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ARTICLE

Tales from the tail: unravelling the role of the tail in the emblematic giant anteater

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Abstract

Tails, as evolutionary appendages, play diverse functional roles in mammalian species, yet little is known about the tail's role in the behaviour and survival of the giant anteater (*Myrmecophaga tridactyla*), a vulnerable Neotropical species. We present the first qualitative description of tail-centred behavioural patterns in free-ranging giant anteaters ($n = 19$). Data were collected through extensive behavioural observations (266 h 11 min) in anthropogenic pastureland of the Brazilian Cerrado from August 2021 to November 2023. A detailed description of 11 distinct behavioural patterns is provided, categorised according to their functions (following Hickman in Mamm Rev 9:143–157, 1979) with tail postures and motions identified. In addition, tail growth and changes over time are described. Our findings reveal the multifaceted functionalities of the giant anteater's tail and underscore the importance of the tail in behavioural plasticity, enabling adaptation to environmental challenges such as habitat fragmentation and climate change. This investigation offers new insights into the tail's role in the survival strategies of this emblematic and threatened species.

Keywords Appendage · Behaviour · Ethogram · Functionality · Wildlife · Xenarthra

Introduction

At some point in their developmental stage, all vertebrates have a post-anal tail, and mammals, more specifically, possess a caudal vertebra, contributing to the formation of the tail (Hickman 1979; Mallo 2020). This appendage, which extends from the end of the body, has been described as "arguably among the most enigmatic parts of the vertebrate body" (Mallo 2020). Mammalian species exhibit a wide diversity of tails, particularly in terms of tail length (Russo 2015). Their length is related to factors such as substrate use, locomotion, diet, and climate (Mincer and Russo 2020), showcasing the tail's evolutionary adaptation to a wide range of ecological niches (Sehner et al. 2018).

It is not a novelty that tails have numerous functions in mammalian species. From a locomotor perspective, tails provide propulsion and steering whilst swimming in aquatic and semi-aquatic animals (e.g. otters), as well as facilitating swinging in animals with prehensile tails, aiding in balance and manoeuvrability for terrestrial locomotion, maintaining balance in arboreal species, and guiding flight in volant species (Hickman 1979). Additional functions include transporting materials (e.g. some marsupials and Cebidae), providing mechanical protection (e.g. Manidae), reducing predation risk through tail autotomy (e.g. some rodents), offering thermoregulation (e.g. as blankets in squirrels), and acting as a signalling behaviour through tail position, movement, and piloerection (Blank 2018; Dalloz et al. 2012). Some mammalian groups have received more attention regarding tail functions than others, with significant investigations into the evolution, morphology, and behaviour of tails in rodents, primates, and ungulates (Blank 2018; Sheard et al. 2024; Siegfried 1990; Young et al. 2021).

Anteater species (Pilosa, Vermilingua) have a very distinctive tail. Their tails are long, almost as long as the length of their body, attracting attention to the appendage. However, few studies have focussed on the function of the anteater's tail. It is well documented that giant anteaters

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(*Myrmecophaga tridactyla*) sleep with their tails folded over their bodies like a blanket, conserving body heat and using it as disruptive camouflage (Medri and Mourao 2005). In *Myrmecophaga*, *Tamandua*, and *Cyclopes* genera, defensive postures involve rearing up on their hind legs and tail to strike forward and downward with their claws (Catapani et al. 2012; Kreutz et al. 2009; Taylor 1985). Recently, the use of the prehensile tail was linked to facilitating mating (Bertassoni et al. 2023). Opportunistic behavioural observations of giant anteaters revealed that tail position and movement can provide signalling and communication. During courtship, due to vaginal discharge, the female raises her tail, and the male follows closely behind, occasionally pawing and sniffing her (Shaw et al. 1987). In agonistic situations, tails become raised when two anteaters circle each other (Montgomery 1985; Rocha and Mourão 2006; Kreutz et al. 2009).

The giant anteater is a Neotropical mammal classified as 'Vulnerable' by the IUCN due to an estimated population decline of at least 30% over the past 10 years, primarily driven by habitat loss, degradation, and fragmentation (Miranda et al. 2014). Adult giant anteaters are preyed upon by jaguars (*Panthera onca*) and pumas (*Puma concolor*), whilstwhilst juveniles are targeted by carnivores and birds of prey (Bertassoni 2018). This insectivorous species, which feeds on ants and termites (Hymenoptera and Isoptera), exhibits morphological characteristics related to this specialised diet (Gaudin et al. 2018; McNab 1985). Its low-calorie diet has influenced metabolic adaptations, including low body temperature (32–33 °C), and coarse pelage, including a large, bushy tail to aid in thermoregulation (McNab 1984). As adults, giant anteaters have entirely bushy tails. In Brazil, this emblematic species is popularly referred to as the "flag-anteater" due to the flag-like movement of its tail when walking. The estimated volume of its tail relative to its body reaches nearly 80% (Meijaard et al. 2014; Wetzel 1985), which suggests a high energy cost to maintaining a large, bushy tail. Therefore, the advantages must be considerable to justify this energetic investment (Meijaard et al. 2014). Although tails appear to provide mammals with a wide range of potential benefits, studies on the tail's multifunctionality are still scarce (Hickman 1979; Mallo 2020).

Notably, despite the giant anteater's tail comprising a substantial proportion of the animal's total body length (head–body: 1000–1400 mm, tail: 600–900 mm, Bertassoni 2018), no research has been dedicated to understanding its role. The scientific literature on the natural history and behaviour of free-ranging giant anteaters is based on opportunistic observations and lacks a tail-centred perspective. Considering the function of the tail in other mammalian species and the length of the giant anteater's tail, we hypothesise that their tails serve multifunctional purposes beyond those previously documented. If our hypothesis stands, we expect to observe a range of distinct tail-centred behaviours serving multiple functional roles. Here, we describe and provide new data on the behavioural categories of the giant anteater's tail, report on tail growth and its physical alterations, and provide insights into how the tail contributes to the adaptive strategies of this vulnerable species.

Materials and methods

Study area

This study is part of the investigation "Understanding maternal and filial behaviour of free-living giant anteaters for conservation decision-making", initiated in 2020 and conducted by the Anteaters and Highways Project (https://www.icasconservation.org.br/) in the Cerrado savanna of Mato Grosso do Sul in the Central-West region of Brazil. Data were collected around a 50-km stretch along the heavily trafficked BR-267 highway, encompassing a mosaic of private ranches (21° 3′ S, 53° 55′ W to 21° 2′ S, 53° 54′ W). In the state of Mato Grosso do Sul, the climate is wet from October to March and dry from April to September (Köppen's Aw), with temperatures ranging from 21–32 °C. At the study site, we recorded temperatures around 36–38 °C with a thermal camera during the hottest hours of the day in the dry season. The landscape is dominated by extensive pastureland for livestock, interspersed with small patches of Cerrado vegetation (see Chhen et al. 2024; Noonan et al. 2021, for further landscape details). This human-modified landscape provided favourable conditions for behavioural studies due to its openness and very fragmented vegetation (Fig. 1). Therefore, we were able to conduct observational sessions at distances that prevented individuals from detecting the researchers whilst still maintaining a clear view of the animals (5–20 m away, depending on the giant anteater's activity).

Field study: sampling method and descriptive analysis

From August 2021 to November 2023, we conducted a behavioural study on GPS-monitored female giant anteaters and their pups. Between 2017 and 2018, these free range females were captured and equipped with biotelemetry harnesses (TGW-4570-4 Iridium GPS plus MOD 400 VHF transmitters, 2-year lifespan; Telonics, Mesa, Arizona) following the procedures in Kluyber et al. (2021). At the time of capture, these females did not have pups. To put on the equipment, the females were physically captured using a long-handled dip net and chemically immobilised (butorphanol tartrate, detomidine hydrochloride, and midazolam hydrochloride, each at 0.1 mg/kg). A combination of antagonists was applied to promote a smooth and rapid recovery

Fig. 1 Human-modified landscape of Cerrado savanna covering an area along a 50-km stretch of the BR-267 highway, state of Mato Grosso do Sul in the Central-West region of Brazil (by Katie Orlinsky)

at the end of the procedure. As the broader project has been monitoring the giant anteaters for an extended period (individual's life), the harnesses of the females were changed when the batteries were low, or the equipment had damage. A team of veterinarians conducted these procedures. Chemical immobilisation was performed at capture, for harness replacement (every 2 years, due to its batteries lifespan), or in case of injury.

A total of 14 GPS-monitored and five unmonitored females were observed individually. The monitored females were found via VHF signals, whilst the others were encountered by chance. In addition, when an individual without a pup was opportunistically encountered, tail-centred behaviour was also recorded if observed. However, since there is no sexual dimorphism in this species, it was not possible to determine whether the observed giant anteater was male or female. The average duration of the observation session was 1 h 27 min (range: 30 min—3 h 32). If the overall behaviour of the anteaters was judged to be impacted by the presence of the researchers, the observation session ended. During each session, two researchers (AB and a volunteer) recorded videos and took photos. We employed ad libitum, focal animal and scan sampling methods, totalling 266 h 11 min of field observation. Throughout these sessions, we recorded a variety of tail positions and movements, which were categorised based on their functions. As the main data collection design on the mother and her pup was not tail-centred, here we present qualitative data on tail-related behavioural patterns.

These tail-related behaviours were categorised into mechanical, behavioural and physiological functions, following Hickman (1979). Mechanical functions included actions providing stability, propulsion, or pup transportation. Behavioural functions encompassed postures that signal a message according to the position and movement of the tail. Physiological functions involved tail positions and movements that contributed to thermoregulation for the species. Using the tail-centred ethogram for pigs (Camerlink and Ursinus 2020) as a guide, we provided tail postures and motions connected to each behavioural pattern described for giant anteaters. In addition, we present data on the tail growth of 20 monitored anteaters (10 males and 10 females) as they age from one to 16.5 months. Tail measurements were therefore taken only during necessary capture events, using a flexible tape measure. When a female was with a pup, tail lengths were collected for both individuals. We also provide images illustrating physical changes in tail morphology over time. Reporting tail size in free-ranging giant anteaters in relation to pup growth is novel and represents a previously undocumented aspect of the species' biology.

Results

We identified and described 11 tail-centred behavioural patterns for free-ranging giant anteaters. Two of these patterns are well-described in the scientific literature, and as such, we have included citations in their description. For each behavioural pattern, we provided details on tail posture and motion (Table 1). Besides the three primary functions (mechanical, behavioural, and physiological) outlined by Hickman 1979, social bonding was noted when the behaviour involved a mother and her pup. A detailed description

Table 1 Tail-centred behavioural patterns of free-ranging giant anteaters (*Myrmecophaga tridactyla*)

#	Behavioural pattern	Tail posture and motion	Category	Image
1	Balance whilst walking	Horizontal and passively hanging	Mechanical	Figure 2a
2	Balance whilst in bipedal position	Following the position of the spine and motionless	Mechanical	Figure 2b
3	Pup transportation	Horizontal and passively hanging	Mechanical and social bonding	Figure 2c
4	Protection and camouflage	Folded over the body and motionless	Behavioural	Figure 2d
5	Pup nestling and affiliative time	Folded over the body and motionless	Behavioural and social bonding	Figure 2e
6	Opening of the folded tail	Folded over the body and active motion	Behavioural	Figure 2g
7	Pup-repelling	Horizontal and actively hanging	Behavioural	Figure 2f
8	Alertness or vigilance signalling	Horizontal, erect, and motionless	Behavioural	Figure 2h
9	Thermoregulatory sleeping	Folded over the body and motionless	Physiological	Figure 2i
10	Tail swishing	Folded over the body and actively swishing	Physiological	Figure 2j
11	Sunshade	Raised and folded over the body and motionless	Physiological	Figure 2k

Description of tail postures and motions categorised by their functions with references to example photos in Fig. 2 and videos provided at: https://bit.ly/4ga08rn

of the 11 behavioural patterns is provided below (Fig. 2 and in the Supplementary Information—https://bit.ly/4ga08rn).

Mechanical functions

Balance

Balance whilst walking Whilst walking, the tail is held just above the ground, moving in coordination with the lateral movement of their paws. The head remains level with the body or slightly inclined. As the animal walks, the tail moves side to side, contributing to balance and stability during movement.

Balance whilst in bipedal position In the bipedal position, which may be adopted during behaviours such as tree marking or fighting, the tail aligns with the spine. Its tip may touch the ground, providing an extra counterweight to help the animal maintain an upright stance. Its head is directed towards the target, such as a tree or another organism.

Pup transportation

This behaviour is exclusive to females carrying their pups. From birth to a young age, giant anteater pups are transported either at the middle of their mother's back or at the base of her tail. For the first few weeks, the pup keeps itself attached at the base of the tail, and as it grows, it moves its way up to the mother's back. The space between the mother's last vertebrae and the base of her tail creates a natural rump for the pup. When clinging on, anteater pups keep their legs open and rest their head on their mother's back. Beyond serving a role in transportation, this behaviour also creates a social bond between the mother and her pup.

Behavioural functions

Protection and camouflage

All giant anteaters engage in the behaviour of folding their tail over their body when in a sleeping position, forming a circle shape on the ground. In this posture, the anteater becomes difficult to detect, especially when it chooses nesting sites that blend in with the colour of its pelage, enhancing its camouflage and protection from predators.

Pup nestling and affiliative time

This behaviour is exclusive to a mother and her pup whilst in the nest. The nest is where the mother and pup stay together, typically within a protected space in a shallow hole, which may or may not have been dug by the mother. Whilst the mother is in a sleeping position with her tail folded over her body, the pup remains nestled in the space between the mother's body and her folded tail. In this position, the pup is hidden and protected by the mother's tail. This shared space allows the pup access to the mother's warmth and teat, and the close physical contact provides a social bond.

Opening of the folded tail

This behaviour is exclusive to a mother and her pup in the nest. Whilst the mother is in the pup nestling posture, the pup may explore the nearby surroundings. When the pup wishes to return and nestle, it touches the mother's tail with its snout. In response, the female may raise her tail to receive the pup to nestle or she may keep her tail folded, leaving the pup unable to hide itself. This communication signal from the female indicates the mother's willingness or reluctance to nestle the pup.

Fig. 2 Tail-centred behavioural patterns of free-ranging giant anteaters (*Myrmecophaga tridactyla*)

Pup-repelling

When the pup is following the mother during foraging activity, it may sniff and paw at her body in an attempt to climb on the mother's back. In response, the female may raise her tail with quick, repeated movements or keep her tail up. This communication signal from the female to the pup indicates that she does not want to carry the pup at that moment.

Alertness or vigilance signalling

The tail is raised horizontally (but not above the spine), and piloerection is present, making the giant anteater appear larger. This posture occurs in response to a change in the anteater's surrounding environment, triggered by the presence of other animals (including humans), loud noises, or a new odour, for instance. The giant anteater freezes with its head aligned with its body, and one forelimb may be slightly raised from the ground (Bertassoni and Milléo Costa 2010). To other animals, this posture signals that the giant anteater is aware of their presence and is maintaining vigilance.

Physiological functions

Thermoregulatory sleeping

When the giant anteater sleeps, its bushy tail is folded over its body like a blanket. Its head may be positioned under or to the outside of the tail. In this posture, body heat is conserved, aiding the giant anteater in thermoregulation (Shaw and Carter 1980; Medri and Mourao 2005).

Tail swishing

Whilst in its thermoregulatory sleeping posture, the giant anteater repeatedly wags its tail up and down in a fan-like motion. Although this behaviour can occur in solitary anteaters, it is predominantly exhibited by mothers with their pups.

Sunshade

This behaviour is exhibited exclusively by a mother with her pup in the nest. The mother raises the middle part of her tail whilst folding the tip, creating a shaded area that covers the pup's body and part of the side of her own body.

Tail growth and physical change over time

Tail growth was demonstrated through a consistent increase in length with age. At one month of age, the recorded tail length was 24 cm, increasing at gradual increments as the pup matured. For instance, by 6 months, the average length reached approximately 40.1 cm. By 12 months, it increased further to an average of 53 cm. By the end of the observation period (16.5 months), the tail length reached an average of 67.5 cm (see Supplementary Information—Table S1). Some age categories are missing, as the data were only collected when the harness needed to be changed. Nevertheless, the growth pattern can still be observed as it indicates a growth trajectory (Fig. 3 and Table S1), with some variation in tail length amongst individuals, reflecting a natural variation in growth rates. As shown in Fig. 3, the tail of giant anteater pups undergoes a developmental progression, from a thin, sparsely furred structure (Fig. 3a, b), to a gradually bushier form with lateral fur growth (Fig. 3c, d), until reaching the dense, rounded shape characteristic of adults (Fig. 3e, f).

To provide a complete perspective, the average tail length for adults was also recorded by the broader project, measuring 71.3 cm in females ($n=36$) and 70.5 cm in males ($n=36$), highlighting the final developmental stage of tail growth.

Physical alterations occur in terms of colour, fur density, size, and length (Fig. 3). At all ages, the giant anteater's tail is long, almost as long as the length of its body. In its first week of life, the pup's tail has greyish colouration, with some pinkish patches due to very short hair and exposed skin, and as it follows the contour of the caudal vertebrae, it appears almost constrained by them in terms of size and thickness. In the following weeks, the tail begins to display a greyish and/or brownish colour and develops more fur. Over time, the tail darkens, and the bushy fur becomes more pronounced. By approximately 12 months, the tail arrives at its unique appearance, which is long, brown and/or dark grey with a distinctly bushy quality.

Discussion

Hickman (1979) claimed that the diversity of tail functions can help interpret behavioural observations. This was the case in our fieldwork. Our attention was drawn to this appendage which in turn provided information on the animal's behaviour and activity. Surprisingly, given its exceptionally long length, the role of the giant anteater's tail had not yet received any detailed interpretation. In general, behavioural studies applying observational methods are scarce for this species due to its cryptic behaviour and often nocturnal activity period. Recently, an appeal has been made to the fields of Ecology and Evolutionary Sciences to carefully observe nature where nature is in order to understand how organisms interact with each other and the environment (Travis 2020; Powers 2024), a critical knowledge gap in the Anthropocene.

As an extension of the vertebral column, tail movements are tied to the flexibility and mobility of the spine (Camerlink and Ursinus 2020). The anteater genera *Cyclopes* and

Fig. 3 Tail growth of free-ranging giant anteater (*Myrmecophaga tridactyla*) pups over time. Frames **a**–**f** highlight giant anteaters at 1 week, 2 weeks, 1 month, 4 months, 6 months, and a year old, respectively

Tamandua have evolved prehensile tails as part of their adaptation to arboreal life, thus retaining this primitive feature (Gibb et al. 2016). As such, a multifunctional tail is not surprising for these taxa. However, giant anteaters are terrestrial and have anatomical features in their caudal centre that limit lateral movement, precluding the presence of a prehensile tail (Gaudin and McDonald 2008). This may contribute to an underappreciation of the tail's role for this species. Despite this, mammalian tails, unlike other body structures, can perform a variety of functions (Hickman 1979; Mallo 2020). For instance, non-mechanical functions have been identified, such as body temperature regulation, fat storage, and use as a tool for intraspecific communication (Mallo 2020). This study shows that the giant anteater's tail was found to be multifunctional in its behavioural patterns.

The survival success of an animal depends, in part, on its behaviour (Lorenz 1986), and understanding behaviour begins with observation and detailed descriptions to determine causes and consequences (Altmann and Altmann 2003). Some of the behavioural patterns identified for the giant anteater are already well documented in mammals, including the tail providing balance for other appendages (mechanical function), indicating alertness or vigilance signalling, and aiding in thermoregulation during sleep (Hickman 1979; Schwaner et al. 2021; Sheard et al. 2024; Stankowich 2008). Alertness or vigilance signalling may be the first step in a decision-making process related to the tail's motionless horizontal position, which may indicate preparation for escape from a threat (Blank 2018) or enhance a bipedal stance if agonistic behaviour occurs.

For the giant anteater, the behavioural patterns of pup transportation, pup nestling, the opening of the folded tail, and pup-repelling are fundamental to individual survival. Pup transportation is one of the most recognisable maternal behaviours of this species, illustrated as far as back as the 1700s by naturalist travellers in South America (Gobierno de Buenos Aires 2024). The base of the caudal vertebrae helps the pup maintain its position by acting as a barrier, and for many months during this period the pup's locomotion depends on this behavioural pattern. Therefore, the mother's tail is essential for the pup's development. In this context, all other postures involving the mother and her pup support and enhance the juvenile's survival, which is significant because, unfortunately, at this age, pups from 0 to 1 year of age have higher mortality rates (Desbiez et al. 2020). In addition, social bonding occurs with some of these postures, providing a safe space for the pup with its mother, which is vital for a species with such a long maternal care period (Gaudin et al. 2018).

Tail postures that promote protection and camouflage, as well as thermoregulation, are essential for the species, especially in human-modified environments, which represent the greatest threat that this species faces (Miranda et al. 2014). Landscape-scale processes such as deforestation, habitat degradation, and fragmentation affect habitat suitability across the species' range. Therefore, behavioural plasticity regarding habitat use will become increasingly important for giant anteaters (Bertassoni and Desbiez 2021). Folding their tail over their body during sleep, for instance, provides them with protection and camouflage, along with thermoregulation. This posture is a great adaptive strategy as it helps the anteater avoid detection by predators, as well as conserve energy in fluctuating temperatures, a challenge that will only grow with climate change. Bearing this in mind, tail swishing and sunshade behavioural patterns are valuable for thermoregulation. Tail swishing may act as a fan, creating air currents that enhance thermoregulation and repel insects (Matherne et al. 2018). The sunshade behavioural pattern has also been observed in tree squirrels (Hickman 1979). The thermoregulatory functions of the giant anteater's tail may confer advantages for the species' survival in specific ecological niches in the near future (Mallo 2020).

When the mother–pup dyad is together, a strong anti-predator defence mechanism is in place, reducing the likelihood of predator detection and increasing survival chances when met with other threats. This protection is particularly critical for pups in their early months, as their tails are still developing. Despite the popular belief that giant anteater pups resemble a miniature version of adults (A.B., pers. comm.), the prolonged maternal care that pups require challenges this notion. We add new insights to this perspective, as the tail proves to be central to this species' survival. Neonate giant anteaters exhibit altricial features at an early age (e.g. being born with their eyes closed, having sparse fur, depending on the mother for nourishment; Derrickson 1992). For them to achieve their independence, their tails must be sufficiently bushy (A.B., pers. comm.), as this increases their chances of surviving on their own. Infant carrying in terrestrial mammalian species such as giant anteaters appears to be a retained feature. Indeed, the carrying of young evolved as a feature in arboreal species, where offspring cannot follow their mothers (Ross 2001). Thus, this characteristic may have phylogenetic associations worth exploring.

Considering the lack of knowledge about tail-centred behaviours in giant anteaters, our findings may be useful for decision-making processes in rehabilitation and care at indoor facilities to improve the welfare of individuals, especially those in early life stages. In addition, giant anteaters with tail injuries require careful attention and specialised assistance to maintain their mechanical, behavioural, physiological, and social bonding functions. The tail plays a noteworthy role in various survival mechanisms, including balance, thermoregulation, and protection. Injuries to the tail can severely disrupt these essential behaviours, making rehabilitation unfeasible. For female giant anteaters, the challenge is even greater due to the critical role the tail plays in pup transportation. Any impairment in tail function can compromise the mother's ability to carry her pup, which is crucial for the pup's safety and survival. As such, anteaters with significant tail injuries may not be suitable candidates for wildlife rehabilitation and release, and anteaters with amputated tails are definitely not suitable for release under any circumstances. The complexity of tail-related functions underscores the importance of considering each individual injury when making rehabilitation decisions.

Conclusion

Giant anteaters exhibit a variety of tail-centred behaviours, and gaining insight into these behaviours is crucial to better understanding this unique species, as well as to improving welfare in indoor facilities. Further investigation into the evolutionary significance of this appendage within the Xenarthra clade would enhance our grasp of wildlife interactions and ecological adaptability. Moreover, recognising the tail's functions has proven to be useful in interpreting behavioural observations.

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Author contributions Alessandra Bertassoni and Arnaud L.J. Desbiez conceived the ideas and designed methodology. Alessandra Bertassoni, Audrey Brisseau and Grazielle Soresini made fieldwork and collected the data. Audrey Brisseau helped with the imagery dataset and Grazielle Soresini with tail growth information. Alessandra Bertassoni performed the data analysis. Alessandra Bertassoni led the writing of the manuscript, and all authors read and approved the final manuscript.

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Data availability The data for this study are available as Supplementary Information.

Declarations

Conflict of interest We declare no conflict of interest.

Ethical approval We were granted permission to all handling performed by veterinarians from the Anteaters and Highways Project, authorised by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) under licence #53798. Our study was conducted in accordance with the local legislation and ICMBio requirements.

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