Black-bellied pangolin *Phataginus tetradactyla* documented in Deng Deng National Park, Cameroon, using camera traps

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Abstract Information on pangolin life history and ecology is becoming increasingly available in African countries through community-based surveys and camera-trapping. However, there is a paucity of information on the largely arboreal black-bellied pangolin *Phataginus tetradactyla*, which is categorized as Vulnerable on the IUCN Red List. By targeting fallen trees or logs with camera traps we recorded the black-bellied pangolin opportunistically in Deng Deng National Park (East Region, Cameroon), a locality within the presumed distribution of the species within Cameroon. We obtained a low trapping rate of 0.063 events per 100 trap-days and the capture probability was one event recorded over 1,571 trap-days (0.0006 captures per day). Deploying camera traps that focus on fallen trees or logs could be explored as a method for detecting black-bellied pangolins.

Keywords Black-bellied pangolin, camera trap, Cameroon, fallen tree, monitoring, *Phataginus*, Pholidota

The diurnal black-bellied pangolin *Phataginus tetradactyla* (Pholidota: Manidae) occurs in West and Central Africa, where it reportedly favours riparian and swamp forests (Ingram et al., 2019; Gudehus et al., 2020). It is threatened because of overhunting for its meat and scales and is categorized as Vulnerable on the IUCN Red List (Ingram et al., 2019) and listed on CITES Appendix I (CITES, 2017). Ecological data remain limited for the black-bellied pangolin across its range.

Confirming the presence of black-bellied pangolins is challenging for several reasons. Firstly, throughout West and Central Africa people often call both of the arboreal African pangolin species (the white-bellied pangolin *Phataginus tricuspis* and black-bellied pangolin *P. tetradactyla*) *petit pangolin* (Difouo et al., 2020), creating uncertainty regarding local knowledge of the presence of these species. Secondly, black-bellied pangolins are particularly challenging to detect using typical ground-based camera traps as they are largely arboreal. Thirdly, this species may live at low densities (Willcox et al., 2019; Gudehus et al., 2020). Twelve previous understorey ground-based camera-trap surveys conducted in black-bellied pangolin habitats did not record a single photograph of this species (Khwaja et al., 2019). In the Centre and East regions of Cameroon the black-bellied pangolin is the least known and least reported pangolin species (Difouo et al., 2020). Carcasses of black-bellied pangolins confirm their presence in some localities; for example, in Campo Ma'an National Park (Ichu et al., 2017), along the Nyong-ékélé divisional road (Difouo et al., 2020) and at a market in Djoum (O. Fokou, pers. obs., 2021). Here we document the presence of the black-bellied pangolin in Deng Deng National Park using log-based camera traps.

The 682 km² Deng Deng National Park lies in the East Region of Cameroon (Fig. 1). It is characterized by a tropical to sub-equatorial transition climate (Tsalefac et al., 2000) and belongs to the forest–savannah transition zone in the north of the Congolian Forest block. Dense evergreen and semi-deciduous rainforest transitions into mixed forest and grassland savannah in this northern zone.

We conducted a camera-trap survey in Deng Deng National Park during 15 November 2021–21 January 2022, with the primary aim of detecting the white-bellied pangolin. We deployed 35 camera traps in a near-primary forest, secondary forest and swamp forest. The camera traps covered a 19 km² area in two grids: 10 km² in the central area and 9 km² in the northern area (Fig. 1). We deployed the camera traps during the dry season for a minimum of 60 trap-days per camera trap. We placed camera traps 1 km apart in accordance with the estimated home range size of the target species, to ensure independence between trapping stations for occupancy analysis (MacKenzie et al., 2006), and the two grids were 16 km apart.

We used 26 Bushnell (Essential E Brown 119837, Trophy Cam HD 119873, Trophy Camera Brown 119836; Bushnell, Overland Park, USA), five Vision UV557 (UOVision, Shenzhen, China) and four Moltrie 30i (PRADCO

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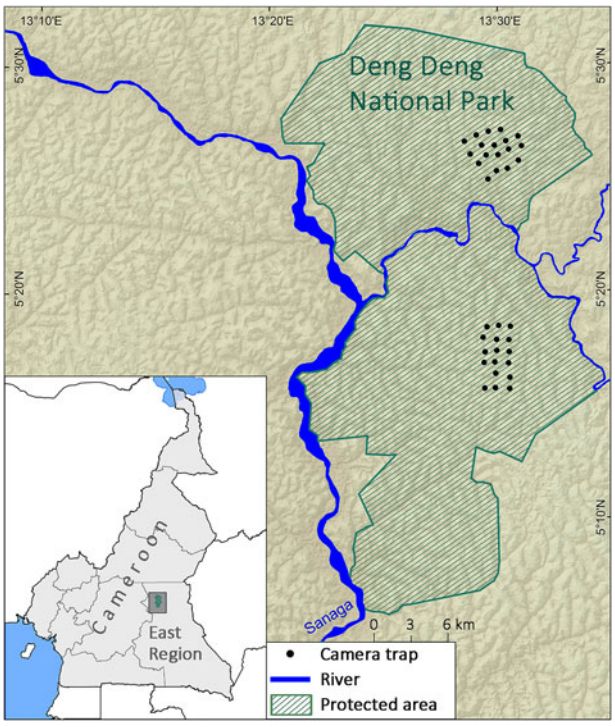

FIG. 1 The location of the two camera-trap grids in Deng Deng National Park, Cameroon. Given the threat posed to pangolins by illegal hunting, only approximate locations are provided.

PLATE 1 A black-bellied pangolin *Phataginus tetradactyla* photographed walking on a log in Deng Deng National Park, Cameroon (Fig. 1).

Outdoor Brands, Birmingham, USA) camera traps. We secured the camera traps onto trees and targeted them at fallen trees or logs (Simo et al., 2020), 3–4 m from the target at 70–80 cm above ground level, so that each camera was aimed 30–40 cm above the top of the logs (Simo et al., 2020). We calculated trapping rate as the number of independent photographic events (two consecutive events of the same species were considered independent if there was an interval of at least 1 h between them; McPhee, 2015) per 100 trap-days. We also calculated the capture probability, which provides the mean frequency that a particular species will be recorded on any given day during the survey period. We calculated the capture rate as the total number of events of a species divided by the total number of events of all three pangolin species combined, multiplied by 100 (McPhee, 2015).

Cameras operated for a total of 1,571 trap-days across the 33 camera-trap stations. One camera-trap station (at 726 m elevation) provided a single photographic event (three sequential photographs) after 35 trap-days of an adult black-bellied pangolin walking on top of a log in a secondary forest at 11.47 (Plate 1). In this habitat the canopy was relatively open (25% canopy cover), with a dense understorey. The black-bellied pangolin trapping rate was 0.063 events per 100 trap-days and the capture probability was low (0.0006 captures per day), with one event being recorded in 1,571 trap-days.

This study confirms the presence of the black-bellied pangolin in Deng Deng National Park through one photographic event comprising three photographs. To our knowledge, there are no other published records of this species photographed in the wild using a camera trap. Previous camera-trap studies have failed to record this species using ground-, burrow- or trail-based cameras (Khwaja et al., 2019; Simo et al., 2020). This lack of detection could be because of suboptimal camera-trap placement, the natural low density of the species and/or low survey effort. Considerably higher survey effort elsewhere, such as by Khwaja et al. (2019) with 8,186 trap-days, Simo et al. (2020) with 3,000 trap-days (including 325 trap-days at logs in Deng Deng National Park), Ichu (2022) with 4,191 trap-days in the tree canopy and at logs in Campo Ma'an National Park, and Simo et al. (2023) with 3,315 trap-days at logs in Mpem et Djim National Park, did not record the black-bellied pangolin. Camera traps targeting logs have been shown to improve detection rates for the white-bellied pangolin (Simo et al., 2020). Although black-bellied pangolin detections through camera-trap surveys are rare (in this study the black-bellied and giant pangolin capture rate was 1.5% of all pangolin captures, compared to the 97.0% of the white-bellied pangolin), focusing camera traps on logs could improve the chances of detecting this species over alternative placements, such as on the ground. The effectiveness of placing camera traps in the canopy remains to be evaluated (D. Alempijevic, unpubl. data, 2020). The combined black-bellied pangolin and giant pangolin detection rate (3.0% of all pangolin captures) indicates the rarity of these species, as reported by local people (Difouo et al., 2020).

We recorded the black-bellied pangolin 35 days after deployment, which is considerably longer than the 12 trap-day mean for giant pangolins at burrows (Matthews et al., 2023)

and the 3 trap-day mean for white-bellied pangolins (Simo et al., 2020). The photograph was captured during daytime in secondary forest, corroborating descriptions of the diurnal activity pattern of this species (Gudehus et al., 2020). The black-bellied pangolin was photographed 355 m from the nearest river, potentially corroborating a preference for riverine and swamp forest habitats with permanent water courses (Gudehus et al., 2020). Our record was in a disturbed forest on a non-decayed trunk of *Xylopia aethiopica* (Dunal) cut by local people, suggesting the species tolerates at least minor levels of habitat disturbance, as suggested previously (Angelici et al., 1999).

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Conflict of interest None.

Ethical standards This research abided by the *Oryx* guidelines on ethical standards.

Data availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

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