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Central American woolly opossum (*Caluromys derbianus*): distribution, ecology and conservation threats in Panamá

Zarigüeya lanuda centroamericana (*Caluromys derbianus*): distribución, ecología y amenazas para su conservación en Panamá

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Little is known about the distribution and ecology of the Central American woolly opossum (*Caluromys derbianus*) in Panamá. Therefore, the aim of this study is to update geographical data and ecological information to fill this gap. Based on examinations of museum specimens, published data and field observations, we obtained 362 records of *C. derbianus* in Panamá. Our results suggest a wide distribution of *C. derbianus* across both natural and disturbed lowland environments. Moreover, we provide baseline information about its potential anthropogenic and natural threats, as well as general aspects of its diet in Panamá.

Key words: Central America; depredation; Didelphidae; diet; environments; synanthropic; threats.

Existe poco conocimiento de la distribución y ecología de la zarigüeya lanuda centroamericana (*Caluromys derbianus*) en Panamá. Por lo tanto, el objetivo de este trabajo es actualizar datos geográficos e información ecológica para llenar este vacío. Con base en revisiones de especímenes de museos, datos publicados y observaciones de campo, obtuvimos 362 registros de *C. derbianus* en Panamá. Nuestros resultados muestran una amplia distribución de *C. derbianus* entre ambientes de tierras bajas tanto naturales como perturbados. Adicionalmente, proporcionamos información base de sus amenazas potenciales naturales y antrópicas, así como aspectos generales sobre su dieta en Panamá.

Palabras clave: Ambientes; amenazas; América Central; depredación; Didelphidae; dieta; sinantropía.

American marsupials include the orders Microbiotheria (1 species) and Didelphimorphia (18 genera and 110 species), which are primarily known as opossums (Voss and Jansa 2009; Amador and Giannini 2016). The most commonly found opossums belong to the genus *Didelphis* due to their synanthropic behavior; however, other species may go unnoticed or be known only by sporadic findings (Reid 2009). This is the case of the Central American woolly opossum *Caluromys derbianus* (Waterhouse 1841), a species with a distribution that extends from southern México to Ecuador, occupying regions ranging from sea level to 2,600 m (Bucher and Hoffmann 1980; Fonseca and Astúa 2015). Through its wide distribution, very little is known about their biology. Some studies have looked at its distribution (Fonseca and Astúa 2015; Marineros *et al.* 2016), ecological importance in the predation of insects, small vertebrates, seed disperser and as a pollinating agent (Lessa and da Cota 2010; Kays *et al.* 2012). In addition, it plays an important role as a prey for other species (Moreno *et al.* 2006; Marineros *et al.* 2016).

In Panamá, the diversity of opossums includes 10 species in 8 genera. Of these, *C. derbianus* has 4 subspecies: *C. d. derbianus*, *C. d. nauticus*, *C. d. centralis*, and *C. d. pallidus* (Bucher and Hoffmann 1980). Apart from sporadic anecdotes, only few studies provide information on the geographic distribution, ecology and conservation threats of this species. Therefore, the aim of this work is to update the known distribution of *C. derbianus* in Panamá by providing a comprehensive set of historical and current records, and to expand on the basic ecological and conservation threats.

For the historical data, we reviewed specimens of *C. derbianus* deposited in the "Dr. Eustorgio Méndez" Zoological Collection of the Gorgas Commemorative Gorgas Institute for Health Studies (CoZEM-ICGES), in Panamá. Besides, we systematically reviewed the literature on this species using databases (BioOne, Smithsonian Libraries, and PubMed), including digital databases of the Smithsonian National Museum of Natural History (USNM), Washington, D. C., U. S. A.; American Museum of Natural History (AMNH), New York, U. S. A.; Philip L Wright Zoological Museum (UMZM), Montana, U. S. A., and the Museum of Vertebrate Zoology (MVZ), California, U. S. A.

Further, we collected recent data from personal observations, animals captured in scientific field studies, photos from camera traps, and revision of dead individuals (which were road-killed, electrocuted, preyed or hunted). We also used confirmed records from iNaturalist Panamá (an online citizen science platform, https://Panamá.inaturalist.org/). For each occurrence point, we recorded data on vegetation cover, type of environment and number of individuals. Finally, we used these historical (1884-1999) and current (2000-2020) data for *C. derbianus* in Panamá to create a map using ArcGis 10.3 software (Esri, Redlands, California, U. S. A.).

We obtained a total of 362 records of *C. derbianus* in Panamá, of which 174 are historical records (1884-1999) and 188 are current records (2000-2020; Figure 1). We obtained photographs of *C. d. centralis* (Figure 2A) and of an individual that showed a pale gray coloration (Figure 2B), which corresponds to an adult of the subspecies *C. d. pallidus* (Bucher and Hoffmann 1980; Fonseca and Astúa 2015).

The broad distribution of the records across Panamá indicate that the species occurs in different types of environments and at elevations that range from sea level to more than 2,000 m. The distribution range included urban and rural sites, primary forest (*e. g.,* Darien National Park), in addition to the islands of the Gulf of Montijo and Chiriqui (Pacific Ocean), the archipelago of Bocas del Toro, and the island of Escudo de Veraguas (Caribbean Sea; Figure 1). Rural areas corresponded to 31.4 % of the data, followed by primary forests (30.3 %), secondary forests (15.9 %), gallery forests (8.0 %), suburban areas (8.0 %) and urban areas (6.4 %; Figure 1).

Of the 188 current records from photos and direct field observations, 11.2 % provided information on the diet of *C. derbianus* (n = 21; Figures 2C, 2D), including bananas (*Musa* sp.; 1.6 %), oranges (*Citrus* sp.; 1.1 %), guavas (*Psidium guajava*; 0.5 %), figs (*Ficus* sp.; 0.5 %), guabas (*Inga* sp.; 0.5 %), jobos (*Spondias mombin*; 0.5 %), mangos (*Mangifera indica*; 0.5 %), cashew fruits (*Anacardium occidentale*; 0.5 %), pink poma (*Syzygium jambos*; 0.5 %), Malay rose apple (*Syzygium malaccense*; 0.5 %), palm seeds (0.5 %) and other fruits (0.5 %). We also found evidence of consumption of nectar in raft flowers (*Ochroma pyramidale*; 1.6 %), poultry eggs (1.1 %), and insects (Orthoptera, Tettigoniidae; 0.5 %).

Current records came mainly from direct sightings (75.5 %), road-kills (6.9 %), captures for scientific purposes (5.3 %), electrocuted individuals (4.8 %), wildlife rescues (2.1 %), camera traps detections (1.6 %), predation by dogs (1.6 %), predation by spectacled owl (*Pulsatrix perspicillata*; 1.1 %), predation by domestic cats (0.5 %), and individu-

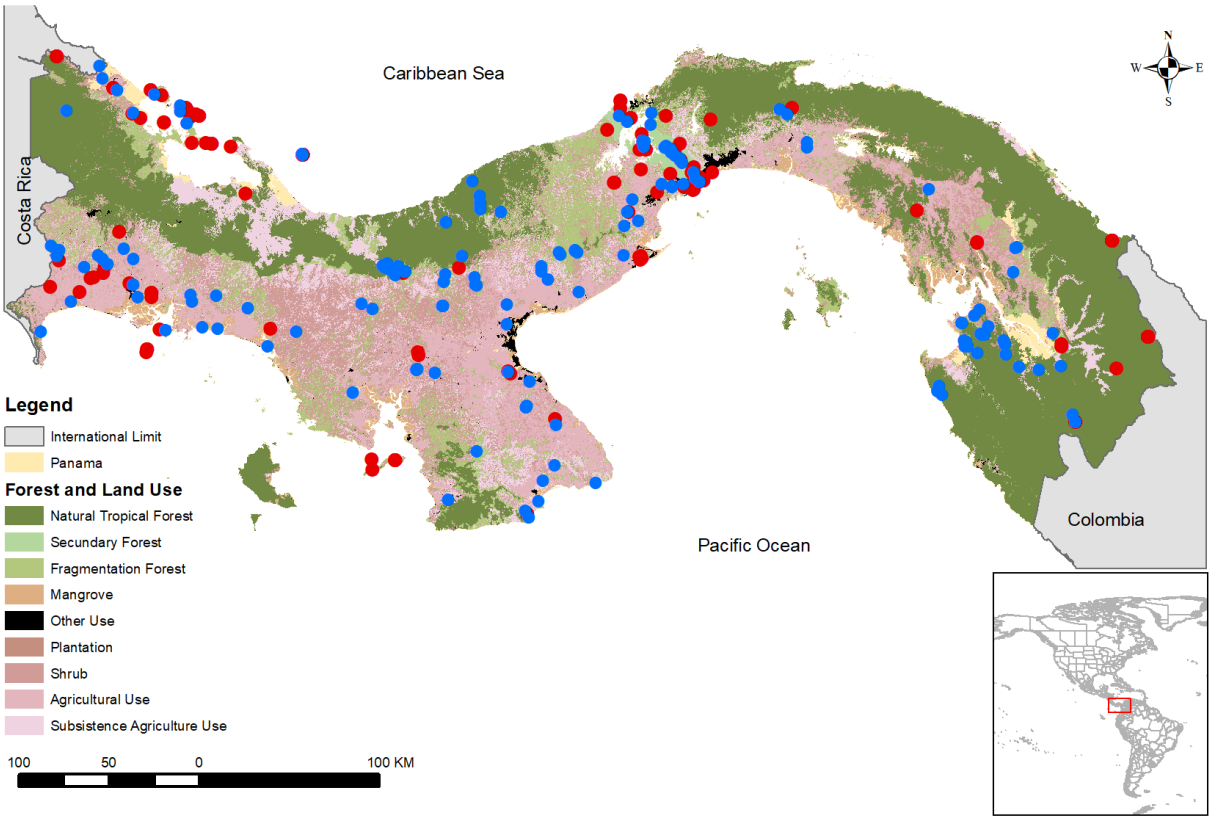

Figure 1. Historical occurrence (red dots, 1884-1999) and current occurrence (blue dots, 2000-2020) of *Caluromys derbianus* in Panamá.

Figure 2. Morphology and subspecies of *Caluromys derbianus* in Panamá: *C. d. centralis* in Changuinola, Bocas del Toro province (A); *C. d. pallidus,* in Breñon, Chiriqui province (B). Diet evidenced in photographs: eating Orthoptera Tettigonidae, Donoso, Colon, province (C); eating palm seeds in Darien National Park (D). Threats and risks: electrocuted, Parita, Herrera province (E); road-killed in La Colorada, Veraguas province (F); killed by domestic cat, Panama province (G). Maternal care in El Valle de Anton, Cocle province (H). Photograph by M. Ponce (A) and (C), M. de Landis (B), J. Ortega (D) and (F), O. Rodríguez (E), S. Roles (G), M. Urriola (H).

als hunted by humans (0.5 %). We present photographic evidence of electrocuted individuals, road-kills, and predation by domestic cats in Figures 2E-2G. Some photographic records show events such as 4 young on the body of their mother (Figure 2H).

In addition, we describe two predation events of a spectacled owl (*P. perspicillata*) on a Central American woolly opossum in Panamá. The first incident occurred on Barro Colorado Island, where a spectacled owl attacked a male Central American woolly opossum that managed to escape into a water drainage culvert. Pictures from a camera trap which was set up in the drainage to monitor a bat roost, showed that the opossum was heavily injured on the head and the forelimbs (Figures 3A-3D). The second event occurred when as a Central American woolly opossum was searching for *S. malaccense* fruits. A spectacled owl landed on the opossum and grabbed it. The opossum began to scream and fight. The owl took off with the opossum in its claws, while the opossum was still alive, screaming and fighting. The owl landed on a distant tree, where the screaming stopped shortly after.

Caluromys derbianus shows a high adaptability to survive and thrive in a variety of ecosystems, which can explain its wide distribution in the Neotropics (Bucher and Hoffmann 1980; Fonseca and Astúa 2015; Marineros *et al.* 2016). The data obtained here confirmed the capacity of adaptation of this species in Panamá, which includes continental areas and islands such as Paridas, Brava, Cebaco and Gobernadora (Pacific coast), the archipelago of Bocas del Toro, and the island Escudo de Veraguas (Caribbean coast; Handley 1966; Bucher and Hoffmann 1980; Fonseca and Astúa 2015). The presence of *C. derbianus* on Coiba island, offshore Panamá (Pacific Ocean), remains to be confirmed (Juste and Guillén-Servent 1997), and based on Bucher and Hoffman (1980) it may correspond with the subspecies *C. d. nauticus*.

Compared to scansorial species like *Didelphis marsupialis*, the preference for inhabiting the canopy allows *C. derbianus* to usually go unnoticed (Steiner 1981; McClearn *et al.* 1994; Voss and Jansa 2009; Aranda-Sánchez 2012). Moreover, the arboreal habits of *C. derbianus* may lead them to frequently climb on power lines, as evidenced by records of electrocuted individuals (Saavedra-Rodríguez *et al.* 2013). However, when there is little canopy connectivity and an absence of artificial passages in human-dominated habitats, individuals may be forced to move on the ground, increasing their risk of being hit by a vehicle or being predated by domestic animals (Artavia *et al.* 2015; Hernández 2018).

Similar to other mesomammals, *C. derbianus* is prey of larger carnivores such as ocelots (Moreno *et al.* 2006) or birds of prey (Marineros *et al.* 2016). To our knowledge, we report the first two records of a spectacled owl (*P. perspicillata*) as a predator of *C. derbianus* in Panamá, which has also been observed in Honduras (Marineros *et al.* 2016). In addition, we show that it is also preyed upon by domestic animals such as cats and dogs (Figure 2H). Although *C. derbianus* might function as an important prey species in the trophic web of Neotropical forests, its ecological contributions as a seed disperser and a pollinating agent are likely more significant but remain poorly studied and mostly anectodical (Steiner 1981; Lessa and da Cota 2010; Aranda-Sánchez 2012; Kays *et al.* 2012). Our diet data suggest *C. derbianus* is mostly frugivorous, but it might also feed on small vertebrates or insects, flowers and nectar (Bucher and Hoffmann 1980; Kays *et al.* 2012). Finally, during our survey, we did not find any evidence of *C. derbianus* value for food, commercial, cultural, religious or domestic use. Nonetheless, it may be threatened by loss of habitat, persecuted for being considered detrimental to poultry farming or simply due to a lack of knowledge about the species. Our data compilation sheds more light on the distribution, ecology and conservation threats on *C. derbianus* in Panamá and could serve as a baseline for future studies.

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Figure 3. Photographic sequence, from A to D, of a deadly attack by a spectacled owl (*Pulsatrix perspicillata*) arrowed at C on a Central American woolly opossum in the island of Barro Colorado, province of Colon, Panamá. Photograph by I. Geipel.

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