	NT
	<i>Euphractus sexcinctus</i>	<i>Euphractus sexcinctus boliviae</i>	LC	LC
Chlamyphoridae / Tolypeutinae	<i>Cabassous unicinctus</i>	<i>Cabassous unicinctus unicinctus</i>	LC	DD
	<i>Cabassous squamicaudis</i>	<i>Cabassous unicinctus squamicaudis</i>	–	–
	<i>Priodontes maximus</i>		VU	VU
	<i>Tolypeutes matacus</i>		NT	VU
Cyclopedidae	<i>Cyclopes catellus</i>	<i>Cyclopes didactylus catellus</i>	LC	DD
Myrmecophagidae	<i>Myrmecophaga tridactyla</i>		VU	NT
	<i>Tamandua tetradactyla</i>		LC	LC
Megalonychidae / Choloepinae	<i>Choloepus hoffmanni</i>		LC	DD
Bradypodidae	<i>Bradypus variegatus</i>		LC	LC

catellus; **TABLE 1**). The genera *Myrmecophaga* and *Tamandua* were studied using the entire mitochondrial genome, but the authors found no changes affecting the species present in Bolivia (Ruiz-García *et al.*, 2021). The genus *Cyclopes* was revised by Miranda *et al.* (2018) using mitochondrial and nuclear DNA, species delimitation analysis, skull morphology, and pelage color and structure. They divided *C. didactylus* into seven species, with *C. catellus* being the species in Bolivia (**TABLE 1**).

Finally, there have been no changes in the number of sloth species present in Bolivia (**TABLE 1**). Two species of sloths continue to be recognized, including one representative of Megalonychidae (Hoffmann's two-toed sloth *Choloepus hoffmanni*) and one representative of Bradypodidae (the brown-throated three-toed sloth *Bradypus variegatus*) (Aguirre *et al.*, 2019). However, a recent mitochondrial DNA study proposed that the morphological subspecies

B. variegatus boliviensis is invalid and Bolivian specimens belong to *B. variegatus infuscatulus* (Ruiz-García *et al.*, 2020).

DISTRIBUTION

The most recent evaluation of Bolivian medium and large-sized mammals (Wallace *et al.*, 2010) and associated database (Wallace *et al.*, 2013) updated the distribution records of Xenarthra in Bolivia. Here we combine those records with new records collected since 2012 (**ANNEX 1, 2**; **TABLE 2**). All distribution maps show records with high (direct observation, specimen collected, high-quality photographs) and medium taxonomic confidence (footprints, tracks, low quality photographs). New distribution records come from four principal sources: camera trap surveys, biodiversity studies, opportunistic visual records by field biologists, and *iNaturalist* (**TABLE 2**). Although the *iNaturalist*

TABLE 2. New distributional records for Xenarthra species in Bolivia by method (the first three collected by field biologists).

Species	Camera trap surveys	Biodiversity studies	Opportunistic visual records	<i>iNaturalist</i>
<i>Dasyus beniensis</i>	44	3	–	–
<i>Dasyus novemcinctus</i>	276	14	1	7
<i>Dasyus septemcinctus</i>	2	2	2	1
<i>Chaetophractus vellerosus</i>	–	1	2	2
<i>Chaetophractus villosus</i>	–	–	–	–
<i>Euphractus sexcinctus</i>	8	11	1	11
<i>Calyptophractus retusus</i>	–	2	1	–
<i>Cabassous</i> spp.	–	–	–	2
<i>Cabassous unicinctus</i>	–	–	–	–
<i>Cabassous squamicaudis</i>	–	–	–	–
<i>Priodontes maximus</i>	122	4	1	3
<i>Tolypeutes matacus</i>	–	1	–	4
<i>Cyclopes catellus</i>	–	1	–	3
<i>Myrmecophaga tridactyla</i>	167	14	1	10
<i>Tamandua tetradactyla</i>	51	11	5	11
<i>Choloepus hoffmanni</i>	–	–	3	8
<i>Bradypus variegatus</i>	–	3	–	29

(<https://www.inaturalist.org/>) citizen science initiative provided abundant data over the last decade, especially at sites near urban areas, we included only records collected by biologists who use that platform, and after validation by the authors of this publication and other specialists. Below we summarize the new records by species.

Dasyus beniensis
(Beni greater long-nosed armadillo)

New records come from the Wildlife Conservation Society's (WCS) long-term camera trap studies in La Paz Department at Pampas del Heath, Madidi National Park and Integrated Management Area, as well as from the Pilón Lajas Biosphere Reserve and Communal Land in Beni Department (WCS, unpublished data). In addition, specimens collected in Beni Department initially reported as *D. kappleri* were reviewed and validated as *D. beniensis* by Feijó & Cordeiro-Estrela (2016).

Dasyus novemcinctus
(nine-banded armadillo)

New records were obtained from WCS's long-term camera trap study in La Paz Department at Pampas del Heath, Madidi National Park and Integrated Management Area, as well as from the Pilón Lajas Biosphere Reserve and Communal Land in Beni Department (WCS, unpublished data). New records also come from sites in Beni Department along the Yacuma River (WCS, unpublished data), in the Great Tectonic Lakes of Exaltación Municipal Protected Area (Montaño, 2016; Ten *et al.*, 2016; G. Ayala & R. Wallace, pers. obs.), and at Barba Azul Nature Reserve in Yacuma municipality, that is part of the conservation area of the endemic blue-throated macaw (*Ara glaucogularis*) (Kingsbury, 2010, 2012). A long-term camera-trap study by the Andean Carnivore Conservation Program (PROMETA & Museo d'Orbigny, Cochabamba) added new records in the dry forests of the central and southern

Andes of Bolivia at Iñaño National Park, Chuquisaca Department and in the San Lorenzo and Cercado provinces of Tarija Department (Velez-Liendo, pers. comm.). *iNaturalist* records come from Pando Department near Riberalta, Santa Cruz Department near Santa Cruz city, San Miguelito ranch in San Antonio de Lomerío municipality, San Carlos in Amboró Integrated Management Area, and Beni Department near Santa Rosa del Yacuma.

Dasypus septemcinctus
(seven-banded armadillo)

New records from Pampas del Heath, La Paz Department, as a result of the WCS's long-term camera trap study (Ayala *et al.*, 2021), extend the known range of the species to northwestern Bolivia. Additional camera trap studies in the Llanos de Moxos in Beni Department provided new localities in the Yata basin (UAGRM & FAUNAGUA, 2017), and in the Great Tectonic Lakes of Exaltación Municipal Protected Area (G. Ayala & R. Wallace, pers. obs.). Opportunistic records by WCS researchers and others include photographs in grasslands along the Madidi River (La Paz and Beni Departments). An *iNaturalist* photo reviewed by Anderson Feijó extends this species' range to Pando Department in the extreme north of the country.

Euphractus sexcinctus
(six-banded armadillo)

New records for Pampas del Heath, La Paz Department, extend the known range of the species to northwestern Bolivia (Ayala *et al.*, 2021). Additional camera trap studies in the Llanos de Moxos in Beni Department reported new localities in the Great Tectonic Lakes of Exaltación Municipal Protected Area (G. Ayala & R. Wallace, pers. obs.), and at Barba Azul Nature Reserve in Yacuma municipality that is part of the conservation area of the endemic blue-throated macaw (*Ara glaucogularis*) (Kingsbury, 2010, 2012). More records were added for the dry forests of the central and southern Andes of Bolivia at Iñaño National Park, Chuquisaca Department from the long-term camera-trap study by the Andean Carnivore Conservation Program (Museo d'Orbigny, Cochabamba). *iNaturalist* records come from Vaca Diez, Yacuma and General José Ballivián provinces in Beni Department and from José Miguel de Velasco province in Santa Cruz Department.

Chaetophractus vellerosus
(screaming hairy armadillo)

New records come from field researchers with the Proyecto Quirquincho (Museo d'Orbigny) in Santiago de Huari and Pampa Aullagas municipalities, Oruro Department (Quiroga & Huayta, 2017); as well as from the boundary of the Kaa Iya National Park and Integrated Management Areas in Santa Cruz Department (Poma-Urey &

Salazar-Miserendino, 2014). *iNaturalist* records come from Colcha "K" municipality in Nor Lípez province and from Uyuni municipality in Antonio Quijarro province, Potosí Department.

Cabassous unicinctus
(southern naked-tailed armadillo);
Cabassous squamicaudis
(Cerrado naked-tailed armadillo)

These two species have no new records, and their distribution maps are based on Feijó & Anacleto (2021), who validated the records for both species in Bolivia. The records published by Wallace *et al.* (2013) are classified as *Cabassous* spp. because the data are insufficient to confirm species. *iNaturalist* records include photos of a carapace of *Cabassous* without the head, from Riberalta in Pando Department, and from San Miguelito ranch, San Antonio de Lomerío municipality, in Santa Cruz Department.

Calyptophractus retusus
(greater fairy armadillo)

Peñaranda Barrios (2020) reported several new records in the Chaco Dry Forest of Tarija Department from biodiversity studies funded by oil companies in their areas of operation.

Tolypeutes matacus
(southern three-banded armadillo)

New camera-trap records come from Cordillera province in Santa Cruz Department (Kosydar *et al.*, 2018). *iNaturalist* records come from Charagua municipality and from San Miguelito ranch in San Antonio de Lomerío municipality in Santa Cruz Department; as well as from Gran Chaco province in Tarija Department.

Priodontes maximus
(giant armadillo)

New records were reported at sites in Beni Department along the Yacuma River (WCS, unpublished data), and in the Great Tectonic Lakes of Exaltación Municipal Protected Area (Ten *et al.*, 2016; G. Ayala & R. Wallace, pers. obs.). *iNaturalist* records come from Abuná Province in Pando Department, Noel Kempff Mercado National Park (San Ignacio municipality), and San Miguelito ranch (San Antonio de Lomerío municipality) in Santa Cruz Department.

Chaetophractus villosus
(large hairy armadillo)

It is noteworthy that the large hairy armadillo has not been recorded in Bolivia in the last 10 years. This may simply be an artefact of the distribution of recent field efforts, because the species was frequently collected by Ioseño hunters in the sand

dune grasslands of southern Santa Cruz Department in the past (Noss *et al.*, 2008).

Cyclopes catellus
(Amboro silky anteater)

Gutiérrez *et al.* (2020) reported two visual records of this species in the Pirá River Metropolitan Ecological Park, Santa Cruz Department. This park constitutes an ecotone between the metropolitan area of Santa Cruz de la Sierra and the remaining habitat for wildlife along the Pirá River. The two individuals were observed about 300 m from human habitation. *iNaturalist* records come from sites near Cobija in Pando Department, as well as from the municipality of Riberalta in Beni Department.

Myrmecophaga tridactyla
(giant anteater)

There are new records from camera trap studies in the Llanos de Moxos of Beni Department in the Yata basin (UAGRM & FAUNAGUA, 2017). New records have been reported at sites along the Yacuma River (WCS, unpublished data), within the Great Tectonic Lakes of Exaltación Municipal Protected Area, Beni Department (Montaño, 2016; G. Ayala & R. Wallace, pers. obs.), and at Barba Azul Nature Reserve in Yacuma municipality that is part of the conservation area of the endemic blue-throated macaw (*Ara glaucogularis*) (Kingsbury, 2010, 2012). *iNaturalist* records come from Germán Busch and José Miguel de Velasco provinces in Santa Cruz Department; as well as from Yacuma, San Javier and General José Ballivián provinces in Beni Department.

Tamandua tetradactyla
(southern tamandua)

There are new localities along the Yacuma River in the Llanos de Moxos in Beni Department (WCS, unpublished data), in the Great Tectonic Lakes of Exaltación Municipal Protected Area (Montaño, 2016; G. Ayala & R. Wallace, pers. obs.), and at Barba Azul Nature Reserve in Yacuma municipality that is part of the conservation area of the endemic blue-throated macaw (*Ara glaucogularis*) (Kingsbury, 2010, 2012). Additional new records were added at El Palmar National Park, Lagarpampa-Mollepampa Municipal Protected Area, and in the San Lorenzo and Cercado provinces of Tarija Department from the long-term camera-trap study by the Andean Carnivore Conservation Program (Museo d'Orbigny, Cochabamba) (X. Velez-Liendo, pers. comm.). *iNaturalist* records include the northernmost location for the species, in Nicolás Suárez province, Pando Department; records from Ñuflo de Chaves y Cercado, Santa Cruz Department; and others from Cercado and Yacuma provinces, Beni Department.

Choloepus hoffmanni
(Hoffmann's two-toed sloth)

WCS field staff obtained photographic records of one individual at the Santo Domingo community near Apolo, La Paz Department and another individual rescued by Madidi park guards on the Beni River (La Paz / Beni Departments). *iNaturalist* records come from Nicolás Suárez and Madre de Dios provinces in Pando Department, as well as from Vaca Díez province in Beni Department.

Bradypus variegatus
(brown-throated three-toed sloth)

Camera trap surveys in Yacuma municipality and the Great Tectonic Lakes of Exaltación Municipal Protected Area, Beni Department provided new records (Ten *et al.*, 2016). *iNaturalist* records come from Vaca Díez, General José Ballivián, Mamoré and Cercado provinces in Beni Department, with many in and near the city of Trinidad; and also from Ñuflo de Chaves, Ignacio Warnes, Sara and Andrés Ibañez provinces in Santa Cruz Department.

ECOLOGY

Habitat selection

No comprehensive population assessment or basic ecological study has been undertaken for any Xenarthra species in Bolivia in the past decade. However, recent studies have used camera traps to evaluate the effect of forest management activities on terrestrial mammals, including armadillos and anteaters. Arispe Liaños (2018) used camera traps at an Amazonian forest site in northern Santa Cruz Department to evaluate the effects of Forestry Stewardship Council (FSC) certified forest management on terrestrial mammals, including four armadillos (*C. unicinctus*, *D. beniensis*, *D. novemcinctus*, and *P. maximus*) and two anteaters (*M. tridactyla* and *T. tetradactyla*). However, with less than five records per species, comparative analyses could not be conducted for most of the species. For the two species with more than 10 records, *D. novemcinctus* and *T. tetradactyla*, the author did not detect any significant differences in abundance across forest blocks harvested recently (0–1 year) versus blocks harvested previously (12–14 years).

Kosydar *et al.* (2014) combined camera traps with track plots at a Chiquitano Dry Forest site (mosaic of protected forest, cattle ranch, and mechanized agriculture) to evaluate the effects of hunting and forest fragmentation on species abundance and richness. Overall, they recorded four armadillo species (*D. novemcinctus*, *E. sexcinctus*, *T. matacus*, and *P. maximus*) and two anteater species (*M. tridactyla* and *T. tetradactyla*). Only *D. novemcinctus* provided sufficient records for comparative analysis, and the

differences were not significant between hunted, fragmented, and protected sites. When grouping the records, the four armadillos had reduced abundance in hunted areas, but the two anteaters did not.

Comparing certified timber extraction operations across four countries—Bolivia, French Guiana, Nicaragua, and Guatemala—Polisar *et al.* (2016) used systematic camera trap survey data to examine the benefits of certification for jaguar conservation specifically and for other species incidentally. They grouped the Xenarthra together, and for the three Chiquitano Dry Forest concessions in Bolivia, they reported xenarthrans to be most abundant at the site with more hunting, fragmentation, and fires. They went further, and proposed *D. novemcinctus* as a possible candidate for managed hunting by local communities because of the species' high reproductive rate and generalist habitat preferences, although this recommendation is not specific to the Bolivian sites.

Pérez-Zubieta (2011) conducted a field study of highland *C. vellerosus* (formerly *C. nationi*) habitat use in the Altiplano of Oruro Department. He monitored track plots and armadillo signs in three types of plots: cultivated potato (*Solanum tuberosum*) fields, sand dunes, and grasslands. He found more armadillo foraging activity in cultivated fields and in sand dunes as opposed to grasslands, and more armadillo burrows in sand dunes. Real or perceived crop damage fosters negative feelings from local farmers and the author suggested working with them to design and implement appropriate conservation measures.

Quiroga & Huayta (2017) built single-season occupancy models for *C. vellerosus* in the municipalities of Huari, Pampa Aullagas, and Orinoca in Oruro Department. In contrast to Pérez-Zubieta (2011), the models suggested that armadillos avoided cultivated areas and preferred a more mixed environment consisting of sand dunes with the presence of *Festuca dolichophylla* (Poaceae) and *Baccharis incarum* (Asteraceae). However, the biggest difference between the two studies was that, in the former, the cultivated fields were dominated by quinoa. This difference might suggest an armadillo preference for certain crops, which could potentially affect the level of conflict, either perceived or real, with farmers.

Predation

Flores-Turdera *et al.* (2021) completed a study of food habits of jaguar and puma (*Puma concolor*) in the lower Tuichi and Hondo Rivers in Madidi National Park and Integrated Management Area and Pilón Lajas Biosphere Reserve. They found that Xenarthra were rare prey species: *M. tridactyla* for jaguar; *T. tetradactyla* and *B. variegatus* for puma.

A curious predator-prey relationship was noted by Berkunsky *et al.* (2012) who found two *D. novemcinctus* and two *E. sexcinctus* in the nest of a crowned eagle (*Urubitinga coronata*) in the Moxos savannas of Beni Department. Armadillos have been reported as prey for this eagle elsewhere (Maceda *et al.*, 2003; Pereyra Lobos *et al.*, 2011), and the authors thought that armadillos may be particularly important prey in the breeding season.

Diet

Wallace & Painter (2013) reported frugivory by *P. maximus* in Amazonian forests of Bolivia. The stomach of an individual killed by a subsistence hunter contained exclusively unidentified figs (*Ficus* sp.), while at another site they observed feeding signs of the giant armadillo under fig trees.

Behavior

To better manage a captive population of *C. vellerosus*, de la Quintana *et al.* (2017) evaluated agonistic behaviors of 12 individuals in the Municipal Zoo Vesty Pakos in La Paz, Bolivia. Agonistic behaviors among males, when several were housed together, included growling, head-butting or body-slammings, and chasing. The most aggressive male did not tolerate any other male, whereas the other males could be habituated to each other and live in pairs. Females were not aggressive to each other.

A spool-and-thread study of *T. matacus* in the Chaco provided information on daily displacement, burrow and nest use, and feeding behavior (Noss, 2013). The method provided a maximum of five days of tracking, and the 350 m daily thread was frequently fully drawn out or broken in a single day. Animals slept in nests of dry leaves, dense bromeliads, or burrows of other animals. Observed signs suggested that animals were feeding principally on insects, including termites, and on plants.

THREATS

Habitat loss

As elsewhere, deforestation is a major threat to xenarthrans, especially to sloths. Pressures in the lowlands (Amazon forest, Llanos de Moxos savanna, Chiquitano dry forest, Chaco, and Pantanal) are also increasing as a result of economic pressures, policy changes, and frequent fires in the past decade. The modeling work of Romero-Muñoz *et al.* (2020, see below) found that habitat destruction was the main driver for the shrinkage of high-quality habitat for xenarthrans. International markets for soy and beef have driven the conversion of forests and savannas to farms and ranches, and the construction and improvement of roads (Fehlenberg *et al.*, 2017). Government policy has further



FIGURE 1. Traditional instrument, the charango, using mainly *C. vellerosus*, formerly *C. nationi*.

fomented conversion by modifying the ecological zoning from forest land use categories to agriculture. Government policy has also promoted the re-settlement of highland farmers into the lowlands; these colonists clear natural habitats for their settlements and farms (Colque *et al.*, 2019).

Fire is used every year to clear pastures and fields, particularly in savanna formations. However, fires from July to September 2019 were especially severe in Bolivia, with over 5 million ha burned; 74% of this area was forest as opposed to grasslands. Fires spread into national, departmental, and municipal protected areas, as well as indigenous territories and private lands (Anívarro *et al.*, 2019; NATIVA, 2019a). The severity of the fires was attributed to the coincidence of environmental conditions (drought and winds) with the socio-economic pressures described above (Colque *et al.*, 2019), and the legalization of “controlled burns” in lowland forests (NATIVA, 2019b; Romero-Muñoz *et al.*, 2019). Fires continued to be severe in 2020 and 2021, with unpublished government reports of *M. tridactyla*, *T. tetradactyla*, and several species of armadillos burned, and some survivors killed by illegal hunters while escaping the fires (E. Aliaga-Rossel, pers. obs.). Initial analyses of the effects of the fires on wildlife have focused on the jaguar as the umbrella species (Anívarro *et al.*, 2019), but also noted that IUCN Vulnerable species including *M. tridactyla* and *P. maximus* were affected (WCS, 2020). News reports also highlighted jaguars, but they did mention anteaters and armadillos among other affected species that were killed or displaced (CE Noticias Financieras, 2019; International Business Times, 2019).

Hunting

The majority of species of both the Cingulata and Pilosa are affected by hunting. Armadillos, especially *Dasypus* and *Priodontes*, are used as a protein source by indigenous and local people throughout their ranges (Noss *et al.*, 2008; Aliaga-Rossel, 2011, ASASG, 2021). Indeed, over the last 30 years, the spatial impact of hunting pressure across the Gran Chaco was as large as that of habitat destruction for xenarthrans (Romero-Muñoz *et al.*, 2020; see below). The law permits subsistence hunting of these species, although some studies show that hunting is not always sustainable (Fragoso *et al.*, 2000; Aliaga-Rossel, 2011), in particular with the acculturation of indigenous people and isolated rural populations. The change from subsistence to commercial armadillo hunting is evident, with armadillos being sold at bus stops in the lowlands along the roads from Cochabamba to Santa Cruz.

In a review of how hunting dogs affect wildlife, Koster & Noss (2013) re-evaluated hunting records from Isoseño-Guaraní indigenous communities in the Bolivian Chaco. Five armadillo species are commonly hunted for subsistence: *D. novemcinctus*, *E. sexcinctus*, *C. villosus*, *C. vellerosus*, and *T. matacus*. Dogs were particularly effective at locating the three nocturnal armadillos (*D. novemcinctus*, *C. villosus*, *T. matacus*), and two or more dogs were more effective than a single dog. Although they were not consumed, the anteaters *M. tridactyla* and *T. tetradactyla* were occasionally chased and killed by hunting dogs, or killed by the hunters in order to protect the dogs from harm. Researchers here also used local hunters with trained dogs to capture *D. novemcinctus* and *T. matacus* alive for abundance and health studies (Cuéllar, 2002; Deem *et al.*, 2009).

Armadillos continue to be hunted for cultural purposes, most importantly quirquincho (*C. vellerosus*) carapaces for the fabrication of *charangos* and *matracas* (Romero-Muñoz & Pérez-Zubieta, 2008; Fobar, 2019). The *charango* (FIG. 1) is a small Andean stringed instrument of the lute family, which probably originated by copying guitars during the colonial period. *Matracas* are rattles used in a traditional dance called the *Morenada*, performed by hundreds of dancers. Between 2008 and 2009, Porcel (2012) counted over 900 dancers at the Oruro carnival event using *matracas* made with the carapaces of armadillos. In interviews, many dancers commented that they tend to lose the *matracas*, break them while dancing, or that they simply have more than one. In a similar study in 2014, Quiroga (2015) counted over 1,500 dancers using *matracas*.

In order to address this problem, the government made it illegal in 2015 to sell or possess a new *matraca* (Fobar, 2019). Therefore, in 2016 the Oruro Folklore Groups Association (Asociación de Conjuntos Folklóricos de Oruro or ACFO) declared to the General Biodiversity and Protected Areas Directorate the use of 2,084 *matracas* (F. Suárez, pers. comm.). Under Administrative Resolution VMABCCGDF No. 004/18 (MMAyA, 15 January 2018) and Inter-Institutional Agreement No. 163 between ACFO, the Ministry of Environment and Water (MMAyA), and the Ministry of Cultures and Tourism, *matracas* were registered for all dancers in 2019. The agreement seeks to prevent, catalog, regulate, replace, and eliminate the use of wildlife specimens and products in all cultural activities in which ACFO participates. Although the laws forbid

and regulate illegal trafficking, the deep-rooted cultural meaning of this species, especially for people living in the High Andes, in addition to a lack of enforcement, make *quirquincho* hunting a challenge that needs more creative thinking. Quiroga (2015) found that *quirquinchos* were still widely available in small markets, as they are also used as good luck charms, and to date we do not know whether the demand for these products has decreased or continues. In the lowlands, *D. novemcinctus* tails are sold as key chains.

Synergistic effects of habitat destruction and hunting

An expansive modeling study, in both geographic and temporal scales, evaluated the effects of habitat destruction and hunting, acting separately and synergistically, on mammals across the three-nation Gran Chaco region from 1985 to 2015 (Romero-Muñoz *et al.*, 2020). Covering 1.1 million km², the Gran Chaco became a global hotspot of deforestation due to the expansion of beef and soy agriculture (Hansen *et al.*, 2013). The study combined habitat suitability with hunting-pressure models to map the change in the footprints of both threats, and the consequent change in high-quality habitat over three decades for 48 medium and large-sized mammals with sufficient data to produce reliable habitat models, including eight armadillo and two anteater species. Among sloth species, only *B. variegatus* reaches the Chaco, but only marginally, and was excluded from the analysis due to insufficient records. On average, xenarthran species lost 3.5% ± 25.4 SD of their high-quality habitat between 1985 and

TABLE 3. Percent change in threats affecting Xenarthra in the Gran Chaco region from 1985 to 2015. Major threats were loss of high-quality habitat, hunting pressure, habitat destruction, and the combined effect of hunting pressure and habitat destruction. Source: Romero-Muñoz *et al.* (2020).

Species	High-quality habitat	Hunting	Habitat destruction	Both threats
<i>Dasypus novemcinctus</i>	-17.3	5.7	118.3	110.7
<i>Chaetophractus vellerosus</i>	40.7	39.5	-27.3	4.6
<i>Chaetophractus villosus</i>	6.4	17.2	2.9	33.8
<i>Euphractus sexcinctus</i>	-1.6	0.6	10.0	11.0
<i>Calyptophractus retusus</i>	31.6	17.9	20.9	23.8
<i>Priodontes maximus</i>	-55.9	43.4	-10.4	29.7
<i>Tolypeutes matacus</i>	-5.1	18.1	15.3	47.0
<i>Myrmecophaga tridactyla</i>	-6.5	12.9	56.2	94.8
<i>Tamandua tetradactyla</i>	-10.8	8.2	6.6	21.7

2015 (**TABLE 3**). This value is somewhat misleading because three species—*C. vellerosus*, *C. villosus*, and *Cal. retusus*—gained high-quality habitat. However, for the remaining seven species that lost high quality habitat the average loss was 16%. *Prionotes maximus* lost the most high-quality habitat (55%), followed by *D. novemcinctus* (~17% loss), while *M. tridactyla* and *T. tetradactyla* lost 6.5% and 10.8% of their habitat, respectively (**TABLE 3**). On average for all xenarthrans, the footprint of habitat destruction increased by 17% over this period, that of hunting by 22%, and that of both threats acting together by 42%.

Roadkills

The construction of new paved roads and the paving of dirt roads, for example the new San Ignacio-Trinidad and San Borja-Yucumo roads in Beni Department, have increased the number of armadillos, sloths, and anteaters killed by vehicles (E. Aliaga-Rossel, pers. obs.). Also, as mentioned previously, animals fleeing forest fires were hit by vehicles. Precise figures for this mortality are not available, but the problem requires further investigation.

Conservation Status

The recent Supreme Decree 4489 (April 2021) forbids any form of sport hunting in the country, as well as activities related to trade, trafficking, or keeping wild animals as pets. However, the lack of enforcement and public dissemination of the law reduces the effectiveness of this Supreme Decree.

Overall, the conservation status for Xenarthra species in Bolivia is thought to be relatively stable, with vast protected areas (national, departmental, municipal, and private), indigenous territories, and certified forestry concessions where deforestation and hunting are limited. However, some ecoregions are especially threatened. For example, less than 4% of the inter-Andean Dry Valleys are under some form of protection. Similarly, the vast Llanos de Moxos savannas are poorly represented by national protected areas. Outside of protected areas, the threats are those described above for all species, especially habitat destruction and road kills, as well as hunting of some armadillos for subsistence purposes. It is not currently possible to quantify the increasing number of wildlife killed by fires, traffic, and illegal hunting. In an attempt to model the potential scenarios for the Bolivian Amazon under future land cover change and climate change, Osipova & Sangermano (2016) used *T. tetradactyla*, the jaguar, and the lowland tapir (*Tapirus terrestris*) as a multi-species umbrella, projecting losses of between 70% and 83% of their ranges by 2050.

A positive response to the pressures described above is the creation of new protected areas, most notably Ñembi Guasu (1.2 million ha) and

Guajukaka (285,000 ha) by the indigenous municipality of Charagua (Santa Cruz Department). Charagua Iyambae is Bolivia's first legally recognized Autonomous Indigenous Native Campesino municipality, established by the Guaraní indigenous people. The two new protected areas in the Bolivian Chaco connect Otuquis and Kaa-Iya National Parks in Bolivia with Paraguay's Héroes del Chaco Departmental Reserve. These new areas extend legal protection to all the Chaco Xenarthra, with *T. tetradactyla*, *M. tridactyla*, and *P. maximus* cited as vulnerable species that benefit from the new protected areas (Arnold & Brown, 2018; NATIVA, 2019a,b; Sierra Praeli, 2019a,b). Sadly, to date more than 250,000 hectares of forest in Ñembi Guasu were burned and destroyed in the fires described above, affecting all the wildlife present (NATIVA, 2019b).

CONCLUSIONS

Few researchers in Bolivia are working directly with Xenarthra species, and efforts should be made to encourage the design of field research focused on the new protected areas mentioned above. Records that are by-catch data from studies focused on other species do not provide adequate ecological data to guide effective site-specific conservation measures for Xenarthra in Bolivia. Therefore, specific long-term field studies on habitat preference, distribution, and population trends should be prioritized.

Because *C. nationi* is no longer recognized as a species endemic to the Bolivian Andes, having been lumped with a more widespread species, it is no longer considered threatened (Vulnerable) by the IUCN. As a result, researchers will face increased difficulties in obtaining funding and generating interest to study this species (Foban, 2019). Officially, the Red List of Vertebrates of Bolivia (MMAyA, 2009) still considers the Andean hairy armadillo (*C. nationi*) to be endangered, and government legislation focuses specifically on reducing quirquincho exploitation for cultural purposes. The Red List is also over a decade old, and should be updated with systematic evaluations of threats facing each species of Xenarthra today.

Support from government agencies and national and international NGOs to implement protected areas and landscape management activities continue. These efforts, although they benefit Xenarthra in general, focus on emblematic species such as jaguars or threatened habitats, and are not specifically directed to Xenarthra.

New records of Xenarthra were obtained from lesser known or neglected ecosystems such as the Inter-Andean Dry Forests and the Bolivian-Tucumán Forest. The number of threatened ecosystems is increasing, and some are more vulnerable to recurrent forest fires as well as to continuous and frequent

droughts, such as the High Andean Sand Dunes, Chiquitano Dry Forest, and Bolivian-Tucumán Forest. Further research and conservation efforts should be focused in these ecosystems.

Future research priorities for xenarthrans in Bolivia should include further distribution studies because recent taxonomic changes and known global distributions suggest that at least four additional species could possibly occur in the country. For Cingulata, given nearby records in northern Argentina, it seems probable that the Yungas lesser long-nosed armadillo (*Dasypus mazzai*) may be present in the extreme south of Bolivia in Tarija Department (Wallace & Porcel, 2010). Similarly, in the southern portion of the Bolivian Chaco it is very possible that, if *Cabassous* is present, then the species would be the Chacoan naked-tailed armadillo *C. chacoensis*, based on Paraguayan records (Wallace & Porcel, 2010; Smith & Rios, 2018). For Pilosa, the recent taxonomic revision for *Cyclopes* (Miranda *et al.*, 2018) is likely to yield additional species for Bolivia. For example, unconfirmed photographic records suggest that the red silky anteater *C. rufus* and Thomas' silky anteater *C. thomasi* may both be present in the north of the country (RAI, 2018).

Finally, the COVID-19 pandemic has changed lives as well as worldwide views on biodiversity, given the possible zoonotic origin of the virus. Preserving biodiversity should be a public health priority. As conservationists, we must increase knowledge and protection of Xenarthra species and their habitats. Our efforts can also benefit from coordination with global initiatives like the UN Decade of Ecosystem Restoration in order to prevent, halt, and reverse the degradation of our ecosystems.

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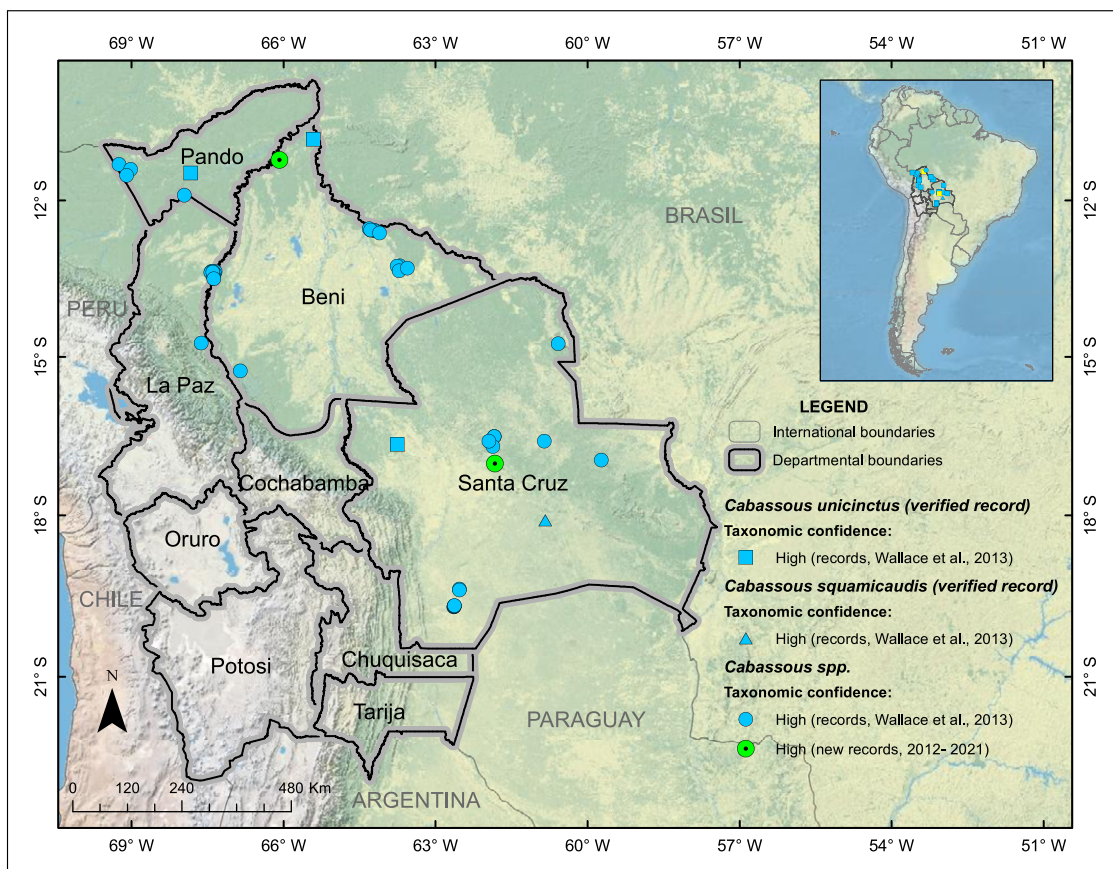
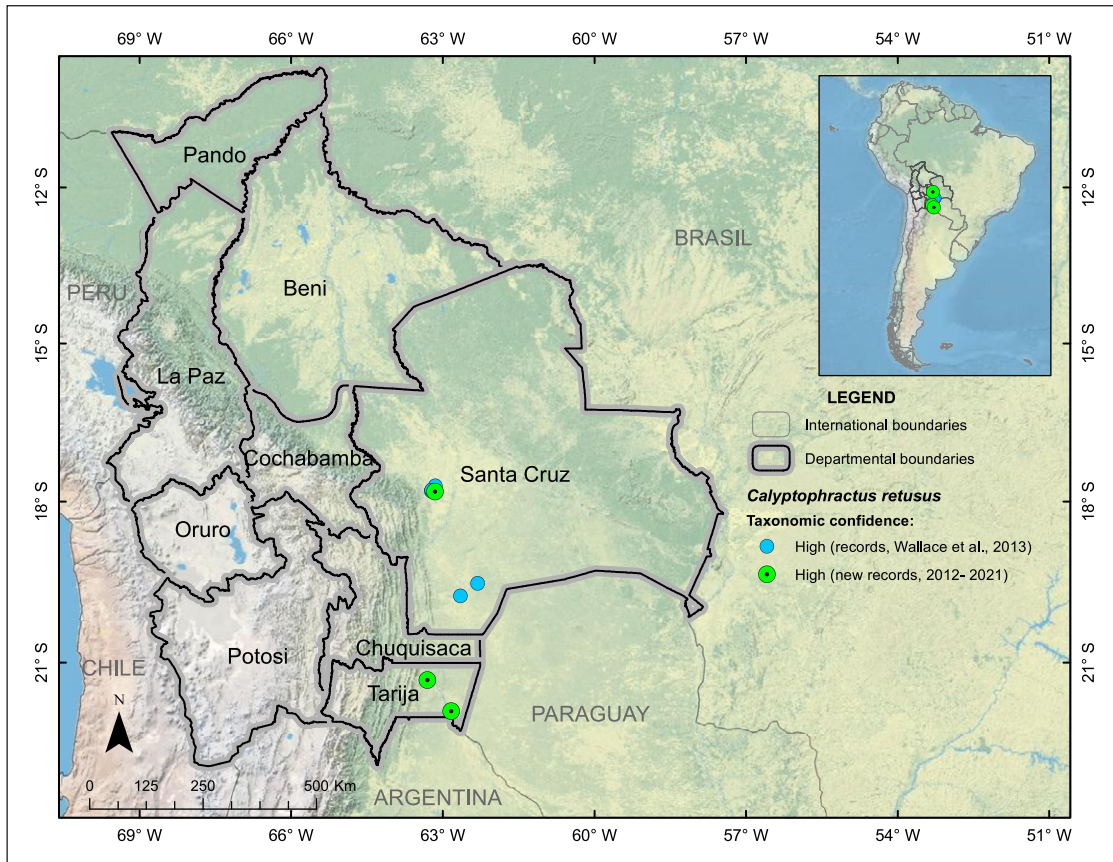
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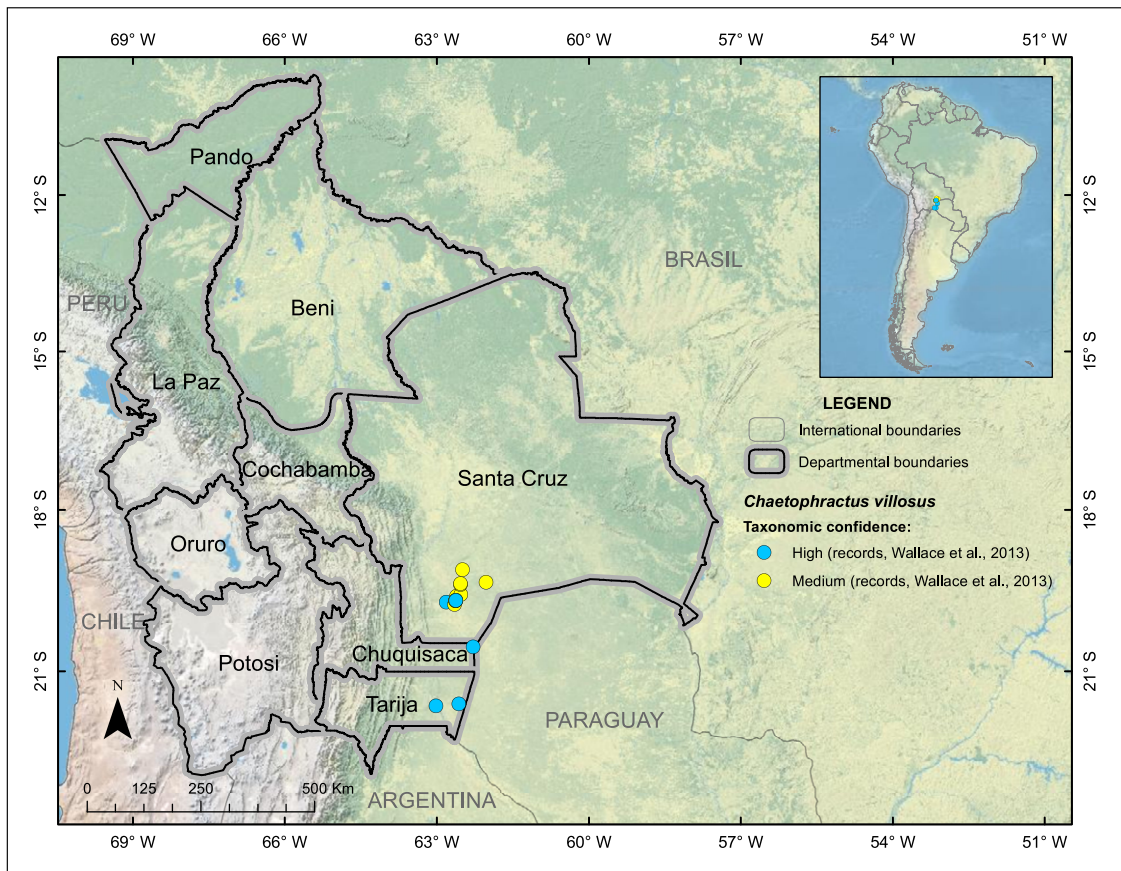
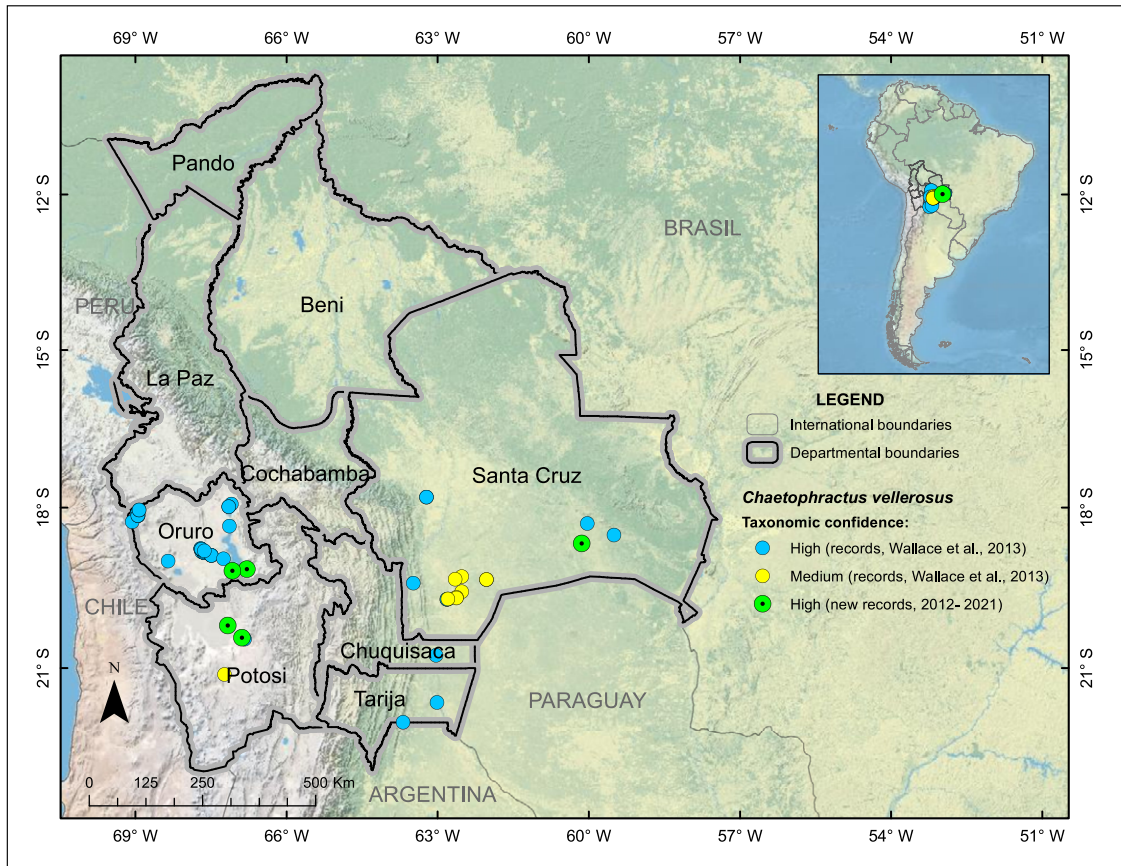
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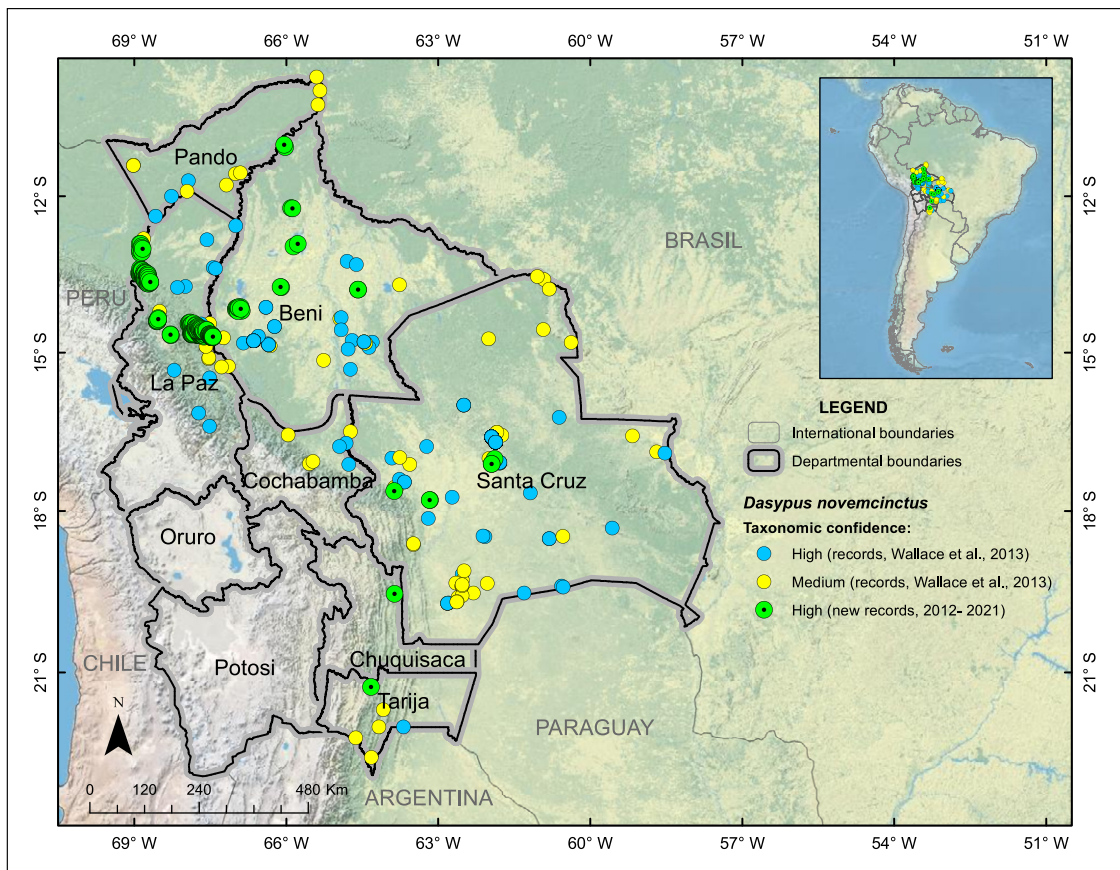
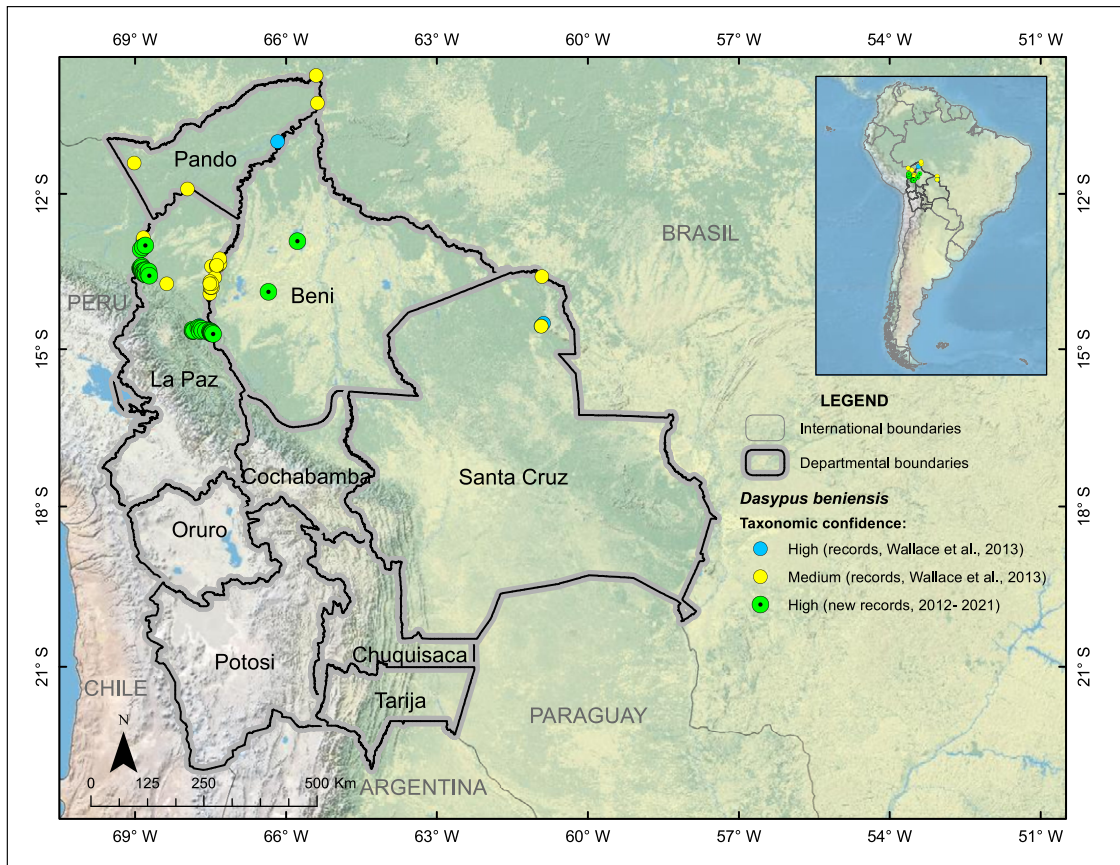
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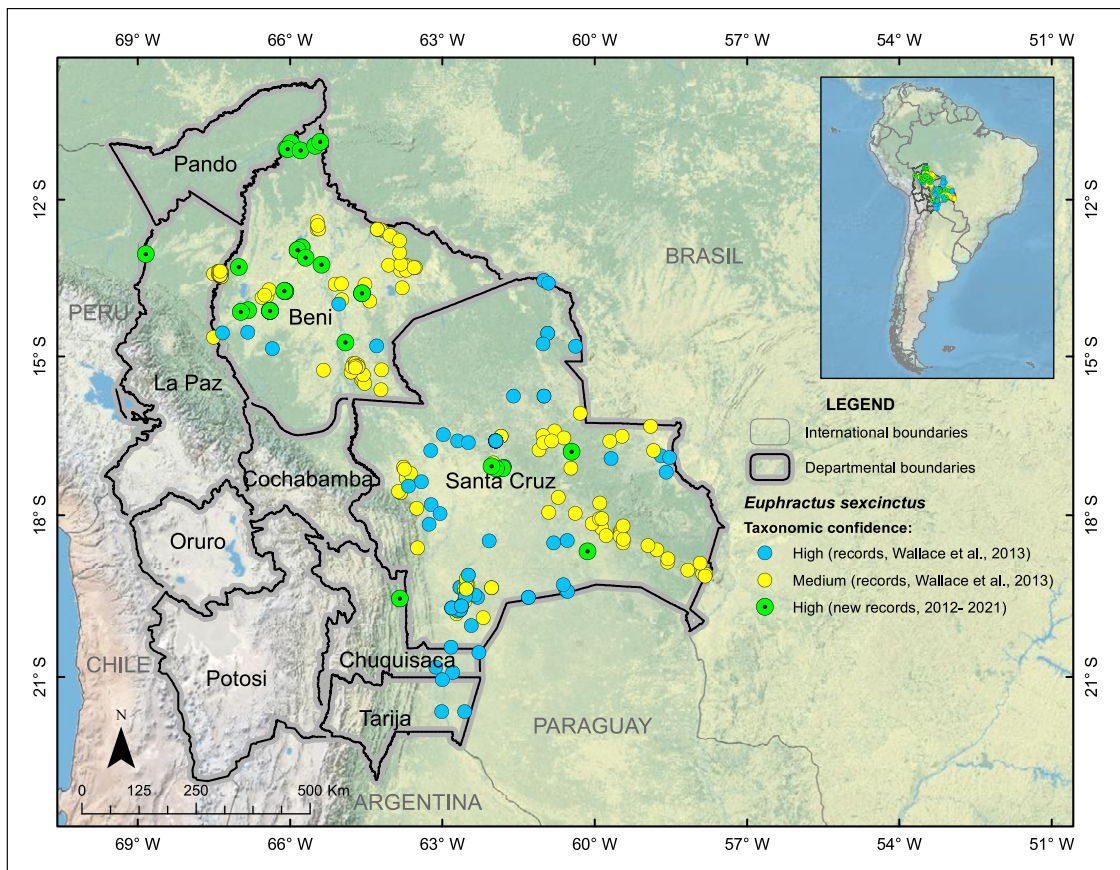
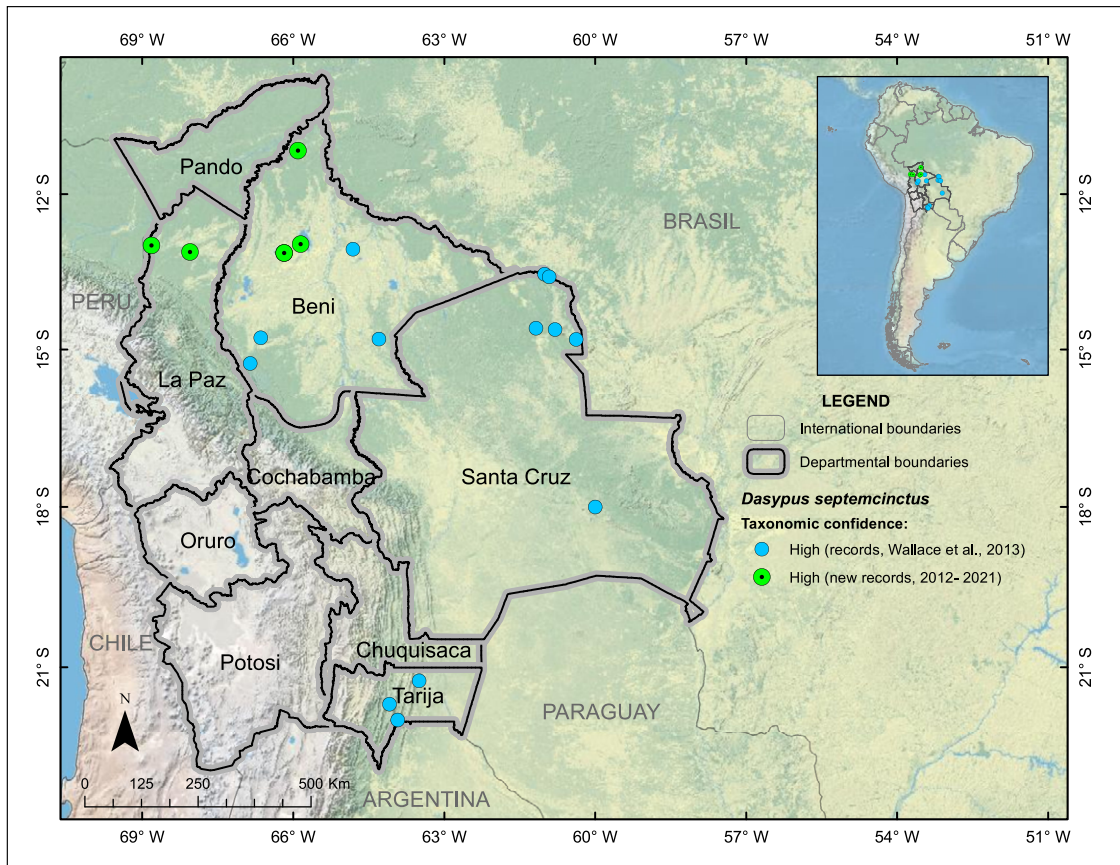
ANNEX 1

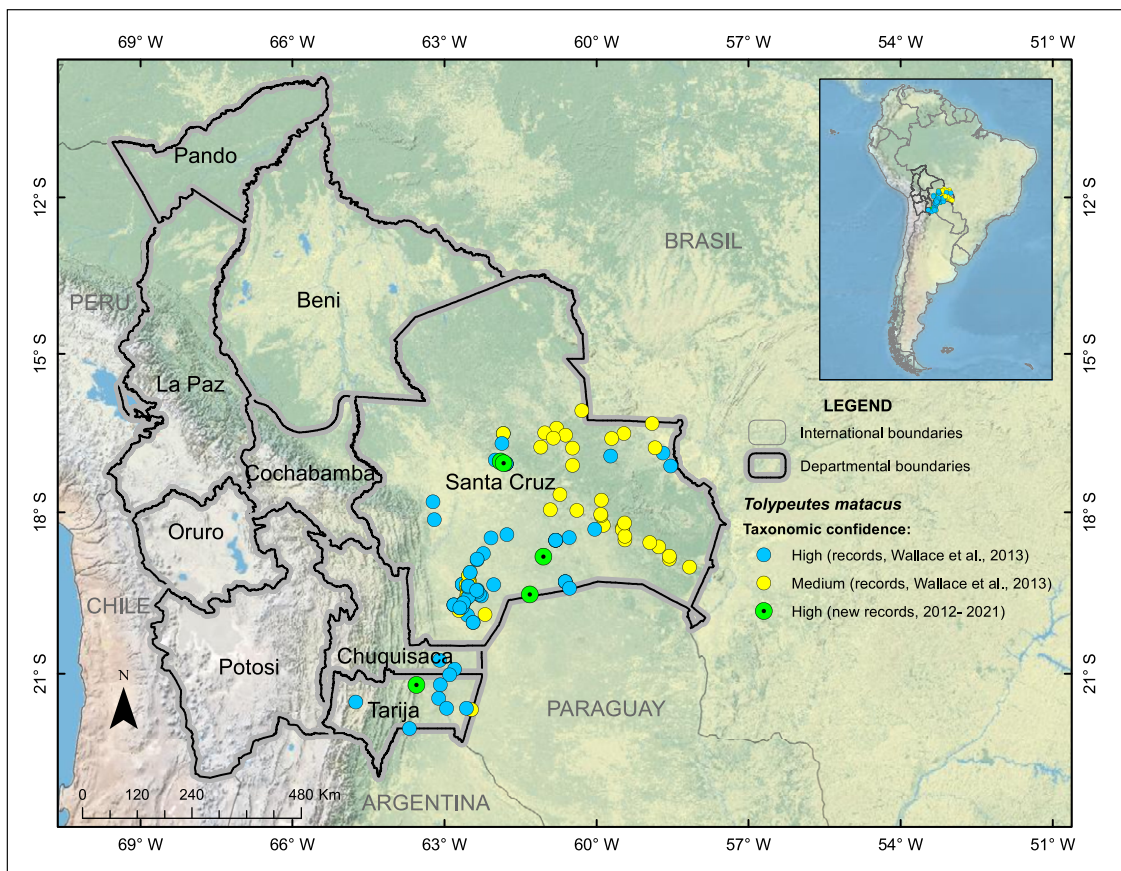
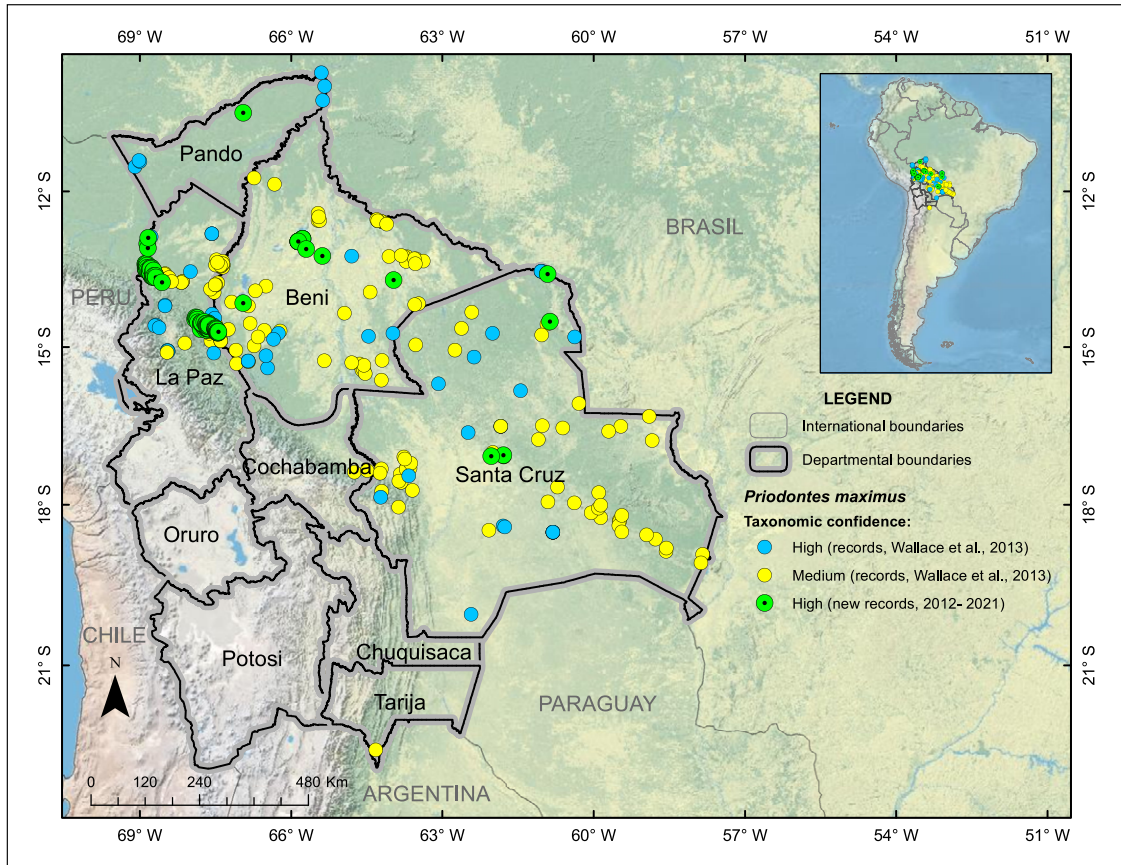
Distribution of the species of armadillos in Bolivia (modified from Wallace *et al.*, 2010, 2013) with new records since 2012. **MEDIUM CONFIDENCE:** tracks or low-quality photographs; **HIGH CONFIDENCE:** direct observation, specimen collected, or high-quality photographs. All records since 2012 had a high confidence level.











ANNEX 2

Distribution of the species of *Pilosa* in Bolivia (modified from Wallace *et al.*, 2010, 2013), with new records since 2012. **MEDIUM CONFIDENCE:** tracks or low-quality photographs; **HIGH CONFIDENCE:** direct observation, specimen collected, or high-quality photographs. All records since 2012 had a high confidence level.

