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Brief characterization of the behavior of the spiny rat *Trinomys setosus* (Rodentia: Echimyidae) in captivity

Breve caracterización del comportamiento de la rata espinosa *Trinomys setosus* (Rodentia: Echimyidae) en cautiverio

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Hairy Atlantic spiny rats (*Trinomys setosus*, Echimyidae) are Neotropical caviomorph rodents belonging to an ecologically diverse group, that is relatively unknown from a behavioral point of view. Grooming is considered prevalent in rodents: wild and laboratory individuals employ grooming during 15–50 % of their waking time. We ask if grooming behavior in *T. setosus* is similarly low as in closely related species, and characterize the main behavioral categories seen in the species in detail. We quantified the occurrence of self-grooming (face washing, body washing, washing of the pelvic region, and scratching) during single 30-minute sessions of 16 adult individuals (four males and twelve females), in the context of activity, resting and maintenance categories (defecation and urination). The following behavioral categories were identified: 1) locomotor activity, 2) remaining motionless, 3) defecating, 4) face washing, 5) body washing, 6) washing the pelvic region, 7) scratching, 8) urinating, 9) shaking, 10) vocalizing. Grooming behavior followed the descriptions of stereotypical behavior observed in other rodent species and its occurrence represented 6.7 % (females) and 5.9 % (males) of the time studied. Grooming, seen across a great variety of animal taxa, involves numerous functions besides the primary role of body caring, which are of great importance for an animal's well-being. Compared to commonly studied rodents, *T. setosus* spent relatively little time with grooming behavior, just as its sister species *T. yonenagae*.

Key words: Behavioral repertoire; body cleaning; Brazil; Euryzygomatomyinae; Mammalia.

Las ratas espinosas del Atlántico (*Trinomys setosus*, Echimyidae) son roedores caviomorfos neotropicales pertenecientes a un grupo ecológicamente diverso, muy desconocido desde el punto de vista comportamental. El aseo se considera frecuente en Rodentia, siendo estimado que tanto los roedores silvestres como los de laboratorio emplean de 15 a 50 % de su tiempo de vigilia con esta tarea. De esta forma, nos preguntamos si el comportamiento de aseo en *T. setosus* es similar a aquel observado en especies estrechamente relacionadas, y caracterizamos en detalle las principales categorías de comportamiento observadas en la especie. La ocurrencia de aseo personal (lavado de cara, lavado de cuerpo, lavado de la región pélvica y rascado) fue cuantificada durante sesiones únicas de 30 minutos en 16 individuos adultos (cuatro machos y doce hembras), en el contexto de actividad, reposo y categorías de mantenimiento (defecación y micción). Se identificaron las siguientes categorías de comportamiento: 1) actividad locomotora, 2) permanecer inmóvil, 3) defecar, 4) lavarse la cara, 5) lavarse el cuerpo, 6) lavarse la región pélvica, 7) rascarse, 8) orinar, 9) sacudirse, 10) vocalizar. El comportamiento de aseo siguió las descripciones estereotipadas para otras especies de roedores y su ocurrencia representó el 6.7 % (hembras) y el 5.9 % (machos) del tiempo estudiado. El aseo, visto en una gran variedad de taxones animales, involucra numerosas funciones además del propósito principal del cuidado del cuerpo, que son de gran importancia para el bienestar animal. En comparación con los roedores comúnmente estudiados, como ratas, ratones, hámsteres y conejillos de indias, *T. setosus* destina relativamente poco tiempo al comportamiento de aseo, de forma comparable a su especie hermana *T. yonenagae*.

Palabras clave: Brasil; Euryzygomatomyinae; limpieza corporal; Mammalia; repertorio conductual.

Spiny rats of the family Echimyidae Gray, 1825 occur in Central and South America and the Caribbean. The family represents the greatest current radiation of caviomorph rodents (Upham and Patterson 2012), comprising fully arboreal, scansorial, terrestrial, fossorial, and semiaquatic genera and distributed throughout all neotropical regions (Fabre *et al.* 2013). Brazilian echimyids of the genus *Trinomys* Thomas, 1921 are terrestrial, occupying mainly forested areas of the Atlantic Forest, while some species are also found in xerophilous dune vegetation and in transition areas between the Atlantic Forest and the Cerrado, or the Caatinga, respectively (Lara and Patton 2000; Lara *et al.* 2002).

The hairy Atlantic spiny rat, *Trinomys setosus* Desmarest, 1817, is endemic to Brazil, with a wide distribution in forested areas of the states of Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro, and Sergipe (Pessôa *et al.* 2015). It is a medium-sized rodent with an average head and body length of around 180–226 mm (Iack-Ximenes 2005),

darker dorsally and laterally, lighter ventrally, and a typical echimyid tail with short hairs on its extremity (Moojen 1952). Their spiny appearance is caused by the presence of modified aristiform hairs on the dorsal and lateral body wall, which are less robust than the *sensu stricto* spines, and have no known biological function (Hoey *et al.* 2006).

The genus *Trinomys* has been the subject of ecological, morphological, physiological, cytogenetic, and behavioral studies (Lara and Patton 2000; Lara *et al.* 2002; Manaf *et al.* 2003a; Manaf *et al.* 2003b; Marcomini and Spinelli Oliveira 2003; Monteiro *et al.* 2005; Fabre *et al.* 2016; Fabio-Braga and Klein 2018; Courcelle *et al.* 2019; Cantano *et al.* 2023). One interesting behavioral feature that has been described in *T. yonenagae*, a species closely related to *T. setosus*, shows a low rate of grooming (self-cleaning), especially when compared with non-echimyid species (Manaf *et al.* 2003b). In this context it has been shown to exhibit among the lowest grooming rate of any echimyid. However, unlike *T. setosus*, *T. yonenagae* occupies sand dune fields within the semiarid Caatinga in northeastern Brazil, building and using extensive underground tunnel systems (Manaf and Spinelli Oliveira 2000; Rocha 1995; Manaf and Spinelli Oliveira 2009).

Studies have demonstrated the innate character of grooming behaviors (Annable and Wearden 1979; Alberts 1996), and in rodents grooming can be used for a variety of purposes, such as thermoregulation (Shanas and Terkel 1996), social communication (Ferkin *et al.* 2001; Wolff *et al.* 2002), stress reduction (Kalueff and Tuohimaa 2004), and removal of ectoparasites (Hawlena *et al.* 2007). In the present study, we characterize in detail the main behavioral categories of body cleaning behavior in *T. setosus*, and we ask if its rate of grooming is similarly low as it is in its closely related species.

Animals. 16 adult *Trinomys setosus* (12 females, 239.8 ± 47.2 g; 4 males, 271.3 ± 17.8 g) were collected in a secondary forested area of Mata Atlântica, Fazenda Oitinga, Jaguaripe municipality (13° 00´S, 38° 01´ W, BA, Brazil; license n° 54841-1 Sistema de Autorização e Informação em Biodiversidade - SISBIO). The spiny rats were housed at the Animal Facility of the FFCLRP- USP (Laboratório de Ecofisiologia e Comportamento de Roedores Silvestres/LECO), in isolated rooms under stable conditions (24 ± 2 °C, relative humidity of 82 ± 2 %, inverted light: dark cycle of 12:12, 3-120 Lux). Water and food pellets (Nuvilab CR-1) were supplied *ad libitum*, and were weekly complemented with seeds and a variety of fresh fruits and vegetables. Animals were maintained individually in standard laboratory cages (40 × 33 × 16 cm). Animal use was approved by the local animal care committee (Comissão de Ética no Uso de Animais-Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto – CEUA/FFCLRP n° 16.5.576.59.4).

Experimental protocol. Behavioral records were made using a portable camera (Sony®, model Handycam Vision CCD-TRV150), on a tripod. The filming took place during the animals' activity period on seven non-consecutive days in an isolated room of the animal facility (maintained at 25 °C). Individuals were weighed and placed individually into a glass box (25 × 40 × 19 cm), covered by a meshed lid and filmed continuously for 30 minutes. After an animal was filmed, the glass box was cleaned using 70 % ethanol.

Data analysis. A total of six hours and five minutes of filming was analyzed using the "all occurrences" method (Altmann 1974). Videos were observed and analyzed at reduced speed through a video editing program (VLC 2.2.6), while simultaneously transcribing the observed behaviors into the computer program Etholog 2.25 (Ottoni 2000) to quantify absolute frequency and relative duration of each behavior. Behaviors were classified following Manaf and Spinelli Oliveira (2000).

The following behavioral categories were identified for *T. setosus*, whose individual frequencies and relative durations are given in Figure 1 and Table 1.

1. Locomotor activity. This includes either one or more of the following actions: moving around the glass box, sniffing, jumping, digging, and rearing.

2. Remaining motionless. This involves any action that is not related to locomotion, such as freezing and rest-

Table 1. Frequencies and relative durations of behaviors during 30 minutes of observation of *Trinomys setosus*. Data are presented as mean ± standard deviations.

Category	Frequency		Relative duration (%)	
	Females	Males	Females	Males
Locomotor activity	43.4 ± 15.4	37.5 ± 4.8	53.8 ± 27.6	66.3 ± 19.6
Remaining motionless	22.6 ± 14.2	16.3 ± 8.0	37.7 ± 29.2	27.5 ± 19.5
Face washing	17.3 ± 9.7	17.0 ± 7.5	3.8 ± 2.2	3.7 ± 2.2
Body washing	13.8 ± 11.6	14.8 ± 6.3	2.3 ± 3.3	1.8 ± 0.9
Washing of the pelvic region	0.5 ± 1.0	0.0 ± 0.0	0.1 ± 0.3	0.0 ± 0.0
Scratching	6.5 ± 7.8	4.8 ± 2.5	0.5 ± 0.5	0.4 ± 0.2
Defecating	10.3 ± 7.5	7.8 ± 7.6	0.6 ± 0.4	0.4 ± 0.4
Urinating	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Shaking	1.4 ± 1.7	1.0 ± 0.8	0.1 ± 0.	0.1 ± 0.1
Vocalizing	7.8 ± 14.8	0.0 ± 0.0	1.0 ± 2.1	0.0 ± 0.0

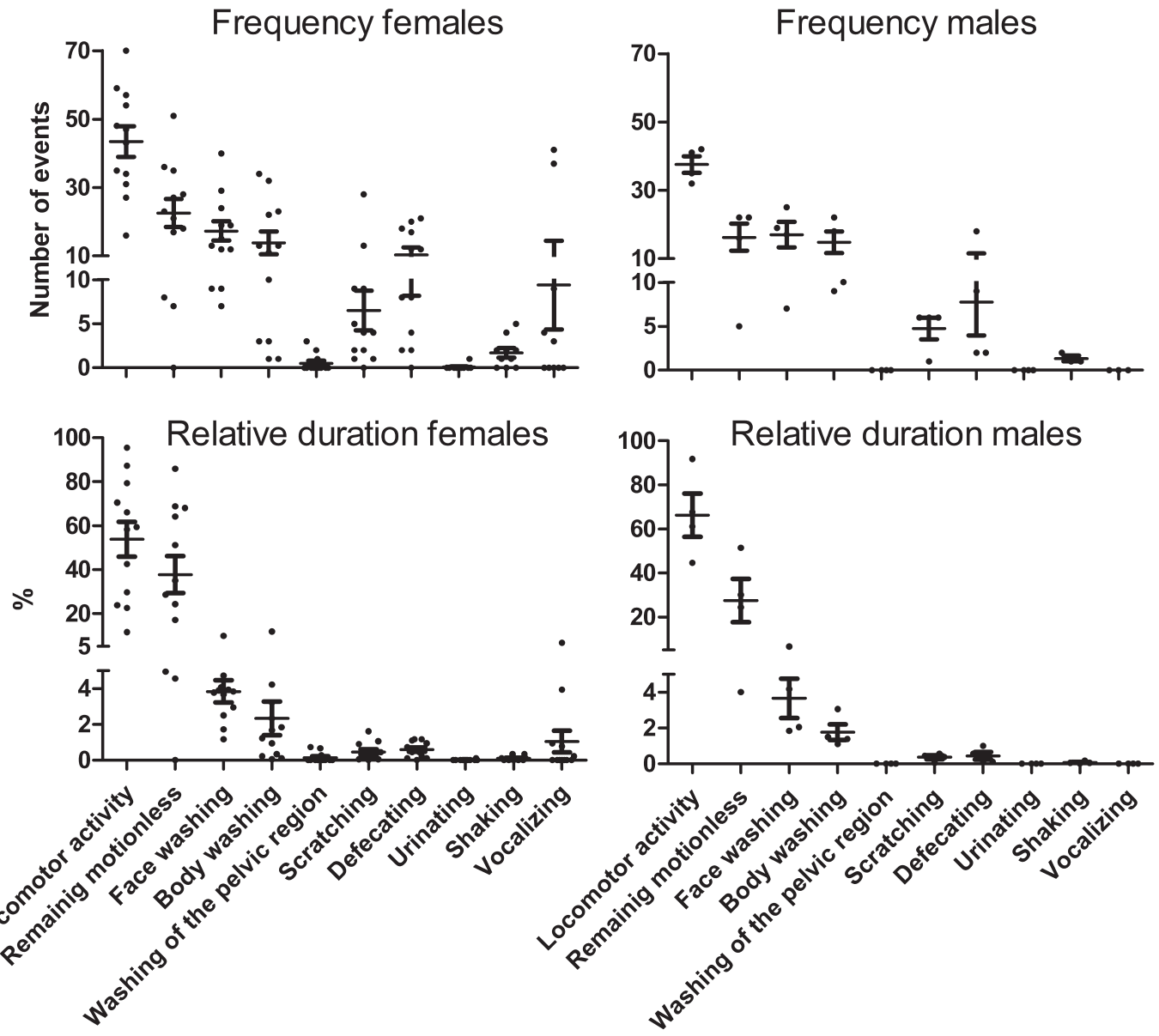

Figure 1. Frequencies and relative durations of behaviors during 30 minutes of observation of *Trinomys setosus*. For reasons of clarity, the y-axes have been split into two different scales. Data are presented as individual values, as well as mean ± S.E.M.

ing or alert postures. In the resting posture, the animal is lying on the stomach with its limbs flexed under the body, assuming a spherical body shape, its tail close to the floor and wrapped around the body. On alert, the animal may be standing using all four legs, with raised ears, open eyes, stretched or raised tail, with or without vibrissae or muzzle movements. The animal may also be standing only on its hind legs, with the perineum resting against the floor, an erect trunk, a taut tail, raised ears, open eyes, with or without vibrissae or muzzle movements.

3. Defecating. With the four legs on the floor, the posterior region slightly lowered, and the tail raised (with small movements of the tail and posterior region of the body), the animal defecates.

4. Face washing. The animal licks the front paws and passes them repeatedly over the face. The movements may extend to other regions of the head, from the region behind the ears to the snout and vibrissae, and in reverse from the snout to the back of the head (Figure 2A).

5. Body washing. The animal directly licks several parts of the body, including the dorsal, lateral, and ventral regions, as well as its paws. This category may include 'combing', which means licking and combing the hair on the flanks, hind legs, abdomen and tail with the incisors teeth (Figure 2B).

6. Washing of the pelvic region. The animal curves its body dorsoventrally, flexing the neck until it touches and licks the pelvic region (Figure 2C).

7. Scratching. The animal uses one of its hind legs to scratch the lateral, ventral, or dorsal regions of the body, as well as the head, including behind the ears, snout and top of the head (Figure 2D).

8. Urinating. The animal urinates with all four feet on the floor, the posterior slightly lowered, and tail raised, with small movements of the tail and the posterior body.

9. Shaking. The animal shakes its head or body by moving one or the other quickly and repeatedly to the right and to the left.

10. Vocalizing. The animal emits a whistle as it repeatedly taps one of the hind limbs on the floor (foot drumming; one hind foot may be tapped repeatedly on the floor, and after a pause, the same foot or the other hind foot may be used), or while moving around the glass box.

Most of the behaviors exhibited by the animals, especially during the initial minutes of filming, corresponded to the exploration of the environment. During the observation period, females showed an overall tendency to exhibit most of the identified behavioral categories more frequently than males. However, the relative durations of the different behaviors were dominated in females and males by 'Locomotor activity' and 'Remaining motionless' categories, comprising more than 90 % of the time spent under observation. The remaining behaviors exhibited, may be relatively frequent, but were only of short duration, even those related to grooming.

The behavioral categories observed in *T. setosus* are commonly described for other rodents (Berridge 1990; Manaf and Spinelli Oliveira 2000; Sabatini and Paranhos da Costa 2001; Kaiser *et al.* 2011). Similar results regarding frequency and duration of behaviors were obtained by Manaf *et al.* (2003b) in a behavioral study of three other species of echimyids—*T. yonenagae*, and the forest dwelling *T. iheringi* and *T. albispinus*, in addition to *Rattus norvegicus*. In an elevated plus maze test and an open field laboratory rats and the spiny rats spent more time in exploratory behaviors, with *R. norvegicus* showing the greatest absolute duration of grooming. Among the echimyids, *T. iheringi* presented the greatest rate of grooming when compared to the other two species. While the behavior of *T. setosus* females and males in the wild is not known, Santos and Lacey (2011) have shown that female *T. yonenagae* visit nearby burrows more frequently than males, suggesting a similar behavior for female *T. setosus*.

Vocal behaviors and foot drumming, which in our study were emitted by females only, were similar to the ones described for *Proechimys* by Emmons and Feer (1997), in which the quick tapping of the hind legs onto the substrate represents a warning sign, especially during defense against predation, and may also function as individual recognition. Additionally, foot drumming has been identified in rodents from arid regions (Randall 1994), including the echimyid *T. yonenagae* (Manaf and Spinelli Oliveira 2000).

Although Manaf and Spinelli Oliveira (2000) have shown that *T. yonenagae* rarely grooms, behaviors related to grooming may constitute between 15 and 50 % of a rodent's awake period, both under wild and laboratory conditions (Kalueff and Tuohimaa 2004; Kalueff *et al.* 2007). Despite this distinction, behavioral studies of the sister species *T. yonenagae* provide a framework to analyze and interpret the behaviors observed in *T. setosus*.

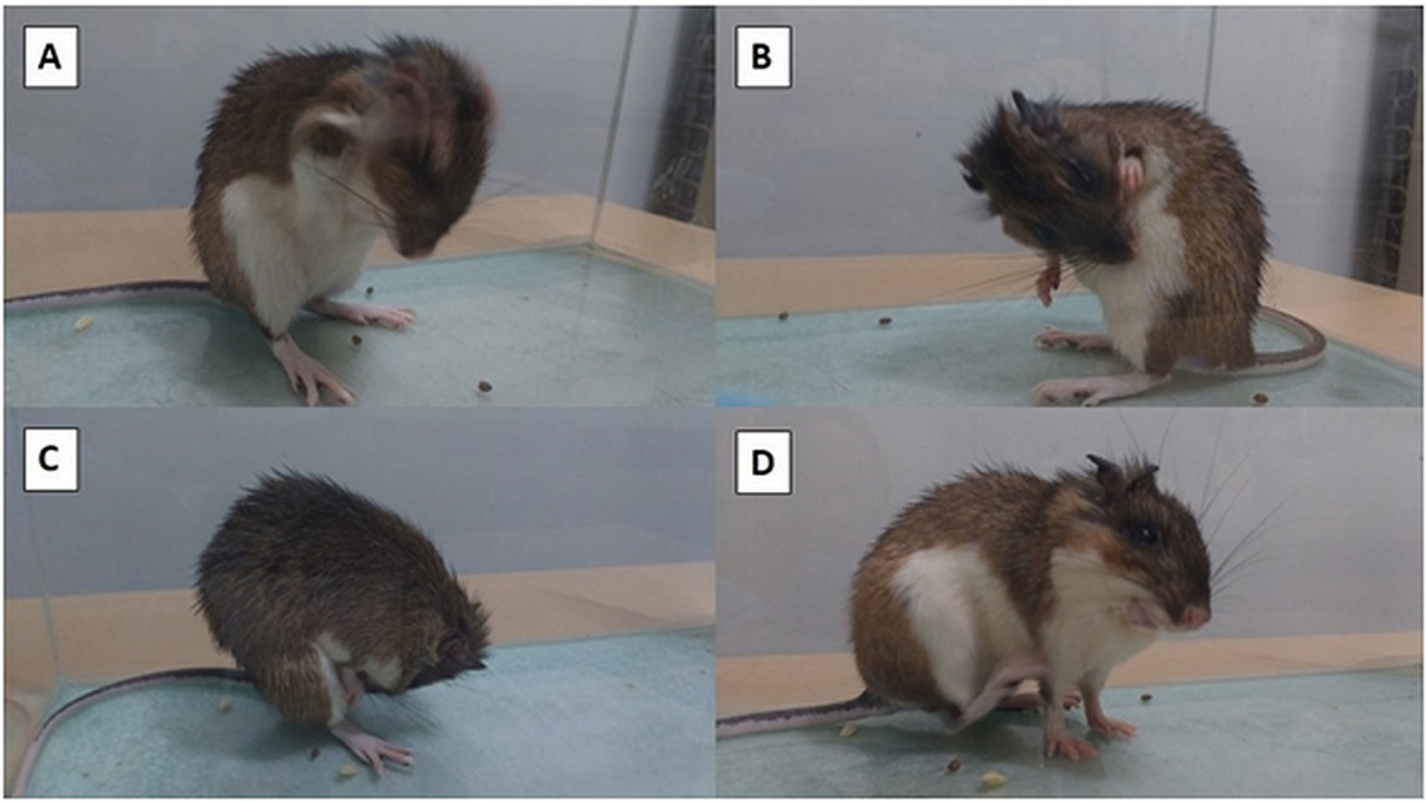

Figure 2. *Trinomys setosus* exhibiting four behaviors related to grooming as observed in our analyses: A) face washing; B) body washing; C) washing of the pelvic region; D) scratching. Photos taken by FRB.

Studies performed on different taxonomic groups have shown that closely related species show minimal differences in grooming behaviors (Farish 1972; Berridge 1990). Possible interspecific variations in grooming behavioral sequences are rarely described in the literature for wild species of rodents since most studies on grooming focus on the description of behavioral subunits. In fact, *T. setosus* shows similar behaviors (washing, combing, scratching, and licking of the anogenital region) related to grooming as described for *T. yonenagae* (Manaf 2000). Differences in grooming behavioral traits in rodents might be related to temporal parameters, or as shown in a comparative study with rats, mice, hamsters, and guinea pigs, might be related to an allometric scale, since the duration of body cleaning cycles was related to the average size of the investigated species (Berridge 1990).

Since *T. setosus* is the sister species of *T. yonenagae*, we could not expect significant differences in its grooming categories. However, the fact that *T. setosus* has twice the body mass of *T. yonenagae* might affect absolute and/or relative duration of the categories, since differences in body size might affect the species' surface to volume ratio, consequently affecting the time needed to clean their body. Therefore, *T. setosus* could be expected to show a lower rate of grooming than its sister species. Such a possible correlation between body size and grooming duration could be tested using animals or species of different sizes, but due to the low variation in *T. setosus* body mass in our study, we cannot make a more direct correlation.

The present study's contribution consists of a brief description of behavioral categories of an endemic Brazilian rodent species, especially related to its grooming behavior. Future fieldwork or experimental studies might benefit from such a description in *T. setosus* and expand it to other species of spiny rats.

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