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Range extension of Northern Naked-tailed Armadillo, *Cabassous centralis* Miller, 1899 (Mammalia, Cingulata, Chlamyphoridae), in Belize

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Abstract
Little is known about the Northern Naked-tailed Armadillo, *Cabassous centralis* (Miller, 1899). Here we present a new record of *C. centralis* in the Maya Mountain Massif of Belize, from camera-trap surveys covering an area of 200 km^2 conducted yearly between 2002 and 2017 in lowland tropical broadleaf evergreen forest, and a dead specimen found adjacent to a highway. The record presented constitutes a range expansion of ca 65 km for *C. centralis* in Belize. This adds valuable data about a species for which the geographic distribution is poorly known.

Key words
Geographical distribution; new occurrence; broadleaf forest; Neotropics; mammal; camera-trap.

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Introduction

The Northern Naked-tailed Armadillo, *Cabassous centralis* (Miller, 1899), is considered Data Deficient by the IUCN (2014), with only 15 published works about the species (see Loughry et al. 2015). It is the single member of its genus, and one of only 2 species of armadillos to have a distributional range outside of South America (Hayssen et al. 2013). The other species is the Nine-banded Armadillo, *Dasypus novemcinctus* Linnaeus, 1758, which is the most extensively studied of all the armadillo species (Superina et al. 2013, Loughry et al. 2015). The current range distribution of *C. centralis* covers an area of approximately 780,000 km^2 from western Colombia,north-western Ecuador, north-western Venezuela through Central America, with its northernmost distribution located in the eastern region of Chiapas, Mexico (Gardner 2005, Tirira 2007, González-Zamora et al. 2011, Hayssen et al. 2013, Loughry et al. 2015, Lopez et al. 2017), from sea level to about 3,000 m a.s.l. (Díaz-N. and Sánchez-Giraldo 2008). Specimens have been found within mosaic landscapes in Guatemala and Mexico, including rubber, banana, and cacao plantations, agricultural and pasture, grasslands, and tropical evergreen forest (Cuarón et al. 1989, Gonzalez-Zamora et al. 2011). Although Belize features many of the same habitats as those reported for the northern-most range of *C. centralis*,

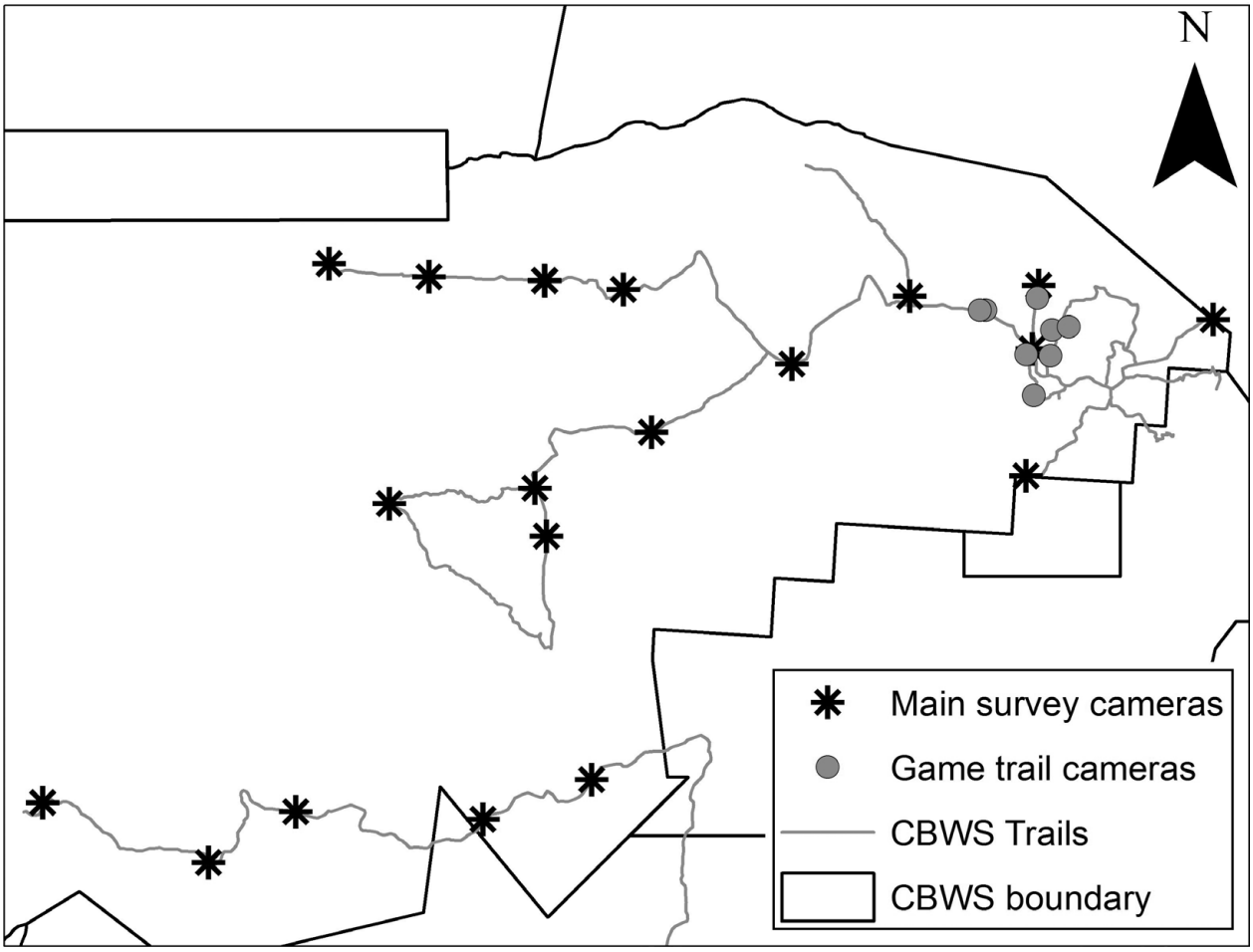

Figure 1. Locations of the camera traps in Cockscomb Basin Wildlife Sanctuary, 2014.

there is only 1 record of this species from Belize: a road-kill specimen found in 1978 in the southern tip of Belize (Toledo district) on an unpaved highway (16°16′48″ N, 088°16′12″ W) in an area of grassland savannah (McCarthy 1982). As such, this formed the most northern extent of the distribution of *C. centralis* along the Atlantic coast. The single record of *C. centralis* in Belize was near the most southern edge of a large contiguous forest block, the Maya Mountain Massif. Here we present data on camera-trap detections and a dead specimen of *C. centralis* from the Maya Mountain Massif.

Methods

Repeated large scale, long-term camera trap surveys have been conducted in the Maya Mountain Massif since 2002: in the Chiquibul Forest Reserve, the Mountain Pine Ridge, and the Cockscomb Basin Wildlife Sanctuary (Silver et al. 2004, Davis et al. 2010, Harmsen et al. 2017). In the current study, we use camera records from the Cockscomb Basin Wildlife Sanctuary (CBWS). The CBWS was selectively logged until 1981, received protected status in 1986, and comprises secondary lowland tropical broadleaf evergreen forest in several successional stages (Harmsen et al. 2010, Meerman and Clabaugh 2017). From 2002 to 2017, we deployed paired camera traps at twenty fixed locations during the dry season (February to June) along the existing trail system as part of a long-term ecological study of the wildlife (Harmsen et al. 2017) (Fig. 1). We placed camera traps roughly 30 cm above ground, with an average distance between stations of 2.02 km (range = 1.07–3.05 km). We conducted the surveys every year except 2009 and 2010. Survey durations ranged from 59 to 98 days and spanned an area of 200 km^2. From February to July 2014, we conducted an additional small-scale survey alongside the annual survey (Figure 1). We deployed single camera-traps at 8 locations, approximately 15 cm above the ground, along game trails, to survey for mammalian species such as Paca (*Cuniculus paca* (Linnaeus, 1766)) and *D. novemcinctus* which may otherwise avoid the main trail system (Harmsen et al. 2010).

Average distance between neighboring locations of the small-scale survey was 616 m (range = 92–1022 m), covering an area of 1.5 km^2. From 2002 to 2008, we used film camera traps (CamTrakker, Cuddeback and DeerCam), and digital camera traps (PantheraCam V3, V4, V6) from 2011 onwards, all with white-flash.

Dasypus novemcinctus are frequently detected by the camera traps and constitute a significant component of jaguar diet in the area (Foster et al. 2010). We hypothesized that if *C. centralis* was common within the study area, we would detect *C. centralis* at a similar rate as *D.*

Figure 2. A. A camera trap image of a Northern Naked-tailed Armadillo from June 2014 in the Cockscomb Basin Wildlife Sanctuary, Belize. **B.** A camera trap image of a Nine-banded Armadillo from the same survey, which shows different morphological features (i.e. a longer armored tail, and long narrow snout) compared to the Northern Naked-tailed Armadillo.

novemcinctus, due to their biological similarity (Reid et al. 2009). However, if the species remained absent or rare in the CBWS, this would be reflected in a lower or zero detection rate compared to *D. novemcinctus*. An understanding of the rarity of detections of *C. centralis* in the CBWS may help to develop hypotheses about the possible occurrence of *C. centralis* beyond our sampling area within the Maya Mountain Massif. Therefore, using a paired *t*-test, we compared the detection rates of *D. novemcinctus* and *C. centralis* during 2014 (1 year after finding a dead specimen).

Results

New records. Belize. Cayo District (17°03′05″ N, 088°34′08″ W, 192 m a.s.l.), collected by Vivian Soriero, March 2013. Stann Creek District: Cockscomb Basin Wildlife Sanctuary (16°47′26″ N, 088°28′42″ W, 94 m a.s.l.), observed by Vivan Soriero on a camera trap image, 02:28, 23 April 2014. Stann Creek District: Cockscomb Basin Wildlife Sanctuary (16°46′55″ N, 088°30′34″ W, 92 m a.s.l.), observed by Vivian Soriero on a camera trap image, 02:32, 08 June 2014. Stann Creek District: Cockscomb Basin Wildlife Sanctuary (16°47′42″ N, 088°34′03″ W, 205 m a.s.l.), observed by Vivan Soriero on a camera trap image, 17:55, 22 June 2014.

We collected an adult carcass from the side of the only paved highway that runs through the Maya Mountains in Belize. The highway is bordered by tropical lowland broadleaf forest and agricultural lands comprising citrus plantations and human settlements (Meerman and Clabaugh 2017). We could not verify the cause of death. However, the carcass was in good condition and did not appear to have been hit by a vehicle.

In 2014, our camera-traps detected *C. centralis* at three locations in the CBWS. Two of the detections were on the main trail system and 1 on a game trail, spaced an average of 6.4 km apart (range = 3.4–9.5 km). Trap effort during 2014 was 4,003 trap-nights across 28 camera locations, with a mean trap effort per camera location of 143 ± 6.6SE days (range = 71–191 days, $N = 28$ camera locations). During 2014, the detection rate (detections/100 trap-nights/camera location) of *C. centralis* was significantly lower than that of *D. novemcinctus* (*C. centralis*: mean 0.1 ± 0.04SE, *D. novemcinctus*: 1.8 ± 0.1SE, $t = 2.66$, df = 27, $P < 0.05$, $N = 28$ camera locations). From 2015 to 2017, we did not detect *C. centralis*, whereas *D. novemcinctus* remained active in the study area (mean detection rate from 2015 to 2017: 0.9 ± 0.02SE detections/100 trap-nights/ camera location, $N = 20$ camera locations).

Identification. We identified the carcass and camera trap images of *C. centralis* via its characteristically short, slightly pinkish tail. This distinguishes it from *D. novemcinctus*, which has a long, armored tail (Fig. 2). We also noted that the *C. centralis* specimen and images had a short, broad, snout which contrasted with the long narrow snout of *D. novemcinctus* and was generally smaller in body size (Reid et al. 2009).

Discussion

Here we present a range extension of approximately 65 km for *C. centralis* from the species' last noted northern distributional limit along the Atlantic coast in 1978, to the current specimen found in the Cayo district in March 2013 (Fig. 3). *D. novemcinctus* are commonly detected by the camera traps, and constitute a significant component of jaguar diet in the area (Foster et al. 2010). The detection rate of *D. novemcinctus* suggests that the camera traps are suitably placed for detecting small ground-dwelling mammals such as armadillos. As such, the extremely low frequency of detection of *C. centralis* likely provides an accurate depiction of its rarity in the study area.

D. novemcinctus are also frequently recorded on camera traps within the Chiquibul Forest Reserve and the Mountain Pine Ridge (located west and north-west

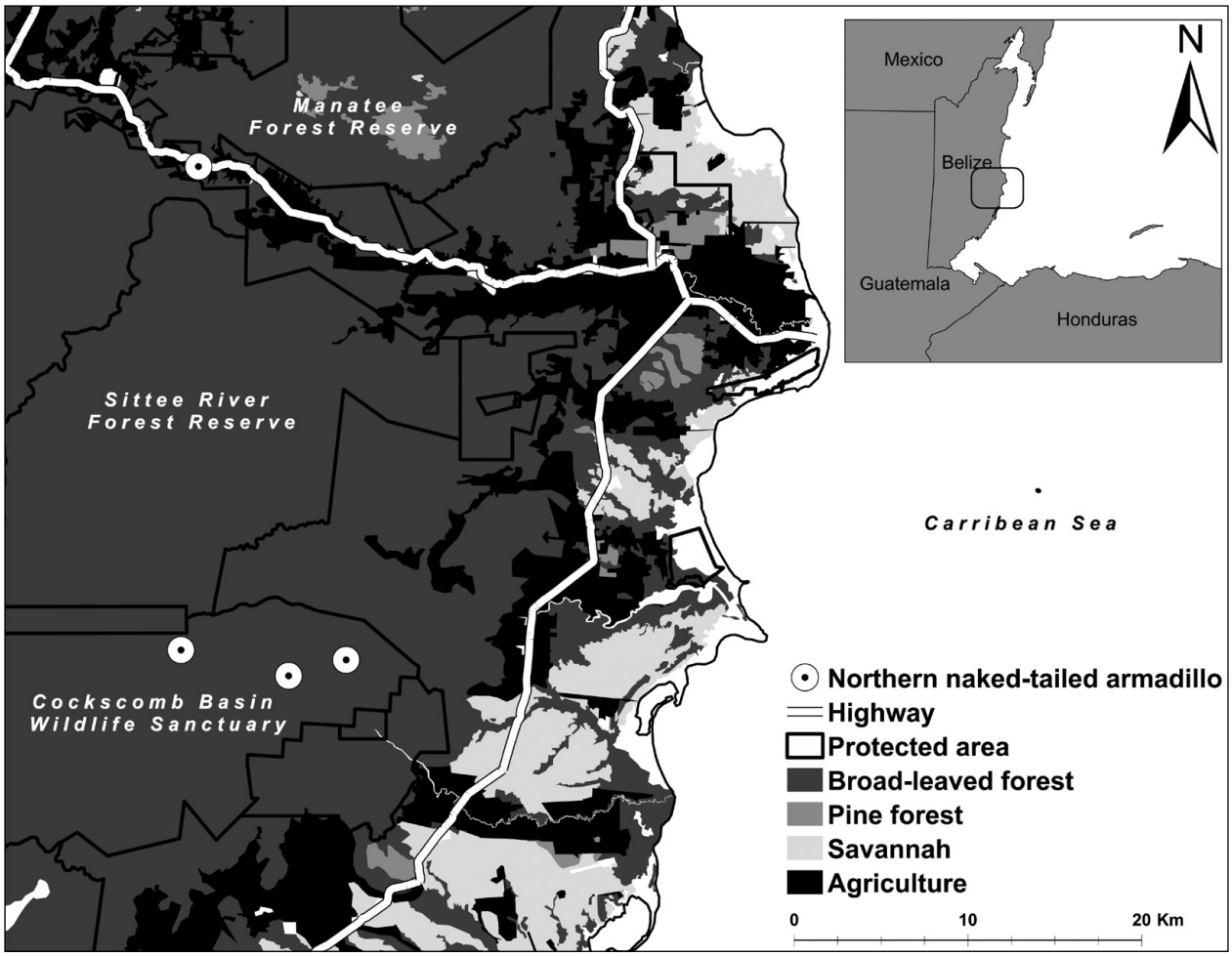

Figure 3. Locations of the new detections (*N* = 4) of the Northern Naked-tailed Armadillo in Belize.

of the CBWS respectively). However, at the time of writing, *C. centralis* have never been detected within these forest reserves (pers. comm. Marcella J. Kelly). As such, the new detections of *C. centralis* within a relatively short time span, despite no detections for the 9 years previous nor 3 years post detections, may reflect a rare but limited northern range extension for this species. As armadillos are difficult to distinguish individually on the basis of photographs, we cannot assess whether the 3 captures of *C. centralis* during 2014 are the same or different individuals. No data exist on the home range sizes of *C. centralis*; however, we may assume that they are similar to that of *D. novemcinctus*, whose home ranges are estimated to be between 0.63 and 20.1 ha (Chapman and Feldhamer 1982, McDonough and Loughry 2008), equivalent to a maximum home range diameter of 500 m. The average distances between our camera-trap detections of *C. centralis* are larger than 500 m (6.4 km); as such, we conclude that the 3 detections are different individuals.

Previous records of *C. centralis* indicate that it occupies similar habitats as *D. novemcinctus*, including tropical evergreen forest, open savannah grasslands, and mixed forest and agricultural lands (Hayssen et al. 2013). As such, we would expect the Maya Mountain Massif to provide suitable habitat for *C. centralis*. However, compared to *D. novemcinctus*, *C. centralis* exists at low densities across its geographic range (Hayssen et al. 2013). Potentially, its naturally low density may result in low detectability by sampling methods such as trail-based camera-trap surveys, especially if it avoids trail systems (Harmsen et al. 2010). Only 1 other study has detected *C. centralis* via camera traps, which was a single detection out of 7,380 trap nights in Chiapas, Mexico (Lopez et al. 2017). Like our study, Lopez et al. (2017) recorded frequent captures of *D. novemcinctus* (81 detections), in comparison to *C. centralis*. It is also possible that a lack of familiarity with the species may result in the misidentification of *C. centralis* as *D. novemcinctus* by researchers using camera traps in areas where the former are rare and the latter are common. However, we can be certain that within the CBWS

Cabassous centralis has not been detected before or after the 2014 survey, and therefore that it remains rare in the Maya Mountain Massif.

The few published articles about *C. centralis* concern either direct sightings or road kills (e.g. González-Zamora et al. 2011). Indeed, road traffic appears to be a possible threat to this species. González-Zamora et al. 2011 reported 6 new records from the Lacandona rainforest of southern Mexico, of which 3 records were road kills, and 3 were live detections. In our study, the cause of death

of the specimen was unknown; however, its location next to a paved highway suggests that it may have been involved in a road traffic accident, although we could see no visible evidence of this on the carcass. We hope that the current study will prompt researchers using camera traps in Central America to pay close attention to detections of armadillos within their study sites and encourage researchers to look out for new records of *C. centralis*.

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Authors' Contributions

MC and VK collected the specimen. BJH, RJF, RLW, and VRS conducted the camera trap surveys. RLW conducted the analyses. RLW, BJH, RJF, and VRS wrote the manuscript.

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