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Period of the day and food-based enrichment affect behaviour activity of *Tamandua tetradactyla* in captivity?

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Período do dia e enriquecimento alimentar afetam a atividade comportamental de *Tamandua tetradactyla* em cativeiro?

Resumo: Animais resgatados passam um período em cativeiro antes de serem devolvidos a natureza. Durante esse período em cativeiro é fundamental que os animais apresentem os comportamentos mais próximos dos apresentados na natureza, e enriquecimento ambiental é uma forma de assegurar o bem estar animal em cativeiro. O objetivo deste estudo foi i) descrever o repertório comportamental de indivíduos do tamanduá-mirim (*Tamandua tetradactyla*) (Ordem Pilosa), e determinar qual comportamento foi mais frequente; ii) avaliar o efeito do período diurno (06:00–18:00) e noturno (18:00–05:59) na frequência dos comportamentos, e iii) comparar a porcentagem de comportamentos com e sem enriquecimento ambiental. Observações foram feitas utilizando o método de animal focal. Cinco machos e uma fêmea foram observados em pares para se observar as interações entre os indivíduos. Foram registrados 30 atos comportamentais distribuídos em seis categorias: locomoção, forrageio, alimentação, inatividade, limpeza corporal e interação. Geralmente, os comportamentos mais frequentemente observados foram locomoção e alimentação, geralmente durante o dia, exceto inatividade, que foi mais comum durante a noite. Esse resultado pode ser atribuído a maior atividade diurna do macho, enquanto as fêmeas são mais noturnas em cativeiro. Nossos resultados sugerem que o enriquecimento ambiental favorece maior bem-estar para os indivíduos em cativeiro através do aumento de comportamentos ativos como alimentação, interação e forrageio. Esse estudo provê uma lista de comportamentos que podem ser úteis em entender a etologia e aspectos relacionados à conservação, especialmente em cativeiro de *T. tetradactyla*.

Palavras chave: Enriquecimento ambiental, tamanduá-mirim, repertório comportamental, animal focal.

Abstract: Rescued animals spend some period in captivity prior to their release. During this period it is fundamental that animals present behaviours that closely match with behaviours presented in nature, and environmental enrichment is an often-applied tool to secure animal welfare in captivity. The goals of this study were i) to describe the behavioural repertoire of six captive individuals of lesser anteater (*Tamandua tetradactyla*) (Order Pilosa), and determine which behaviours were more common; ii) to compare the effect of daily (06:00–18:00) and nocturnal (18:00–05:59) periods in the activity pattern of the lesser anteater; and iii) to determine the effect of food-based enrichment in the frequency of behaviours of lesser anteater.

During a year, six individuals of *T. tetradactyla* were monitored in pairs. An ethogram was prepared based on focal-animal observations for five males and one female. We recorded a total of 30 behavioural patterns in six categories: inactivity, feeding, foraging, locomotion, self-maintenance and interaction. Generally, the most frequently observed behaviours were locomotion and feeding, mainly during daylight hours, while inactivity was more common at night. This could be because the majority of our studied individuals were males, and males are more diurnal, while females are more nocturnal in captivity. Our results also suggest that food-based enrichment items enhance well-being for captive individuals by increasing active behaviours such as feeding, foraging and interaction. This study provides data that can be useful for management of the species in understanding the ethology of *T. tetradactyla*, especially for *ex situ* and *in situ* conservation efforts.

Key words: Environmental enrichment, lesser anteater, behavioural repertoire, focal-animal.

Introduction

Rescued animals often need to spend some period of time in a captive environment before they can be returned to their natural habitat (Melo & Santos-Filho 2007). Captivity forces animals to be in an environment different from the natural ecological habitat (Baer *et al.* 2010). In such situations, animals usually have limited opportunities to perform certain behaviours due to space restrictions, absence of or different stimuli and limited nutritional options, which can increase stereotyped behaviours (Morgan & Tromborg 2007), and most mammals tend to fatten due to less effort (Garland 1983). In the natural habitat, animals need to face many biotic and abiotic factors to be able to find food sources, defend themselves against predators, reproduce, and for some species defend their territories (Broom & Johnson 1993). Behaviour evaluation is one of the main tools that allow researchers and technicians to assess the well-being of animals. Nonetheless, behavioural observations of captive animals can provide a valuable baseline for appropriate management and further ecological studies of species in the wild (Del-Claro 2010).

One way to increase behavioural diversity in captivity is by food-based and environmental enrichment (Hosey *et al.* 2013). Alimentary enrichment, for instance, changes how food sources are presented to animals, as well as providing food items that are similar to what would be found in natural habitats (Newberry 1995). Such activities provide physical and psychological improvements to animal welfare (Catapani *et al.* 2019). For example, responses to environmental enrichment improved the welfare and intensified the active behaviours of zoo-housed lesser anteaters through adrenocortical activity (Eguizábal *et al.* 2013). In the wild, lesser anteaters are solitary, cryptic animals, and interact with conspecifics only occasionally for specific activities (Medri *et al.* 2006). In order to assess the impact of environmental enrichment, one of the first needs is to know how individuals behave in captivity in the absence of enrichment, and then test whether their behaviours change with enrichment (Sobroza & Fortes 2018).

Ethograms have long provided a valuable tool for understanding the behaviour of animals in their natural habitats (Martin & Bateson 1993). The goal of an ethogram is to define and quantify all the different types of behavioural patterns exhibited by individuals of a species (Del-Claro 2010). Ethograms exist for a great variety of taxonomic groups, including amphibians (Davis 2002), birds (Brown & Veltman 1987; Porto & Piratelli 2005), reptiles (Greenberg 1977; Shine & Torr 1994), and mammals (Martin 1980; Albuquerque & Codenotti 2006). Although mammals are probably the best-known group in terms of their natural behavioural patterns (Del-Claro 2010), there have been few studies of the lesser anteater, *Tamandua tetradactyla* (Linnaeus 1758) (Eguizábal *et al.* 2013; Catapani 2014; Eguizábal *et al.* 2019).

The lesser anteater, popularly known as tamanduá-mirim or tamanduá-de-colete, in Brazil (Tavares 2008), or *Northern tamandua* in English speaking countries or even *oso melero* in Spanish speaking countries, is a specialized mammalian myrmecophage species distributed across an area of more than 1.500.000 km^2 (Medri *et al.* 2006), comprising four subspecies (Wilson & Reeder 2005). This species ranges from southern Mexico to northern Uruguay and Argentina (Superina *et al.* 2010), among habitats including gallery forests adjacent to savannas,

and lowland and montane moist tropical rain forest (Eisenberg 1989), but also fragmented areas in the Brazilian Cerrado (Zimbres *et al.* 2013). Females gives birth to only one young per year, with the gestation ranging from four to five months (Silveira 1968). Mean individual home range size varies from 25 hectares in Ecuador (Tirira 2007) and 70 hectares in Panama (Eisenberg 1989) to 380 hectares in the llanos of Venezuela (Montgomery & Lubin 1977).

In the wild, the lesser anteater rests in trees or burrows of armadillos and it is more active at night (Rodrigues *et al.* 2008), but in captivity these animals can be also active during the day (Montgomery 1985; Medri *et al.* 2006). *T. tetradactyla* is one of the most specialized predators of small and large nests of termites and ants, both on the ground and in trees contributing to ecosystem dynamics (Montgomery 1985). Though considered primarily arboreal, individuals may also move, feed and rest on the ground (Montgomery 1985; Rodrigues *et al.* 2008), and can also swim (Esser *et al.* 2010). When *T. tetradactyla* feels threatened, it assumes a tripod posture, formed by the hind legs and tail, with forelimbs extended and claws free for defense (Medri *et al.* 2006).

Little is known about the behavioural repertoire of *Tamandua tetradactyla*. This may have management implications because their populations are declining in their natural habitats due to threats, such as highway mortality, fire and illegal hunting (Ferreira da Cunha *et al.* 2010). The lesser anteater is a common victim of car-based wildlife accidents. Often these cause mortality (Pereira *et al.* 2006). When debilitated, animals are taken into captivity by environmental agencies such as the Wild Animals Triage Center (CETAS/IBAMA/Brazil). Also, lesser anteaters are often captured during wildlife rescues following wildfires, habitat fragmentation and habitat loss due to agriculture (Superina *et al.* 2010). Consequently, a large number of lesser anteaters are present in wildlife rescue centers (Pereira *et al.* 2006), which means that there is a need for behavioural studies that allow the animals to be cared for appropriately and their needs anticipated, as has been done for the giant anteater, *Myrmecophaga tridactyla* (Schmidt 2012).

The goals of this study were: i) to describe the behavioural repertoire of captive, rescued *T. tetradactyla* individuals; ii) to compare the effect of daily (06:00–18:00) and nocturnal (18:00–05:59) periods in the activity pattern of the lesser anteater; iii) to determine the effect of food-based enrichment in the frequency of behaviours of lesser anteater. In accordance with the behaviour of wild animals (Marques & Fabián 2018), we expected that captive *T. tetradactyla* would be more nocturnal than diurnal, and with more active behaviours presented upon the introduction of food-based environmental enrichment. Also, we predicted that even in diurnal periods *T. tetradactyla* will increase active behaviours (e.g., foraging and feeding) with their enclosure enriched.

Material and Methods

Housing

The study was carried out at the Vale do Tamanduá farm (16°59'25.2" S, 49°24'17.2" W), in Aragoiânia municipality, Goiás, west-central Brazil. It is a wildlife refuge that maintains enclosures for animals that need to spend time under care and is used by the Wild Animals Triage Center (CETAS/Intituto Brasileiro do Meio Ambiente) for screening and treating wild animals received via official confiscation, rescue or voluntary donation of illegally wild-captured individuals. The area inside and surrounding the enclosures are characteristic of Cerrado, and includes different types of Cerrado formations such as cerradão, gallery forest and open cerrado (Eiten 1978).

Study individuals

All observed *T. tetradactyla* individuals were rescued in the Goiás State in the Cerrado biome and had been checked by CETAS veterinarians before placement in the enclosure. In total, the group consisted of six animals: five males (M) and one female (F). Of the five males,

one was an infant (2–3 months: M1), two were young males (9–15 months: M2, M3), and two were adults (24–60 months: M4, M5). The one female (F1) was young (12 months). Animals were easily recognized individually due to variation in coloration and body size. All animals were kept in pairs for two months prior to the observation sessions in enclosures with similar characteristics as the ones that we monitored. For the observation sessions, pairs of individuals were kept together in two enclosures of 2.72 m x 2.40 m x 3.94 m, allowing the animals to interact with each other. We worked in pairs and the type of food sources were changed daily to create opportunities for social interactions and to mitigate the effects of space restrictions, and thus enhance welfare for this species (Catapani *et al.* 2019). Animals were fed every morning (06:00–07:00) with a mixture of ripe fruits (oranges, papaya, and banana) and eggs. There was permanent running water for drinking, and one large non-mobile aluminium feeder. Food material was refreshed continually. A thick paste composed of curds, broccoli or cabbage, dog food, assorted fruits, vegetables and boiled pig's liver was also provided. These ingredients were homogenized in a blender and provided to the animals in the feeders. The paste was developed by CETAS veterinarians and zoo technicians as a supplemental food for young and adult anteaters arriving at the center in a debilitated state.

Behavioural sampling

Ethogram

Preliminary observations were made in 2011 and behavioural sampling occurred between February 2012 and March 2013 (except for May and November 2012), during at least one weekend of each month, totalling 29 sampling days. Before monitoring, we randomized which individuals in each pair were going to be observed. We observed pairs of individuals because we were interested in social interactions, which are important from an animal welfare viewpoint. Because all animals were easily identified, we used focal-animal sampling in which all behaviour occurrences were recorded continuously during each sample period to evaluate the effects of both of the day period and environmental enrichment (Altmann 1974). Four observers switched between weekends and worked in pairs on two different enclosures that each contained a pair of animals. Descriptions and photographs of behaviours were thus made for four animals at the same time, but overall, all six individuals were monitored. We used this same procedure and follow the same ethogram for both behavioural sampling and environmental enrichment. Prior to collecting the data, all the observers trained together to minimize observer bias. We could see the entire enclosure. The observers made preliminary observations for the two months prior to data collection, and were therefore familiar with the identities of the subjects.

Period of the day

Adding up all hours of observing, animals were observed for a total of 280 hours, 173 hours during daylight (06:00–18:00; 62% of survey) and 107 hours at night (18:00–05:59; 38%). During sampling, two observers recorded behaviours per time period (night or day), standing some two meters from the enclosure, always concealed behind surrounding vegetation.

Environmental enrichment

In order to test the effects of environmental enrichment, we added to the enclosure a modified diet and modified environment, including terrestrial and arboreal termite mounds hidden in trees and vegetation, ripe fruits and eggs, as well as tree trunks with cavities that could be used as shelter. Soil and arboreal termites were taken from natural areas close to the enclosure. For this enrichment treatment we continued to work with two individuals for each per pair of observers. For the other enclosure, we only offered the routine diet, which was not hidden. We worked Saturdays and Sundays for two weekends (6 hours per day) with a total effort of 24 hours with enrichment and 24 hours without enrichment. This was done simultaneously in

different enclosures, with two pairs of observers switched between weekends, both during the day and night. All six animals were submitted to this experiment. The study was non-invasive and complied with Brazilian law; authorization for the study was received from Cetas-Goiás.

Data analyses

To test whether *T. tetradactyla* activity is greater during night we used an unpaired two-sample T-test using the sum of all the individual behaviours per category for all individuals. Data for both periods were standardized by sampling effort. We used the same test to evaluate the effects of environmental enrichment in the behaviour of animals. We also represented graphically the average number of behaviours per category without and with the introduction of enrichment items for all individuals with ggplot2 package (Wickham 2016). Statistical analyses were performed in R version 3.3.1 (R Core Team 2016).

Results

Six broad behaviour categories were identified and described. Across 29 sampling days, six individuals of the captive *T. tetradactyla* displayed 30 different types of behaviours, with some photographic registers (**Table 1**, **Figure 1**). We classified a total of 2,113 total events in: feeding, foraging, inactivity, interaction, locomotion and self-maintenance. Summing the behaviours for all individuals, locomotion was the most common behavioural category (42.09% – 887 behaviours), followed by feeding (24.85% – 528 behaviours); inactivity (9.93% – 209 behaviours); interaction (8.83% – 186 behaviours); self-maintenance (8.3% – 175 behaviours) and foraging (6% – 128 behaviours; **Table 2**, **Figure 2**).

Active behaviours increased in the morning (see **Table 3**). For example, active behaviours such as feeding (t-test = 15.85; p = 0.008), interaction (t-test = 1.91; p = 0.05), locomotion (t-test = 4.40; p = 0.001) and maintenance (t-test = 5.19; p = 0.04) increased, whereas inactivity behaviours (t-test = -2.91; p = 0.001) were more common at night. Foraging did not differ significantly (t-test = 4.66; p = 0.96) (**Figure 3**).

With the introduction of enrichment items we found that feeding (t-test = 3.64; p = 0.02), interaction (t-test = 1.78; p = 0.03) and foraging (t-test = 3.64; p = 0.02) increased, but there was a decrease in self-maintenance activities (t-test = -2.19; p = 0.009) (**Figure 4**). Locomotion (t-test = 0.57; p = 0.64) and inactivity (t-test = -3.50; p = 0.33) did not differ significantly.

Figure 1. Examples of behaviours observed for captive *Tamandua tetradactyla* in West-Central Brazil: **A**. Resting; **B**. Sleeping; **C**. Feeding on terrestrial termite mounds; **D**. Feeding on the diet offered in the enclosure.

Table 1. Description of observed behaviours and corresponding categories for six captive *Tamandua tetradactyla* in West-Central Brazil.

Behaviour category	Activity	Description
Locomotion	Moving arboreally	Individual moving in trees, on trunks, branches and other off-the-ground structures in the enclosure. Individual moved using fore- and hind-legs and the prehensile tail by hanging, climbing.
	Moving terrestrially	Individual moving on the ground, supported by all four limbs and tail slightly raised or in contact with the ground. Activity began with the movement of the limbs, leading to the horizontal locomotion of the body.
	Running	Individual moving quickly, using the front and back limbs for propulsion. During this time, the head remained horizontal to the body plane, while the tail remained in contact with the ground.
	Suspended	Individual hanging vertically or horizontally from branches or trunks during locomotion on these substrates. Individual used their hind legs and tail or just the tail. Suspension sometimes occurred upside down. Alternatively, the animal might grab another branch soon after inversion and begin moving its head and forelegs in the direction of interest.
	Sliding	Individual descending deliberately downwards vertically, clinging with the fore-limbs and its tail onto an arboreal substrate always head down.
Foraging	Digging	Individual using the front paws with repeated movements to part the soil, using limbs sequentially, pulling the soil toward the ventral region of its body.
	Scratching trunks	Individual rubbing the trunk of living trees with front claws. Animal stands vertically positioned with the tail holding a trunk or twig. Head is tilted and directed at the substrate. After the event, the substrate had several claw-made incisions from which exudates flowed. The animal licks the exudate and rubs it on itself.
	Opening terrestrial and arboreal termite mounds	Individual breaking open termite nests using the forelimbs and claws to access the termites inside.
	Olfactory investigation	Individual exploring by sniffing some specific element of the environment, such as a termite mound or the soil. During this process, the head makes slow and short movements up and down.
Feeding	Drinking	With the head facing the water source, legs and forelegs supported on the ground or on the water source, individual introduces its muzzle and tongue into the water.
	Feeding on terrestrial termite mounds	Individual introduces and moves its highly mobile and saliva-covered tongue into a termite nest to obtain and ingest termites. This act may be interspersed with opening termite mound behaviour (**Figure 1C**).
	Feeding on arboreal termite mounds	Individual ingesting termites from nest in trunks of dead or living trees. To do so, it uses its front claws to break open the termite mounds located on the arboreal substrate, and the long tongue to access the food source. This act usually occurs in arboreal strata, and it is often undertaken with the support of the tail. The animal is generally positioned vertically with the head up and the limbs secured on the arboreal substrate. The animal can also position itself with hind legs and tail secured on a branch, with forelegs and trunk directed to the food source.
	Feeding on ants	Individual ingesting ants in the soil, using its claws to reach its prey, remaining with all limbs on the soil and head facing the substrate.
	Feeding on the diet offered in the enclosure	Individual ingesting fruits, licking the pulp and other vegetables after opening them with the front claws. With the four limbs on the ground or arboreal substrate. Chicken eggs and prepared nutritious paste were also consumed (**Figure 1D**).
	Licking exudate	Individual feeding on exudates, passing its tongue over cracks in the tree trunk bark. As far as we know, this is the first record of this behaviour for this species.

Table 1. Description of observed behaviours and corresponding categories for six captive *Tamandua tetradactyla* in West-Central Brazil (continued).

Behaviour category	Activity	Description
Inactivity	Resting	Individual sheltered and resting, usually with the belly facing downwards and limbs extended, with eyes partially closed (**Figure 1A**).
	Sleeping	Individual is sheltered and resting, lying down, usually with the limbs and muzzle facing the belly, with the back curved. Individuals may also lay in hollows or inside termite mounds and remain inactive for periods of three to 12 hours with eyes completely closed (**Figure 1B**).
Maintenance	Cleaning	Individual moistening its front claws with tongue and passing them across snout, back or belly. Rarely, the tongue is placed directly on these body parts.
	Scratching	Individual passing hind limb claws repeatedly over body-parts such as head, snout, abdomen, limbs, back and tail.
	Urinating	Animal slightly lowering the posterior portion of their body, urinating on trunks or soil. This act is performed both while walking and when stopped.
	Defecating	With slight abduction of the hind limbs from the axis of the body the animal eliminates feces. When defecating on branches, the tail remains lightly attached to the supporting substrate. Animal may commence locomotion while defecating. The act also occurred on the ground, but in this case the tail remained slightly raised.
	Sunbathing	The animal actively seeks a place in the sun and remains on tree substratum or soil. It will remain stationary, with the head slightly inclined, in the sun for more than two hours, usually in the morning.
Interaction	Play	Two individuals approach and interact with each other by mutually touching front legs or total body rolling following contact on the ground.
	Agonistic interaction	Individuals adopt a tripod position, formed by the tail and hind limbs, facing the possible opponent. Front limbs are in contact with the other individual, presumably in an attempt to injure each other.
	Holding other individual	Young individuals use the hind limbs to hold onto the back of an adult individual.
	Touching	Individuals touch or push another with the forepaws, accompanied by olfactory inspection following touching.
	Chasing	One animal continuously moves behind a second individual.
	Standing up	Adult male performs intense sniffing over an adult female upright in the tripod stance. This action is performed when one male follows a female, usually after the female had just urinated.

Table 2. Average percentage of total observed behaviours and corresponding categories performed for all individuals at the Vale do Tamanduá ranch, Aragoiânia, Goiás, Brazil. The behaviours were counted as the number of times a behaviour was observed divided by the total number of observed behaviours.

Behaviour category	Activity	Percentage
Locomotion	Moving arboreal	16.46%
	Moving terrestrially	24.65%
	Running	0.66%
	Suspended	0.23%
	Sliding	0.09%
Foraging	Digging	0.14%
	Scratching trunks	0.66%
	Opening terrestrial and arboreal termite mounds	0.33%
	Olfactory investigation	4.87%
Feeding	Drinking	0.42%
	Feeding on terrestrial termite mounds	11.21%
	Feeding on arboreal termite mounds	2.31%
	Feeding on ants	1.37%
	Feeding on the diet offered in the enclosure	8.84%
	Licking exudate	0.70%

Table 2. Average percentage of total observed behaviours and corresponding categories performed for all individuals at the Vale do Tamanduá ranch, Aragoiânia, Goiás, Brazil. The behaviours were counted as the number of times a behaviour was observed divided by the total number of observed behaviours (continued).

Behaviour category	Activity	Percentage
Inactivity	Resting	3.31%
	Sleeping	6.62%
Self-maintenance	Cleaning	0.18%
	Scratching	5.44%
	Urinating	1.27%
	Defecating	0.14%
	Sunbathing	1.27%
Interaction	Play	6.10%
	Agonistic interaction	0.1%
	Holding other individual	0.94%
	Touching	0.52%
	Chasing	0.33%
	Standing up	0.56%
	Alert	0.28%

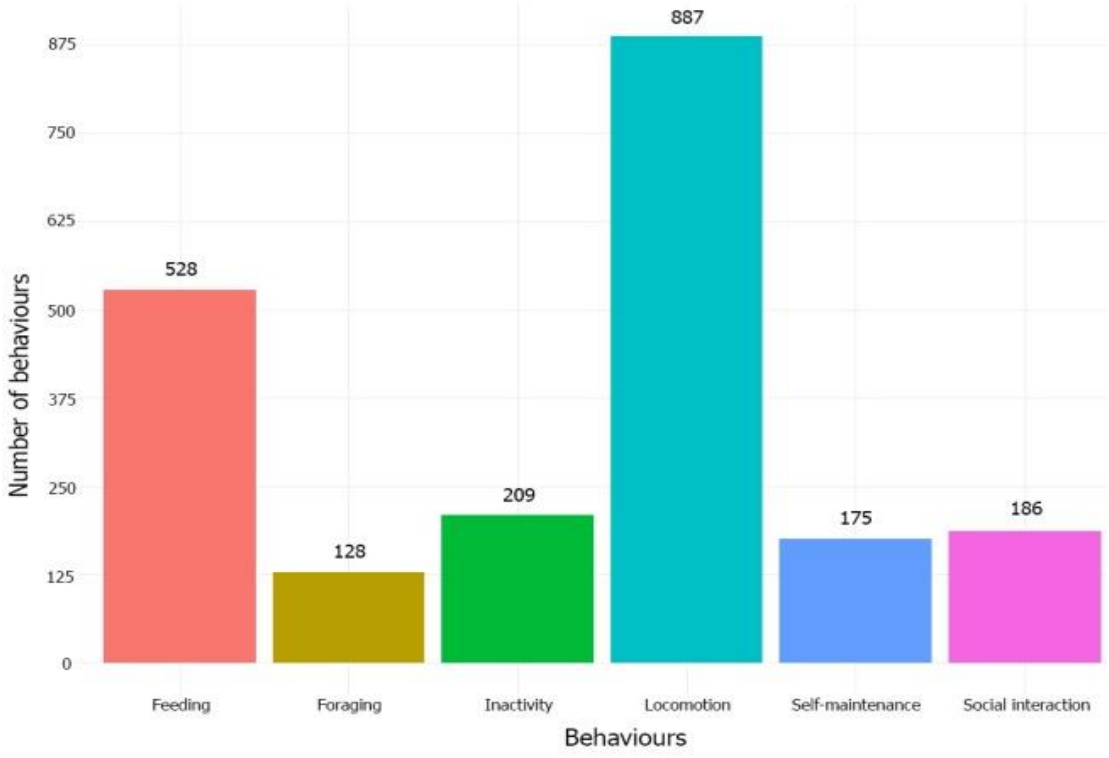

Figure 2. Number of behaviours per category. Numbers on top of the bar graph indicates the amount of behaviours sampled per category.

Table 3. Summary of T-test results on the effect of enrichment and period of the day on captive lesser anteaters behaviour (N = 6). SD = Standard deviation.

	Enrichment						Period of the day					
	With		Without		Unpaired t-test		Day		Night		Unpaired t-test	
Behaviours	Average	SD	Average	SD	t	p	Average	SD	Average	SD	t	p
Locomotion	26.67	3.82	25.33	3.54	0.57	0.64	31.50	4.50	11.00	1.00	4.40	0.001
Foraging	15.00	6.40	6.67	1.80	3.64	0.02	4.00	1.00	2.50	0.50	4.66	0.96
Feeding	12.50	4.11	4.33	2.87	3.64	0.02	19.50	1.50	5.00	1.00	15.85	0.008
Inactivity	1.00	0.58	9.17	5.18	-3.50	0.33	3.00	1.00	7.00	2.00	-2.91	0.001
Maintenance	2.33	1.89	5.83	3.02	-2.19	0.009	6.50	1.50	1.50	0.50	5.19	0.04
Interaction	2.50	0.96	1.33	1.11	1.78	0.03	6.00	2.00	2.93	1.07	1.91	0.05

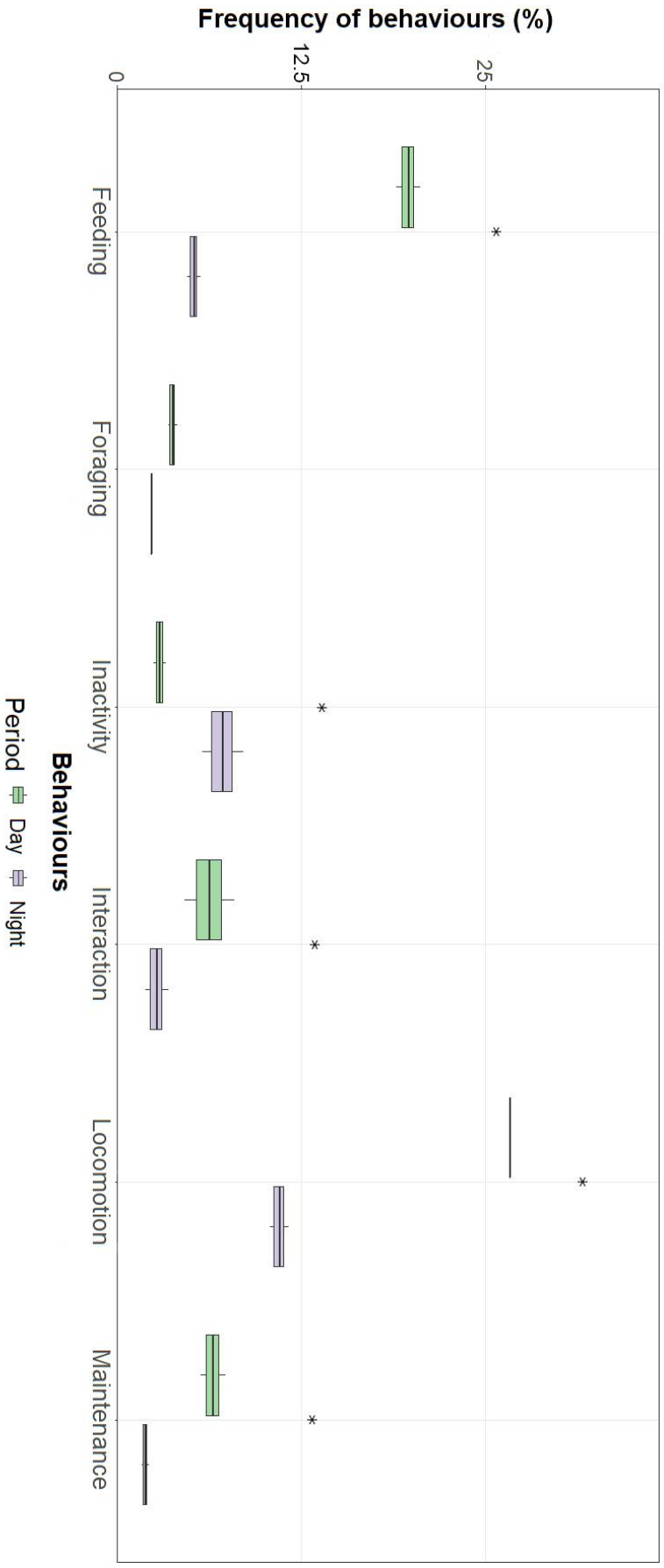

Figure 3. Frequency plots with y-axis indicating the frequency of behaviours, whereas the x axis is the sum of all behaviours for all individuals per category. Colour indicates the period of the day (green) and night (purple). (*) Indicates behaviours that differ significantly between day and night periods ($p < 0.05$).

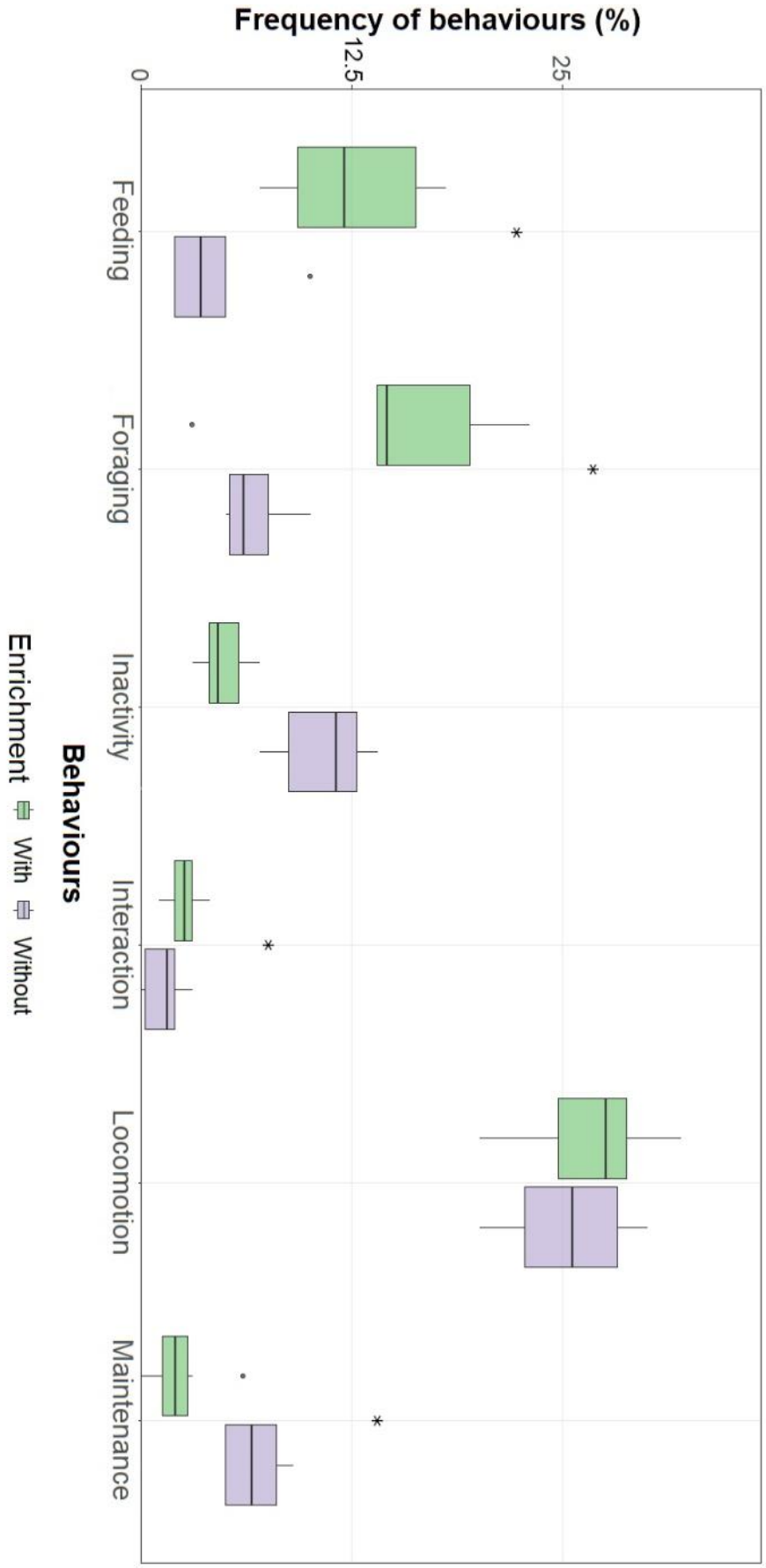

Figure 4. Frequency plots with the frequency of behaviours of all individuals per category with (green) and without (purple) the introduction of enrichment items in the enclosure. (*) Indicates behaviours that differ significantly with and without enrichment ($p < 0.05$).

Discussion

The most frequently observed behavioural categories in captivity were locomotion and feeding, but foraging, inactivity, interaction and self-maintenance were also recorded. Moving terrestrially (24.65%) was the most common activity followed by moving arboreal (16.46%) within the locomotion behavioural category. Locomotion in the wild could be related to searching for reproductive partners and increasing availability of food sources (Gallo *et al.* 2017; Trovati & Brito 2009). Individuals of this species tend to move about 1 km per day (Trovati & Brito 2009), but repetitive locomotion in captivity can also be a stereotype behaviour that future studies could work to decrease by stimulating natural behaviours such as interaction, foraging and feeding (Eguizábal *et al.* 2019). Feeding was also commonly recorded (almost a quarter of records), and included acts related to feeding on terrestrial (11.21%) and arboreal (2.31%) termite mounds. These feeding behaviours were also recorded commonly in captive giant anteaters, *Myrmecophaga tridactyla*, which frequently look for termites in mounds located within their enclosures (Andrade *et al.* 2009).

Social interactions and self-maintenance behaviours were also commonly recorded. Interactions between *T. tetradactyla* individuals were recorded in almost 9% of all the observed behaviours. One of the interaction activities observed involved one individual holding onto the back of another individual, an action that may be related to the age of the animal concerned (three months), and its possible need for activities approximating to maternal interaction (Catapani *et al.* 2019). This interaction was usually accompanied by a vocalization that was performed by the same infant. Cubs arriving in a captive environment are generally vulnerable and appear to find it difficult to adapt to feeding and maintaining body temperature (Pérez Jimeno 2003). Juvenile individuals emitted a repeated characteristic call for about two minutes, generally when the animal was looking for food. Usually the adults let the infant climb on them; similar adult-young interactions were reported by Catapani (2014). We also observed agonistic interactions (0.1%) between juvenile males, behaviour also recorded in the wild, where the attack posture tends to be followed by aggressive movements to defend against predators (Araujo *et al.* 2015). We have not observed mating actions during the survey, possible due to the proportion of adult females (only one) in relation to males (five) in this study. One of the least observed behavioural categories was self-maintenance (body cleaning activities), which accounted for 8.3% of all behaviours. All observed individuals received medical care from veterinarians, and were exposed to sunlight. Thus, it is possible that the real percentage found in nature might be higher because free-living individuals are commonly infested with ectoparasites (Martins & Guglielmone 1995).

Few studies have been undertaken in relation to how activity patterns for this species vary. While *T. tetradactyla* was found to be mostly nocturnal or crepuscular in the Cerrado (Rodrigues *et al.* 2001), here, counter to what we predicted, we found that these individuals were more active during the day. Individuals of captive *T. tetradactyla* increased significantly in most of the active behaviours such as feeding, interaction, locomotion and maintenance for the period of the day, whereas inactivity behaviours were more common at night. This could be because in the wild lesser anteaters are subject to different environmental pressures (predation and resource limitation), in relation to their conspecifics in the wild (Price & Stoinski 2007). These results could also be explained because male individuals tend to have more diurnal behaviours, while females are more nocturnal in captivity (Eguizábal *et al.* 2019). Here, five of six studied individuals were males, and we confirmed that males are more active during the day, but more females would be needed to confirm their nocturnal activity pattern.

Behavioural activity of lesser anteater was also affected by food-based enrichment. We found increased activity among lesser anteaters, such as for feeding, foraging and interaction in captivity during the enrichment period, whereas maintenance behaviours were more common without food-based enrichment, and locomotion did not differ. These results could be an indicator of greater animal well-being, supporting the application for food-based enrichment for captive individuals (Eguizábal *et al.* 2013). This could imply that by adapting the enclosure with

environmental and food-based enrichment, we can maximize natural behaviours and avoid repetitive stereotypic locomotion behaviours for the lesser anteater (Koontz & Roush 1996). Thus, our results are consistent with environmental enrichment favouring greater well-being for captive individuals.

Conclusion

In this study, we i) compiled a behavioural repertoire for captive individuals, to determine the frequency of activities and found that locomotion and feeding were the most common behaviours for this species. ii) We found that the activity pattern of *Tamandua tetradactyla* individuals increases during the day, relative to the night period, especially feeding, interaction with other individuals, self-maintenance and locomotion, while inactivity was more common at night. iii) The pattern of activity increased with the introduction of enrichment items, and individuals preferred to forage, feed and interact more, while behaviour activities related to self-maintenance were more common without enrichment items. In providing an ethogram for the lesser anteater and indicating the pattern activity during day period and the introduction of enrichment items, the current article provides data that raise information in relation to the needs and the best practice for this species in captivity. We encourage future studies that involve a greater number of individuals and account for sex differences, to show a more accurate relationship between food-based enrichment, activity patterns and the behaviour of lesser anteaters.

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