Original Study

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Expanding the frontiers of camera-trapping in Colombia: application of the "Mostela" system to gain knowledge on small non-volant mammals from an Andean cloud forest

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Abstract: Recently, the Mostela system emerged as an expansion of camera trapping to gain new insights into the assemblages of small-sized and cryptic mammals. Despite being an established technique to study the natural history and ecology of rodents, shrews and small carnivores in Europe, its potential in tropical areas remains unexplored. We present the results of a pilot hybrid survey with conventional trail cameras and Mostelas conducted in a private protected area situated in the Cordillera Occidental of Colombia. We installed eight Mostelas paired with an external trail camera 550 m apart from each other from May to October 2022 in the Mesenia-Paramillo Nature Reserve. The Mostelas recorded two species of small carnivores, the threatened and unknown Colombian weasel (*Neogale felipei*), and the Long-tailed weasel (*Neogale frenata*), including several small rodents and marsupials. Mostelas captured a larger proportion of small non-volant mammals that could at least be identified to genus level compared to conventional trail cameras. We found that using baits inside Mostelas yielded a greater number of detections and richness compared to surveys not using them. Finally, we encourage the use of this hybrid system to improve the monitoring of poorly known small non-volant mammals in the Andean cloud forests.

Keywords: baits; cloud forests; *Neogale felipei*; non-invasive surveys; richness; small non-volant mammals

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1 Introduction

Small non-volant mammals are model organisms for biodiversity conservation and management, as their population growth rates can be tracked to understand biodiversity responses to environmental changes (Marneweck et al. 2022). The mountain cloud forests of the Northern Andes are considered a hotspot for multiple lineages of Neotropical small non-volant mammals (Mena et al. 2011; Sanchez-Giraldo and Diaz-Nieto 2015). Mice (Cricetidae, Echimyidae), shrews (Soricidae), opossums (Didelphidae), shrew opossums (Caenolestidae), and even some ground-dwelling carnivores (Mustelidae) have diversified in these landscapes due in part by their variable environmental conditions and complex topographies (Mena et al. 2011). However, the limited knowledge about the current status of the native small non-volant mammal assemblages in terms of structure, composition, and occurrence, hinders their inclusion in conservation planning (De Bondi et al. 2010; Sanchez-Giraldo and Diaz-Nieto 2015).

The study of the ecology and natural history of small non-volant mammals has been largely based on live-trapping techniques which often involve the use of

Sherman and/or Pitfall traps (Woodman et al. 1996). Employing live trapping often requires considerable sampling effort, ethical permits, and animal handling skills (De Bondi et al. 2010; McLean et al. 2016; Palmeirim et al. 2019; Preece and Fitzsimons 2022). In addition, daily reviews of the stations to guarantee their constant operation and that captured animals are handled in time, make life trapping very labor intensive (Littlewood et al. 2021; Palmeirim et al. 2019). In areas with rugged terrain and poor road infrastructure, the periodic monitoring of the sampling units may impose a serious logistic constraint that usually compromise sampling efforts. Contrastingly, remote techniques, such as trail cameras, are beginning to be applied on small non-volant mammals, as they can efficiently collect large amounts of data, over broad spatiotemporal scales, and with minimal welfare implications (De Bondi et al. 2010; Glen et al. 2013).

Small mammals are difficult to detect using conventional camera trapping (Delisle et al. 2021). As a consequence, a variety of methods have been developed over the last decade to adjust trail camera application to focus on small mammals (Gracanin et al. 2022; Hobbs and Brehme 2017; Littlewood et al. 2021; McCleery et al. 2014; Mos and Hofmeester 2020; Soininen et al. 2015). Several of these approaches use a trail camera that is placed looking down onto the animals (Hobbs and Brehme 2017; McCleery et al. 2014; Soininen et al. 2015), which can lead to complication in species identification when similar taxa occur in an area. Other approaches (Gracanin et al. 2022; Littlewood et al. 2021; Mos and Hofmeester 2020) place the camera parallel to the animals, photographing the sides of animals, which makes species identification easier. However, to date, none of these methods have been used to study small non-volant mammals in Tropical systems.

Here, we report the first use of the Mostela system in communities of small non-volant mammals from an Andean cloud forest. The Mostela consists of a trail camera inside a closed box that is traversed by a plastic tracking tunnel (Mos and Hofmeester 2020). It was originally developed to study small carnivores (Croose and Carter 2019; Croose et al. 2022; Mos and Hofmeester 2020) but has the potential to study the whole small mammal assemblage. We chose the Mostela system as we were specifically interested in the occurrence of two small carnivore species, the Colombian weasel (*Neogale felipei*, Izor and de La Torre 1978) and Long-tailed weasel (*Neogale frenata*, Lichtenstein 1831). We combined the Mostelas with a classic trail camera to compare the performance of both methods and provide recommendations for their future use in field studies. In particular, we had three main objectives: First, we investigated the composition and structure of the mammal assemblage detected by both classic trail cameras and Mostelas. Second, we compared the number of detections of small non-volant mammals and the proportion of animals that could be reliably identified to at least genus level between the external trail cameras and the Mostelas. Third, we analyzed the influence of using baits and two different diameters of the plastic tracking tunnel on the number of small non-volant mammal detections, and the number of taxa (e.g., species, genera) detected inside the Mostelas.

2 Materials and methods

The Mesenia-Paramillo Nature Reserve (MPNR) is a private protected area located on the eastern slope of the Cordillera Occidental, in the southern part of the Antioquia Department, Colombia (Figure 1). The MPNR covers an area of ca. 35 km^2 mainly consisting of Andean cloud forests in an elevational range between 1500 and 3120 m.a.s.l. Average annual temperature and annual rainfall range between 15 and 23 °C and 2000–3000 mm, respectively. Rains mainly occur in two bimodal peaks, between March–May and October–November. The surrounding landscape of the MPNR is a mixture of pastures for cattle grazing, tree plantations, and crops of coffee, banana, and avocado. A small but active group of rangers patrols the area to avoid illegal extractive activities and a maximum of 10 persons per day are allowed to use the available trails in the protected area.

2.1 Trail camera sampling

Between May and October 2022, we installed eight Bushnell Trophy Cam HD trail cameras with Infra-Red LED inside Mostelas and separated each station by an average distance of 550 m. The original design of the Mostela consists of wooden boxes 61 cm long by 30 cm wide attached to a 35 cm long plastic tracking tunnel with diameters of 8 and 10 cm respectively, a mesh that separates the camera from contact with entering animals, and a +2-dioptre lens placed in front of the camera (Mos and Hofmeester 2020). We adapted the original Mostela design by changing the material from wood to galvanized steel to deal with the constant moisture conditions of the cloud forest while avoiding physical degradation. We also used two different diameters (8.3 and 10.2 cm) of the plastic tracking tunnels as these were the diameters available on the local market that were closest to the previously published diameters and no +2-dioptre lens were used (Figure 2). We fitted half of the Mostelas with an 8.3 cm tube, and half with a 10.2 cm tube. We installed the Mostelas in flat terrain while trying to target areas where we expected a high use by small non-volant mammals. We conducted two different surveys to compare the performance of Mostelas. First, we tested the Mostelas against classic trail cameras aimed at the Mostelas, and second, we tested the avoidance or attraction of baits inside the Mostelas. In the first survey (May – July, 2022), we installed an external Infra-Red LED trail camera (Blaze Video Animal Cam A262) ≤2 m in front of the tunnel entry of each Mostela and did not use baits. This array was employed to preventing the exclusion of detections by our target species outside the Mostela (Croose et al. 2022). In the second survey (July – October, 2022) we removed the external trail cameras to be used for other purposes and installed a non-reward bait inside the Mostelas. The complete sampling scheme can be consulted in the

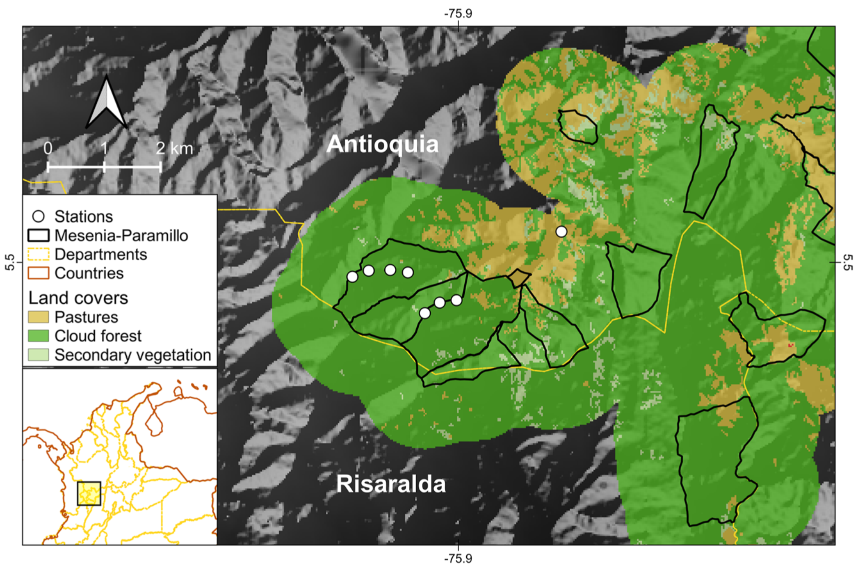

Figure 1: Location of the Mostelas installed in the Mesenia-Paramillo Nature Reserve, municipality of Andes, Department of Antioquia, Colombia. The red line delimits the political boundaries between three departments of Colombia (Antioquia, Risaralda, and Caldas). Land cover types (González et al. 2022, https://doi.org/10.1016/j.jag.2022.102688) and elevation with the non-void filled NASA SRTM DEM (version 1; https://doi.org/10.5066/F7K072R7) are layers available online.

supplementary material (Supplementary Table S1). The bait consisted of semi-closed cans of either sardines or tuna, which were safely pegged into the ground to prevent animals from removing them (Diete et al. 2015; Ferreras et al. 2018). Though fish oil is a benchmark mustelid attractant (Randler et al. 2020), we could not use pure fish oil during this survey given its scarcity in the local market. Instead, we opted to used sardine and tuna cans as they were locally accessible and have previously been recognized to be good carnivore attractants (Avrin et al. 2021; Randler et al. 2020). We also alternated the use of sardine and tuna baits in equal proportions to the Mostelas with both tube sizes. In the first survey, sampling effort was 581 trap nights with four Mostelas actively recording during 73 days, three Mostelas during 72 days, and one Mostela without records. In the second survey, sampling effort was 624 trap nights with all the eight Mostelas recording during 78 days.

We programmed the cameras to take three photographs over a 1-s period for the Mostelas and a 0.1-s period for the external trail cameras to obtain animal records in different postures (De Bondi et al. 2010; Ferreras et al. 2018). Each sequence of three photographs was defined as a single photographic event, which was pooled for subsequent analyses. We choose this setting to increase the reliability of the identification of the animals photographed. When possible, we identified the animals detected at the species level by using measurements and descriptions provided by different systematic accounts (Patiño-Castillo and Solari 2017; Patton et al. 2015; Teta and Jayat 2021). Within each Mostela, we placed a measuring tape in front of the camera's field of view to obtain observable measurements of the head-body length and tail length to improve taxonomic identifications (Figure 2). We used some baseline external traits during the taxonomic identification process, such as coloration patterns, head shape, body shape, ear morphology, how the animal held its tail, or any other distinctive features (De Bondi et al. 2010).

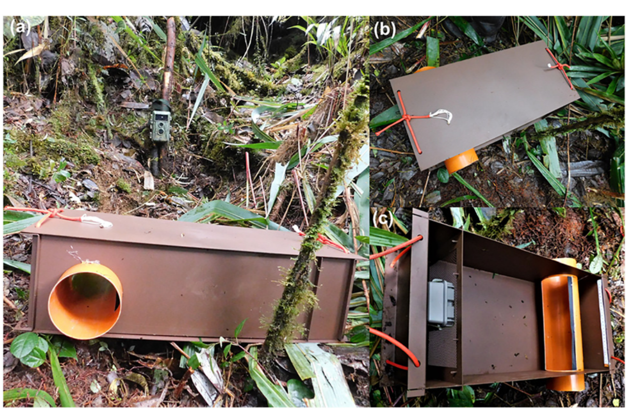

Figure 2: Representation of the hybrid station integrated by a modified Mostela system together with an external trail camera during the first survey in the Mesenia-Paramillo Nature Reserve. (a) Frontal view, (b) upper picture with lid, (c) upper view without lid.

2.2 Data analysis

We processed the information obtained by classic trail cameras and Mostelas to extract date, time, sampling effort (number of operative days), number of detections, and number of species from the picture metadata using the camtrap R package version 2.2.0 (Niedballa et al. 2016). We considered as independent detections those pictures that corresponded to different individuals or an individual of the same species after a 60-min interval. To describe the small non-volant mammal composition in the external trail cameras and the Mostelas, we calculated the number of independent detections and the naïve occupancy of each taxon detected. The naive occupancy (Ψ naïve) or proportion of sites occupied was calculated as follows: Ψ naïve = x/s. Where x is the number of sites with at least one presence or detection of the species and s is the total number of sites (MacKenzie et al. 2017). We calculated the proportion of identified small non-volant mammals as the ratio of detections recognized at least at the genus level of the total detections for both the external trail cameras and Mostelas.

To compare the number of detections and proportion of small non-volant mammals identified between Mostelas and classic trail cameras, we used Generalized Linear Models (GLM). Before modeling, we pooled the number of independent detections of the different taxa observed for both methods. We recognize that this coarse taxonomic resolution may compromise the inference of fine-scale patterns, but it is helpful to increase the sample size under this comparative approach. We run a negative-binomial model with number of detections as the response variable with the method type (e.g., Mostela or external) as its factorial predictor. For the proportion of identified individuals, we performed a data transformation of this variable before the modeling process, since there were some stations with all, or no animals identified at least to taxonomic genus (Smithson and Verkuilen 2006). The transformation was made through the following formula: $x' = \frac{x(N-1)+s}{N}$ where N is the sample size and s is a constant between 0 and 1, and we choose an $s = 0.5$. We run a beta model with the transformed proportion of identified animals as the response variable and the same factorial predictor mentioned above (Douma and Weedon 2019). To compare if explained deviance by the method type in each model was significant compared to null model (no effect), we used the chi-square test considering p values between 0.05 and 0.10 as marginally significant given the low sample size (Murtaugh 2014).

To explore if the use of attractants and the tracking tunnel size were relevant predictors in explaining the effectiveness of Mostelas to detect small non-volant mammals, we build two additional models. First, we run a Poisson GLM using the number of taxa detected as a response variable against two factorial predictors, the presence of bait and the tube size. Second, we run a negative binomial GLM using the number of independent detections against the same factorial predictors mentioned above. Due to the set-up of our experiment, we had equal numbers of cameras with and without bait, as well as with the two different sizes, allowing us to disentangle the two effects. However, we acknowledge that due to the period difference between the test with and without bait, we cannot strictly separate between potential effects of season and bait. We test for explained deviance between each variable against the null model, using the chi-square test with alpha values between 0.05 and 0.10.

For validating our discrete count models (detections and richness) we check for over-dispersion, zero-inflated effect, and distributional assumptions of residuals using the DHARMa package version 0.4.5 (Hartig 2018). For the proportion model, we visually inspected the distribution and homogeneity of variance using weighted residuals in the betareg package version 4.1.3 (Cribari-Neto and Zeileis 2010). The data processing and modeling procedure were done through the R statistical language version 4.2.2 (R Core Team 2020).

3 Results

3.1 Mostela

The Mostela accumulated a total of 1205 trap nights and 512 detections of wildlife with 55 % corresponding to insects, 41 % to small non-volant mammals, 2 % to medium and large-sized non-target mammals, 1 % to unidentified birds, and 1 % to unidentified mammals. We managed to identify a total of 13 small non-volant mammal taxa among all the records obtained, with 84 % identified at the genus level, 10 % at the species level, 5 % at the order level, and 1 % at the family level. In the observed assemblage (Figure 3), we only detected a single threatened species, the Colombian Weasel. We observed that the species with the greatest number of detections corresponded to three genera of Sigmodontinae rodents (*Melanomys*, Thomas, 1902, *Thomasomys* Coues 1884, and *Nephelomys* Weksler, Percequillo and Voss, 2006), whereas the lowest values corresponded to *Caenolestes* (Thomas, 1895), *Chilomys* (Thomas, 1897), and *Neogale* (Gray, 1865) (Table 1). Irrespective of the species, the $\Psi_{\text{naïve}}$ of all the small non-volant mammals detected was relatively low (from 0.12 to 0.38, Table 1).

Following the baiting of the Mostelas, we loosed one of our sampling units with small tracking tunnel due to an intrusion of an Andean bear (Supplementary Figure S1), which was seeking for the cans inside the box. We also provide results corresponding to the bird species detected during the external trail camera survey which can be consulted in the supplementary material (Supplementary Table S2).

3.2 External cameras

The external trail cameras accumulated 581 trap nights and 481 detections of wildlife with 54 % corresponding to birds, 35 % to small non-volant mammals, 6 % to medium and large-sized mammals and 5 % to unidentified animals. Of the small non-volant mammal taxa detected, we identified 12 % at the genus level, 10 % at the species level, and 79 % were at the order level. Some mammals detected in the external trail cameras fall within a threat category, such as the Olinguito (*Bassaricyon neblina*, Helgen, Pinto, Kays, Helgen, Tsuchiya, Quinn, Wilson, and Maldonado, 2013), the Colombian Weasel (*N. felipei*, Izor and de la Torre, 1978), and the Andean Tiger Cat (*Leopardus tigrinus*, Schreber, 1775). The species with the greatest number of detections was the Mountain Paca (*Cuniculus taczanowskii*, Stolzmann, 1865) whereas the lowest values corresponded to the Long-tailed and Colombian weasels, olinguitos, Red-tailed squirrels (*Syntheosciurus granatensis*, Humboldt, 1811), and northern naked-tailed armadillos (*Cabassous centralis*, Miller, 1899). The species with the greatest naive occupancy was the Andean Tiger Cat (Table 1).

3.3 Camera method effects

We found slight differences in the number of small non-volant mammal detections as they were lower in the Mostelas compared to the external trail cameras ($Xi^2 = 3.73$, $df = 1$, $p = 0.053$) (Figure 4a). In contrast, we found that the proportion of small non-volant mammals that could be confidently identified at least at the genus level was greater

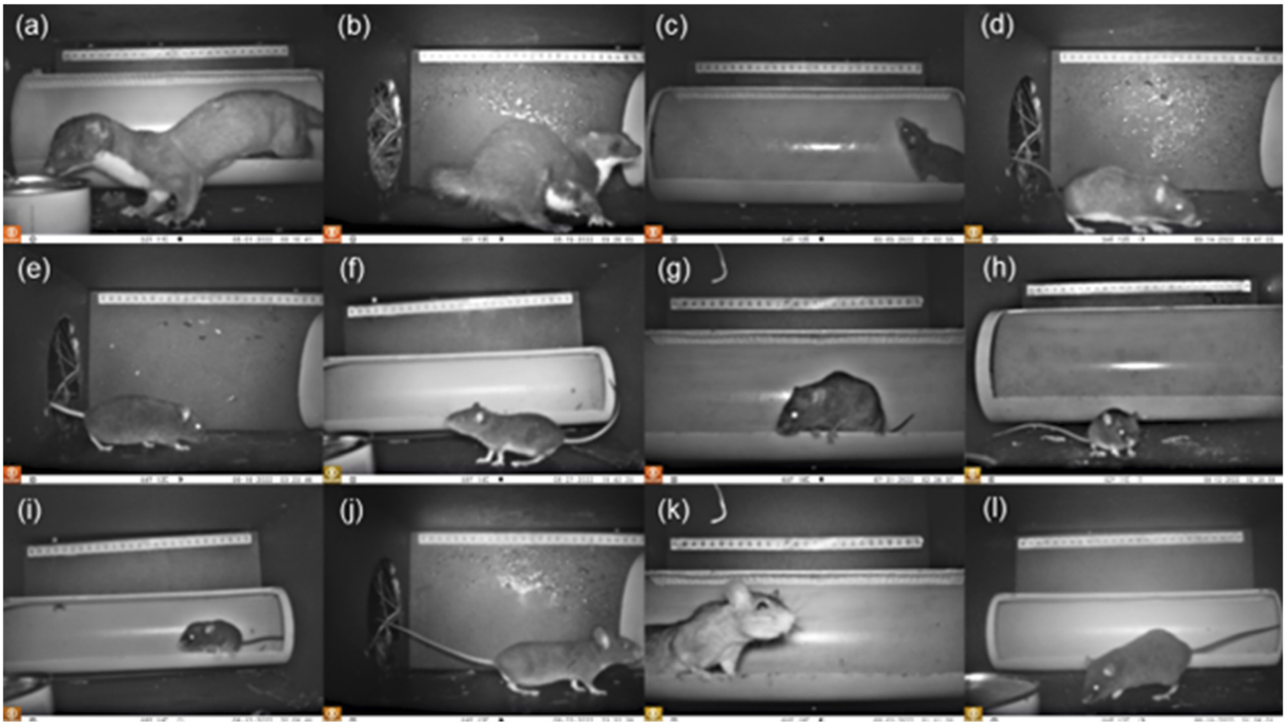

Figure 3: Small non-volant mammals detected with the Mostela survey conducted between July and October 2022 in the Mesenia-Paramillo Nature Reserve, Western Cordillera, Colombia. (a) *Neogale frenata*, (b) *N. felipei*, (c) *Caenolestes* sp., (d) *Heteromys* sp., (e) *Chilomys* sp., (f) *Handleyomys* sp., (g) *Melanomys* sp., (h) *Microryzomys* sp., (i) *Neacomys* sp., (j) *Nephelomys* sp., (k) *Rattus norvegicus*, (l) *Thomasomys* sp.

in the Mostelas compared to the external trail cameras (Xi^2 = 20.22, df = 1, $p < 0.05$) (Figure 4b).

3.4 Bait and tracking tunnel size effects

We found that using baits yielded a positive effect in both the number of taxa detected (Xi^2 = 3.31, df = 1, p = 0.068) (Figure 4c) and the number of small non-volant mammal detections (Xi^2 = 4.48, df = 1, p = 0.034) (Figure 4d), while it was marginally significant in the first case (Table 2). In terms of the tracking tunnel sizes, we found no differences in the number of taxa detected (Xi^2 = 1.98, df = 1, p = 0.158) (Figure 4e) or the number of small non-volant mammal detections (Xi^2 = 1.30, df = 1, p = 0.253) (Figure 4f). None of the selected models showed a lack of goodness-of-fit (Supplementary Figures S2–S5).

4 Discussion and conclusion

We confirm that extending the conventional frontiers of camera trapping was fruitful to overcoming the inherent challenges of surveying small non-volant mammals with these non-invasive devices. To the best of our knowledge, this is the first application of the increasingly popular Mostela system in a tropical habitat, and our results confirm that the use of Mostela can be useful to detect small non-volant mammals as shown in non-tropical environments (Croose and Carter 2019; Croose et al. 2022; Mos and Hofmeester 2020).

Conventional camera trapping in the northwestern Andes of Colombia has mainly been focused on medium and large-sized (>400 g) species from different trophic guilds (Bedoya-Durán et al. 2021; Bonilla-Sánchez et al. 2020; Mejía-Correa 2014; Mosquera-Muñoz et al. 2014). Particularly in the MPNR, a systematic study conducted between 2018 and 2019 reported the presence of 16 medium and large mammal species (Bonilla-Sánchez et al. 2020). This study however, detected only two species of small non-volant mammals, the Long-tailed weasel, and the Red-tailed squirrel. Another study conducted between 2020 and 2021 with the same array of trail cameras, reported the sympatric occurrence of the Colombian and Long-tailed weasels and proposed the use of the Mostela system to improve the knowledge of the former (Cepeda-Duque et al. 2021). Live trapping efforts that had been previously deployed at the MPNR (Patiño-Castillo and Solari 2017) reported nearly seven species of Sigmodontinae rodents

Table 1: Number of independent detections and naïve occupancy ($\Psi_{naïve}$) of the mammal species observed in the Mostelas and the external trail cameras.

Species/taxon	Detections in Mostelas	Detections in external trail cameras	$\Psi_{naïve}$	IUCN threat status
Carnivora				
Felidae				
Felis catus	0	6	0.12	LC
Leopardus tigrinus	0	6	0.5	VU
Mustelidae				
Neogale felipei	1	1	0.25	VU
Neogale frenata	2	1	0.37	LC
Eira barbara	0	2	0.12	LC
Procyonidae				
Bassaricyon neblina	0	1	0.12	NT
Nasua nasua	0	3	0.25	LC
Ursidae				
Tremarctos ornatus[a]	1	0	0.12	VU
Cingulata				
Chlamyphoridae				
Cabassous centralis	0	1		LC
Didelphimorphia				
Didelphidae				
Didelphis pernigra[a]	1	1	0.12	LC
Marmosa	2	2	0.12	–
Paucituberculata				
Caenolestidae				
Caenolestes	1	1	0.12	–
Rodentia				
Cricetidae				
Chilomys	1	0	0.12	–
Handleyomys	3	1	0.25	–
Melanomys	61	0	0.12	–
Microryzomys	4	0	0.25	–
Neacomys	2	1	0.25	–
Nephelomys	36	14	0.25	–
Thomasomys	53	0	0.38	–
Unknown Cricetidae	13	157	1	–
Cuniculidae				
Cuniculus taczanowskii[a]	10	9	0.25	LC
Echyimidae				
Heteromys	6	5	0.25	–
Muridae				
Rattus norvegicus	17	17	0.12	LC
Sciuridae				
Syntheosciurus granatensis	0	1	0.12	LC

IUCN threat status are: LC, least concern; NT, near threatened; VU, vulnerable. The surveys were conducted in the Mesenia-Paramillo Nature Reserve, between May and October 2022[a]. [a] Corresponds to non-target species detected inside the Mostelas.

among six genera from which two (*Akodon* and *Rhipidomys*) were not detected with our Mostela survey. By applying the Mostela system, our pilot study was able to detect nearly 12 genera of small non-volant mammals, including genera (*Chilomys* and *Microryzomys*) not previously reported by those live trapping sessions. Mostelas also detected other elusive species of conservation concern, such as Colombian weasels, Colombian forest mice (*Chilomys* sp), Western montane mice (*Handleyomys* sp., Voss, Gómez-Laverde and Pacheco, 2002), and shrew opossums (*Caenolestes* sp.) (Cepeda-Duque et al. 2021; Pisso-Florez et al. 2022; do Prado et al. 2015). With the increasing knowledge on the structure and composition of small non-volant mammals in the mountain cloud forests from the northwestern Andes (Brito et al. 2020, 2022; González et al. 2022; Ruelas et al. 2021), it is possible that >20 species could be expected to be found within a single assemblage. This means that none of the surveys were able to show the complete diversity of small non-volant mammals in the region. Therefore, we suggest that a combination of Mostelas, conventional trail cameras, and live-trapping surveys should be considered to further infer the activity patterns, habitat preferences, and predator–prey interactions of this small non-volant mammal assemblage. Future interests should be directed to simultaneously compare the performance of Mostelas against such techniques in terms of the identification accuracy, costs of habituation, ethical implications, and trade-offs between effort and information obtained.

We found weak support for differences in the number of small non-volant mammal detections between the Mostelas and the external trail cameras. Small non-volant mammals can display a wide range of behaviors when introducing novel objects into their habitats (Bytheway et al. 2021). Some species could become attracted to inquire into these new objects, while others may display indifference or strong avoidance (Bytheway et al. 2021). Croose et al. (2022) found that several individuals of the Irish stoat (*Mustela erminea hibernica*, Thomas and Barrett-Hamilton, 1985) did not enter the Mostela suggesting that behavioral flexibility and learn from individual experience might result in avoidance of novel objects in this species. In our case, we detected some individuals of both the Colombian and the Long-tailed weasels with the external cameras moving past the Mostela, but not enter it. This might suggest both an attraction (the animals were attracted to the vicinity of the Mostela) and avoidance (the animals did not explore inside the Mostela). Nevertheless, our low sample size prevent us to be conclusive regarding which method could be better in detecting

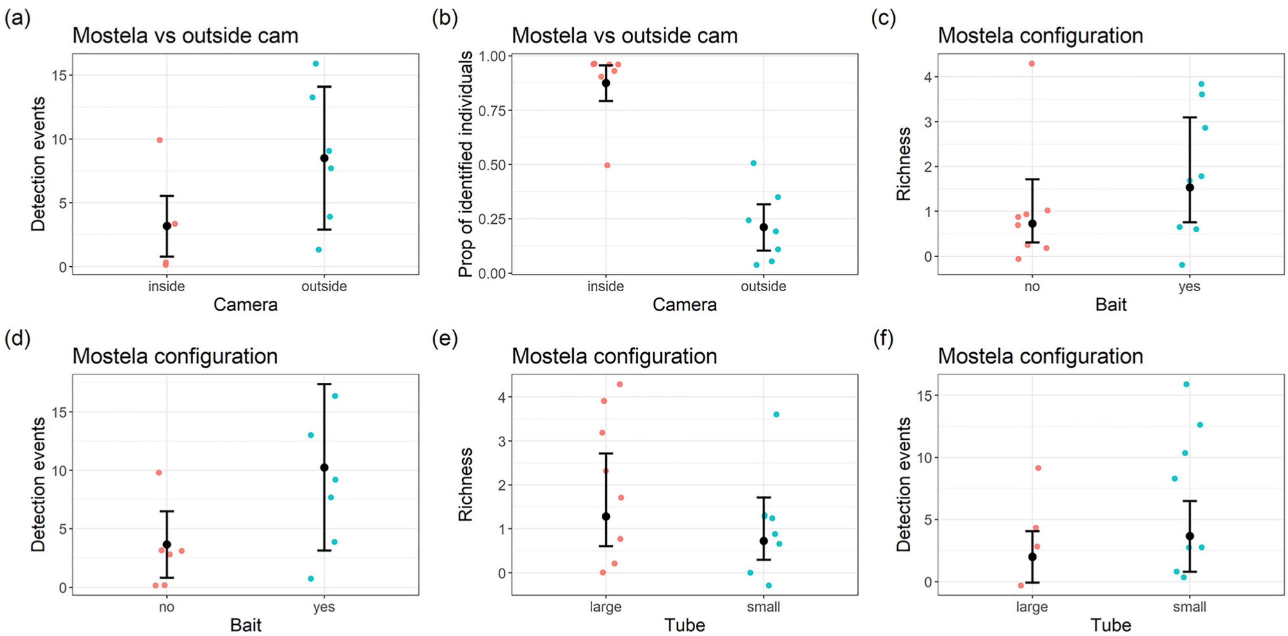

Figure 4: Predictions of the models relating the number of detections (a) and the proportion of identified individuals (b) against camera method, the number of taxa detected (c) and the number of detections (d) against the use of bait, the number of taxa (e) and the number of detections (f) against the tube size. Points and whiskers represent the mean and 95 % confidence intervals, respectively.

Table 2: Results of the generalized linear models performed in this study.

Model	Fixed effects	β coefficient	Confidence intervals	*p*-value
Number of small non-volant mammal detections versus camera method	Intercept	1.15	0.42; 1.93	0.002
	Method	0.98	−0.01; 1.99	0.052
Proportion of animals with known taxonomic identity versus camera method	Intercept	1.93	1.19; 2.67	<0.001
	Method	−3.25	−4.29; −2.22	<0.001
Number of small non-volant mammal detections versus baits + tube size	Intercept	0.77	0.10; 1.35	0.01
	Baits	0.98	0.47; 1.53	0.03
	Tube size	0.52	−0.01; 1.11	0.06
Number of taxa detected versus baits + tube size	Intercept	0.24	−0.59; 0.92	0.52
	Baits	0.75	−0.05; 1.65	0.07
	Tube size	−0.57	−1.43; 0.22	0.16

not only the small mustelids, but also the rest of small non-volant mammal species. The difficulties in taxonomically identifying other small-non volant mammals outside the Mostelas hampered us to make comparisons at genus or species levels.

Identifying species of small non-volant mammals from images of conventional trail cameras is often difficult as they mainly appear blurred, in grey scale (with infrared cameras), or capture the animals in postures that confound their body proportions (Diete et al. 2015; Hofmeester et al. 2019). Small non-volant mammal identification can also be difficult if the animal is trap-shy and remains hidden behind objects around the detection field, if it moves quickly during the capture sequence, or both (Avrin et al. 2021; Glen et al. 2013). With Mostelas we experienced an improvement in the accuracy of small non-volant mammal identifications, which could be refined even for inexperienced observers if white flash cameras are used to obtain high-quality pictures in color and with greater contrast (Burns et al. 2018; Diete et al. 2015). However, testing whether species could be misleadingly identified through coloration or if the white flash cameras could trigger unexpected behavioral outcomes (Burns et al. 2018; Glen et al. 2013), will also be required.

In terms of detectability, Mostelas have the potential to be experimentally manipulated to seek relevant features that could improve or influence the detections of target mammal species. This may include the size and color of the tracking tunnel, the use of baits and lures, or even the opened vegetation and the paths made by researchers. Detectability of weasels inside the Mostelas was previously found to be two-fold for the larger 10-cm tracking tunnel than for the smaller 8-cm tunnel (Mos and Hofmeester 2020). In contrast, we showed that the size of the tracking tunnel did not appear to predict different outcomes in either the number of small non-volant mammal detections or the number of taxa detected. It is also possible that the widely complex microhabitat structure of the cloud forest could elicit a relatively flexible response in small non-volant mammals to enter into cavities of different sizes, but testing this is also needed.

We demonstrated that using non-reward baits yielded a significant improvement in the expected richness of the small non-volant mammal assemblage compared to the control survey with no baits. Our results agreed with recent evidence with small non-volant mammals in Australia and small carnivores in Europe which highlights the use of baits to increase their detectability on trail cameras (Diete et al. 2015; Ferreras et al. 2018; Paull et al. 2011; Randler et al. 2020; Rendall et al. 2021). The employment of non-reward baits can also be useful to reduce the amount of required effort to reliably confirm that a given species is absent in a site, and thus, cost-effectively surveying rare or cryptic mammals (Avrin et al. 2021; Ferreras et al. 2018). Using non-reward baits can also improve identification accuracy by causing animals to spend more time in front of the camera in their attempt to access the bait (Ferreras et al. 2018). Paull et al. (2011) recommended to use several baits to avoid unexpected variation in a survey due to differences in bait preference among species and individuals. Peanut butter for instance, is found to elicit a more successful increase in the detectability of small non-volant mammals when compared to other baits (Diete et al. 2015; Paull et al. 2011; Rendall et al. 2021). Likewise, cans of sardines and tuna successfully proved to increase the detectability of several carnivore species simultaneously (Avrin et al. 2021; Randler et al. 2020). Recent evidence however, showed that baits can also be subject to different decaying rates under exposure to the environment (Avrin et al. 2021), with sardine cans in particular, having a faster decay compared to more synthetic baits (i.e., fatty acid tablets). This also needs to be tested in future studies with Mostelas as we noted that baits can be sheltered from environmental conditions once they are inside the box. Another important issue that needs to be addressed in the future is to test if transient dynamics in small non-volant mammal populations can influence bait performance. However, recent evidence highlights that highland populations of Sigmodontine rodents in Colombia do not seem to experience population fluctuations across years or between rainfall seasons (Villamizar-Ramírez et al. 2017, 2019). For instance, in an Andean Oak forest from the Cordillera Oriental, females of the Buff-bellied Climbing mice (*Rhipidomys fulviventer*, Thomas 1896), and the Mérida Oryzomys (*Nephelomys meridensis*, Thomas 1894) were aseasonally polyestric and males of the former species were reproductively active all year round.

It is well-stablished that prebaiting, or the deployment of sampling units prior to being armed, helps to overcome neophobia in small non-volant mammals towards traps (Bytheway et al. 2021), which might also improve trapping success in the Mostelas surveys. This can be applied either with or without using baits, by placing the boxes without cameras for a given time to promote habituation, and then arming the boxes with the cameras. With or without baits, we also suggest exploring new applications of deterrent features that could be used inside or alongside the Mostelas to avoid intrusion of non-target wildlife. Recent experiences with conventional trail cameras suggested that mounting the devices at heights not reachable by bears can help to avoid damage (Jacobs and Ausband 2018). However, such solution could not be functional enough for Mostela surveys, as they are only mounted in the ground, so, this is another open field of research.

We conclude that our survey of small non-volant mammals with Mostelas provided valuable information about its potential to expand our knowledge of several key and unknown small non-volant mammal taxa. With minimal ethical implications and continued methodological optimization, Mostelas would catalyze our basic understanding of the natural history, ecology, and the interactions between small non-volant mammals and human activities in a tropical context. This new evidence-based information will bring robust arguments into the conservation and management strategies (e.g., habitat restoration, pest control) related to an integral component of the Andean wildlife.

Research ethics: All procedures were in accordance with the national laws, and no illegal human activity or human individuals were photographed during the course of the study.

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