Use of artificial nest boxes by two species of small, arboreal mammals in ecuadorian tropical dry forest

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ABSTRACT
The nest structure of two species of small mammals, Marmosa simonsi and Rhipidomys latimanus were recorded for the first time. Nests were found inside artificial nest boxes in a tropical dry forest remnant ecosystem in Western Ecuador. We described the nests and categorized them as rearing nest, permanent resting nest and transient refuge, depending on their intended use. Artificial nest boxes provide an optimal place for pup rearing and resting for these small mammals. These nest sites can be useful for ecological studies of behavior and habits of elusive, poorly-known mammalian species.

RESUMEN
Se presentan por primera vez observaciones de la estructura del nido de dos especies de mamíferos pequeños, Marmosa simonsi y Rhipidomys latimanus. Los nidos fueron encontrados dentro de cajas nido artificiales instaladas en un remanente de bosque seco tropical en Ecuador occidental. Describimos los nidos y los categorizamos como nido de crianza, nido de descanso permanente y refugio transitorio, de acuerdo al uso por parte de M. simonsi. Las cajas nido artificiales proveen un lugar óptimo para la crianza, y un lugar de descanso atractivo para estos mamíferos pequeños. Estos sitios de anidación pueden ser útiles en estudios ecológicos, que incluyan determinar los hábitos y comportamientos de mamíferos pequeños, en especial especies poco conocidas y elusivas como las de hábito arborícola.

The practice of using artificial boxes as an alternative to study vertebrates in situ [1] is an ideal method to study behavior and provides the opportunity to record species that very rarely fall into widely-used traps, such as small, arboreal mammals [2,3]. For example, some marsupial species build their nests inside of artificial boxes using plant materials [4,5], and several species of Marmosa (Didelphidae) have been found inside nest boxes set up for ornithological studies [6,7]. However, to our knowledge, there is no description of the behavior of species of Marmosa inside nest boxes, and particularly, how they build their nests. Our objective was to describe the behavior and nest structure of small mammals, opportunistically surveyed, inside artificial bird nest boxes set up on a tropical dry forest ecosystem.

The observations were conducted at Bosque Protector Cerro Blanco (−2.18305°, 80.015833°), a coastal tropical dry forest remnant located just outside of the city of Guayaquil on the southeast edge of the Chongón-Colonche mountains, Guayas Province, Western Ecuador. Tropical dry forests are dominated by at least 50% drought-tolerant deciduous trees, with a mean annual temperature above 25°C, annual precipitation ranges between 700–2000 mm, with three or more dry months per year [8]. Cerro Blanco comprises around 2,000 ha of protected forest, adjacent to a limestone quarry mine and urbanized areas, therefore this reserve constitutes an Island of habitat for a number of endangered and endemic plant and animal species [9]. One hundred and fifty nest boxes were set up by attaching wires and nails on trees at a height
of 1.5 m, at elevations from 30 to 200 m asl, and separated at least 60 m from each other, adjacent to tourist trails and secondary roads. We monitored the artificial nest boxes twice weekly during daylight from 8:00 to 18:00, between January 2014 and June 2015. Each box had an entrance hole of 3.8 cm in diameter and a lateral opening for nest inspection [10]. The nest boxes had an approximate volume of 5000 cm³, a height of 25.4 cm and a width of 16.5 cm, described in Bulgarella et al. [11]. We recorded the presence of small mammals by direct observation, and indirectly by the presence of organic material (leaves) used for nest construction; species were identified using the Field Guide for Mammals of Ecuador [12].

We found two mammal species, *Marmosa simonsi* Thomas 1899 (Didelphimorphia, Didelphidae) and *Rhipidomys latimanus* (Tomes 1860) (Rodentia, Cricetidae) occupying the nest boxes. We recorded a percentage of nest box occupation of 13.3% (*n* = 20), by the two mammals, *M. simonsi* (*n* = 18; Figure 1), and *R. latimanus* (*n* = 2; Figure 1F). For *M. simonsi*, we propose three categories for nest box usage, based on observations of the activity, 1) Rearing nest, where the female uses the box as a breeding refuge, lining the interior with dry leaves that occupy the full space of the box. The leaves are packed in such a way that they do not disassemble if the box side door is opened for inspection (Figure 1A, B). Inside the nest, the opossum builds a small depression shaped like a bag, where the female and pups lay, connected to the main entrance hole of the nest box. During the rearing period, the female often closes the entrance with leaves, likely to avoid predators and/or sunlight; we observed this type of nest twice, in January 2014 and in March 2015, during the rainy season. 2) Permanent resting nest, similar to the rearing nest as it is also constructed with leaves, but these are loosely arranged inside, and do not occupy more than 50% of the nest box space (Figure 1C, D); we recorded ten permanent nests. 3) Transient refuge, *M. simonsi* uses the nest box only to briefly rest inside before abandoning it. In this case, it does not bring any organic material inside the nest box (Figure 1E); we recorded six examples of this usage. Box occupation by *M. simonsi* during the first year was 2.6% (*n* = 4), increasing to 9.3% (*n* = 14) during the second year, which is common because with time animals get used to the presence and safety of the nest boxes.

The leaves used in the construction of rearing and permanent resting nests were no longer than 5 cm, probably because it facilitates the transport to the nest boxes. The majority of leaves were identified as *Guazuma ulmifolia* (Malvaceae) and *Cecropia* spp. (Urticaceae) fragments, typical trees present in Ecuadorian dry forest, possibly the opossums choose leaves due to their small size and abundance in the surrounding area. Our observations coincide with the behavior of several Neotropical marsupials that use leaves to line their roosts [13,14], transporting the leaves using their tails. Thus, it is possible that *M. simonsi* might show this behavior.

We also observed, at two separate instances, nests built by the rodent *Rhipidomys latimanus*. This species built their nests using thin grass leaves. The leaves are loosely arranged inside the nest box, not compacted, making a small bed that covers a third of the nest box space, without a defined entrance or exit hole.

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**Figure 1.** Three nests categories according to the activity of *Marmosa simonsi* inside the nest box. **A, B)** Rearing nest, **C, D)** Permanent resting nest. Note the abandoned wasp nests inside the nest box, those did not seem to stop the opossum from using the box. **E)** Transient refuge. **F)** Examining a *Rhipidomys latimanus* found inside a nest box.
Both small mammals observed in our study are native to Western Ecuador. Simon’s Mouse Opossum (*M. simonsi*) inhabits Western Ecuador from 0 to 1900 m asl [12,15]. This species is closely related to *M. robinsoni* [16] and little is known about its natural history [17]. It is thought that they occupy abandoned bird nests or tree cavities [18,19], with no records on what materials they use to build their nests and how they use their nest space previous to this study. The use of the artificial nest boxes as a transient refuge coincides with the nomadic habit of other species of *Marmosa* in the wild that are known to use any available refuge at dawn [20]. Thus, artificial nest provides a safe refuge during the day without the need to create a nest in trees or a burrow in the soil, which is energetically costly. Finally, observations of females with pups in the rearing nest coincide with previous observations of *Marmosa* spp. during the breeding season [21,22]. We observed one female opossum escape to the treetops with the pups in their pouch when we opened the nest box door (Figure 2). Once we had ascertained that a nest box was occupied by an opossum, we stopped the weekly checks to avoid disturbance, thus, we had no cases of nest abandonment.

Some *M. simonsi* individuals displayed an aggressive and threatening posture, hissing repeatedly when the nest box door was opened for examination (Suppl. Video 1). Other opossums had a calm and relaxed attitude to being found. These individuals did not seem worried about human presence/disturbance (Figure 1C–E, Suppl. Video 2).

*Rhipidomys latimanus* occupies all levels of the forest, but it spends most of its time in the canopy. Apparently, this species prefers mature or well-preserved forests and is considered a rare species to register [23], possibly for its arboreal habits. We know little about its basic ecology [24], and most knowledge is extrapolated from what it is known from other species in the genus *Rhipidomys* [25]. We therefore present the first information on *R. latimanus* nests.

Although the number of occupied nest boxes in our study was low and similar to previous studies [2,5], the use of artificial nest boxes can prove helpful for observing behaviors displayed by elusive, arboreal, poorly-known mammal species [17,24,26], especially if combined with camera trap techniques [2,13,14,27]. Our novel data describing how two small, non-volant mammals built their nests in a remnant tropical dry forest ecosystem in Western Ecuador, exemplifies the utility of artificial boxes for understanding reproductive and behavioral patterns with relatively low cost [2,28].

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**Disclosure statement**

No potential conflict of interest was reported by the author(s).

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