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Ring-tailed coatis anointing with soap: a new variation of self-medication culture?

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When following a free-living ring-tailed coati *Nasua nasua* group behind a tourist complex on Ilha do Campeche (an island in the State of Santa Catarina, Brazil), we observed them rubbing laundry and cleaning substances onto their bodies. In order to describe this anointing behavior, spontaneous and induced anointing sessions were studied over two visits to the island. The induced events were prompted by offering bar soap in five experimental sessions. In all experimental sessions, one to three animals of both sexes performed soap-anointing behavior. It was most commonly self-directed (self-anointing), but also sometimes applied onto others (allo-anointing), or sometimes performed collectively and in close proximity to other group members. The genital area was the most often rubbed location, followed by the tail. We suggest that ring-tailed coatis may be deterring ectoparasites when applying soap to their integument. Ring-tailed coatis are known for anointing their fur with resin or arthropods, but this is the first description of the use of soap. Close contact with humans and easy access to soap inadvertently left outside may have been responsible for this arbitrary innovation. Because this behavior has persisted for more than 10 years and is practiced by different age groups, we suggest that this behavior is being socially transmitted across generations within the group from older to younger individuals.

Rubbing of odoriferous substances onto the body has been described in non-human animals as anointing behavior (wet grooming) or 'fur-rubbing' (for a recent review in capuchin monkeys, see Bowler, Messer, Claidière, & Whiten, 2015). The substances applied usually have pungent smells (Meunier, Petit, & Deneubourg, 2008) and are proposed to serve a communicative function such as in urine spraying (Alfaro et al., 2012), a thermoregulatory effect as that promoted by sand bathing in gerbils and baboons (Brain & Mitchell, 1999; Pendergrass & Thiessen, 1983), or act as a repellent against ectoparasites as a form a zoopharmacognosy (Rodriguez & Wrangham, 1993) or self-medication (Huffman, 1997). The well-studied anting behavior of songbirds (Revis & Waller, 2004) and primates (e.g., Verderane et al., 2007) are good examples of this purported ectoparasite/insect repellent behavior, attesting to its widespread phylogenetic occurrence.

Human-introduced substances (e.g., tobacco, eau de cologne, pepper, laundry soap, ammonia, oil of lavender, orange juice, onions) have also been used in anointing behavior by free-ranging and captive capuchin monkeys living in close contact with people (Alfaro et al., 2012). Interestingly, among this list, the preferred substances are cleansing-products such as laundry soap, detergent, and disinfectant and supposedly serve as repellent, fungicidal or some kind of curative agent (Alfaro et al., 2012; Bowler et al., 2015). These were exactly the same items we observed ring-tailed coatis adopting in our study area. While primate sociality still receives

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much more attention in the literature as a model to discuss the evolution of cognitive abilities, once again ring-tailed coatis challenge *primate supremacy* (Romero & Aureli, 2008). In 2012, Hirsch, Stanton and Maldonado, showed that female support in aggressive conflicts between adult male and juveniles was commonly performed by *Nasua nasua* and that this behavior was reciprocally exchanged in as complex a way as that seen in primates (Romero & Aureli, 2008). The present study offers evidence of a culture of self-medication in ring-tailed coatis, with similarities to primates in their social learning abilities.

The population of ring-tailed coatis introduced onto Ilha do Campeche, a small island at the Southwest of Ilha de Santa Catarina (State of Santa Catarina, Brazil), is using toilet soap, laundry soap, and degreasing soap in their anointing behavior. In our long experience following groups of *N. nasua* at different geographical areas from Southern to Mid-western Brazil, we have never seen them using such products. Knowing that routine interactions with humans can create opportunities for the development of new habits in non-human primates (Kawai, 1965), we propose that soap-anointing by ring-tailed coatis of Ilha do Campeche may be a case of self-medication or health maintenance, i.e., the use of natural or human-introduced substances for self-medication (i.e., Huffman, 1997, 2011; Morrogh-Bernard, 2008) to alleviate or to control illness. The use of these substances seems to be a practice peculiar to this group only.

Free-ranging ring-tailed coatis, like several primate species, have reportedly been observed rubbing millipedes over their bodies and exhibiting prey-rolling behavior of spiders and other noxious arthropods (Weldon, 2004; Weldon, Cranmore, & Chatfield, 2006). It has been shown that the secretion released by millipedes deters ticks (Carroll, Kramer, Weldon, & Robbins, 2005; Weldon, 2004). Inasmuch as ticks exert selective pressures over both coatis and primates, it is reasonable to infer self-medication as an adaptive behavior in the repertoire of *Nasua* species, as the use of a resin has already been described to occur in white-nosed *N. narica* (Gompper & Hoylman, 1993). From Romero and Aureli's (2008) findings as a premise that ring-tailed coatis are similar to primates in their social complexity and cognitive abilities, we discuss soap-anointing by ring-tailed coatis in terms of culture (i.e., transmitted at least in part via social learning) and self-medication.

Materials and Methods

Subjects and Study Area

Ilha do Campeche is 1.4 km from Campeche Beach, located on the southeast coast of Ilha de Santa Catarina, in the municipality of Florianópolis, Santa Catarina State, between coordinates 27º41'22'' S and 27º42'18'' S and 48º27'33'' W and 48º28'08'' W" (see Chamas & Schmidt, 2011 for a detailed description). This island is within the Right Whale Marine Protected Area (Instituto do Patrimônio Histórico e Artístico Nacional [IPHAN], 1998) and is a National Archaeological and Landscape Heritage for its unique rock art site dating back 4,000 years (Chamas, 2008). It is mainly formed by dense ombrophilous forest (IPHAN, 1998). In the western part, there is a sandy beach called Enseada, and behind it is housing and tourism infrastructure. The island belongs to Florianópolis municipality, but it is under a participatory management scheme based on a partnership between Pioneira da Costa fish company and Couto de Magalhães de Preservação da Ilha do Campeche association (ACOMPECHE), that promotes fishing activities, and also Monitores Ambientais da Ilha de Santa Catarina and Pescadores Artesanais da Armação do Pântano do Sul associations, that promotes recreation and generates intense tourism activities (e.g., one thousand visitors were counted to be on the island in one summer day; Chamas, 2008). The weather is humid with 1,406 mm of annual precipitation and an average annual temperature of 20ºC (16.4ºC in winter July to 24.3ºC in summer January; IPHAN, 1998).

There is no census of coatis available for the island. However, the mammalian fauna is noticeably impoverished in comparison to avifauna, and ring-tailed coatis may not be native but imported to the island (Cimardi, 1996). An unofficial report states that an adult couple of *Nasua nasua* trapped at Baixada do Maciambu, municipality of Palhoça (Serra do Tabuleiro, State of Santa Catarina, Brazil) was brought to the island in the 1950s. The only initiative for estimating population density was completed by Bonatti (2009). For one year, ending in February 2006, he tracked ring-tailed coatis over most parts of the island using a systematic sampling protocol for 420 total hours. He counted 80 encounters with solitary individuals and 190 with groups of ring-tailed coatis. The breeding season took place at the end of winter and infants were born from November to December, the spring season. The ring-tailed coatis used mostly the forests and human habitation areas (Bonatti, 2009).

Over the course of 2014, we followed a group consisting of 15 individuals in January. Almost all were individually recognized using natural marks and scars that lived close to the tourist complex behind the beach. This is our study group in the present work. Throughout the study, the animals were noticeably in poor health, thin and infected by ticks. Authorities have been discussing the possibility of removing coatis from the island for the safety of the animals, as it is becoming more and more popular for humans to poison coatis, as reported by the Diário Catarinense (available on dc.clicrbs.com.br, accessed at July 3rd, 2012).

Procedure

This study was conducted in two non-consecutive island visits, on October 11th and November 8th of 2014. From our arrival at the recreation area (at 9:30 a.m.) until almost 18:00, when animals moved up to their arboreal nests, we recorded (1) all occurrences of spontaneously executed anointing behaviors, i.e., that occurred without our encouragement. Additionally, (2) five experimental sessions were performed in which laundry products (see Figure 1C-D) were deposited on the sandy ground (see Figure 1E) as soon as we observed the arrival of ring-tailed coatis. The deposit area (an unmarked square meter area, Figure 1E) was in the middle of the recreation area where the ring-tailed coatis used to find toilet soaps and other cleaning substances inadvertently left out by humans (tourists, visitors and inhabitants using barbecue and bathing facilities; Figure 2A). These items were also present in the recreation area, and even before the initiation of this study we noticed a juvenile anointing itself with liquid degreasing solution (see Figure 1A). Cleaning products were not available in other locations on the island.

The products used to induce anointing as part of the experimental sessions were pieces of bar soap (a 0.75 kg non-toxic strained-soap bar produced from tree ashes cut into 10 pieces; Figure 1D) and a bucket with laundry soap diluted in water and full of foam (see Figure 1C). In the last session, the offered item was toilet soap instead of ash soap and the bucket. It was thrown on the ground by an old resident of the island, and used by the ring-tailed coatis. Because this occurred in our presence and we could neither avoid it nor move the ring-tailed coatis away, and because the coatis instantaneously began collecting and using the toilet soap for anointing, we considered this the fifth session.

The experimental sessions took place between 09:30 – 14:44, depending on the presence of animals at the recreation area. They lasted between 16-87 min. Spontaneous and induced events of anointing and grooming (sniffing, scratching, nibbling) were recorded with a Canon HX50S camera. We opted to additionally register grooming to compare and distinguish this behavior from anointing, since other authors have described resin used for grooming instead of anointing behavior. The video recordings were analyzed in order to quantify number, type and duration of behaviors, participants (by sex, age category and number), items and body parts related to anointing and grooming (Table 1). Results are described in terms of occurrences (for now on called event) of the following behavioral categories: self-anointing, allo-anointing, self-grooming, allogrooming, soap on mouth (eating or carrying), soap defense, soap rubbing on ground and presence without interacting, i.e., whenever a ring-tailed coati entered the recreation area during the experimental sessions but did not interact with the items deposited on the ground (see Supplementary Material).

Results

Our study group was composed of 17 individuals by October 2014 and 21 individuals by November 2014. The group consisted of juveniles, sub-adults, and adults, but we could not identify all of them individually or by sex. No infants were present, though because they had been observed in previous visits to the island that year, from January to April, it is likely they had become juveniles by October and November. During the two single-day visits, our data collecting effort totaled 16 hr 49 min; 7 hr 52 min in October 11th and 8 hr 57 min on November 8th. A total of 116 behavioral events were recorded in 285 min of video recording; 215 min of experimental sessions and 70 min of spontaneous behaviors. Details and the number of events are summarized in Table 1.

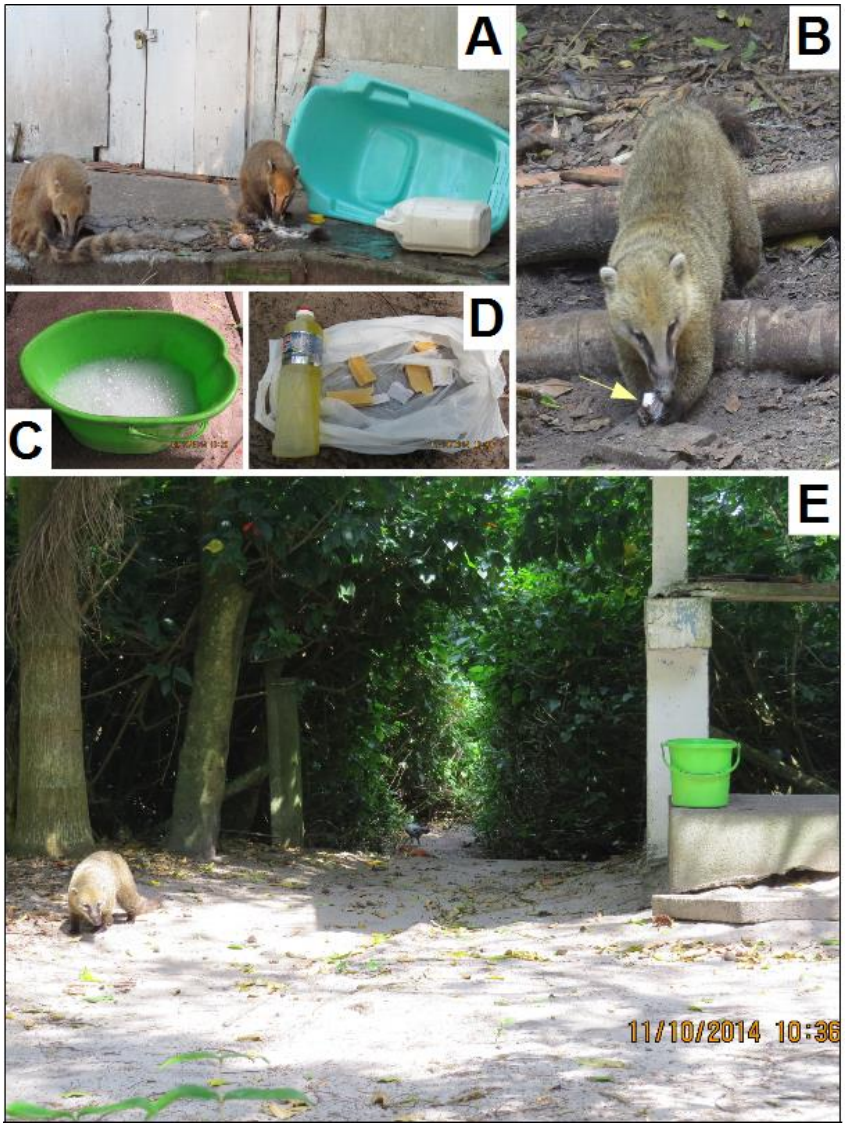

Figure 1. *Nasua nasua* on Ilha do Campeche (State of Santa Catarina, Brazil). A: spontaneous self-anointing with degreasing soap by an adult female (left) and a juvenile (right), after pulling out the bowls cap; B: an adult male grabbing the piece of strained-soap (arrow), producing suds that would be then used in anointing; C: a bailer of soapy water full of foam offered in the experimental session; D: a bottle of neutral dish detergent (left) and pieces of strained-soap (right); E: the square meter area used to deposit items during the experimental sessions. Photos by ADCG.

Outside of the five experimental sessions, 15 events of spontaneous anointing behavior (2 of them of allo-anointing) were observed. Animals used toilet soap and degreasing soap they found in the recreation area or used suds (resulting from soap chewing) or foam (produced by mixing the laundry soap with water on the bucket) they collected from the bodies of other coatis. All of these items were the unintentional byproducts of tourist and resident occupation. An additional spontaneous use of an item for anointing, observed during one experimental session, was performed by a sub-adult that found a small rock on the floor and rubbed it against its tail using paws, mouth and nose. Two events of soap defense (actively maintaining possession of the soap), 16 self-grooming behaviors (see Figure 2D), and 10 allogrooming behaviors (see Figure 2C) events were also recorded outside the experimental sessions.

During the five experimental sessions we identified 46 anointing behaviors (10 of them were allo-anointing behaviors; Figure 2F), 5 self-grooming behaviors (see Figure 2D), and an additional 14 behaviors were directed to pieces of soap, such as putting soap in the mouth (eating or carrying it, 8 times), rubbing against the sandy ground (4), and fighting to maintain possession of the soap (2; see Supplementary Material). A ring-tailed coati ignored soap, suds, or other items deposited in the recreational area in only 9 out of the 74 behavioral events identified during the 5 trial sessions (4 hr of video). They simply sniffed the item and moved away from it. In 6 of these 9 events, there was just 1 adult male animal. In other 13 events during these experimental sessions, when only 1 or 2 animals were present in the observation area, half of them groomed, took a piece of soap and eventually rubbed it on the floor before moving away from it (2 females and 5 males). In the other half, anointing was performed with pieces of soap and no suds, always self-directed and while alone in two females and the rest males. Whenever more than two animals were present at the same time, during induced sessions, there was anointing (40 events). In 30 of these events, it was self-performed (10 allo-anointing behaviors, one in a juvenile and all others in sub-adults of unknown sex). In the remaining 14 events, it was a collective act involving two to three animals simultaneously self-anointing and eventually integrating this with allo-anointing (see Figure 2F). Nevertheless, when both spontaneous and induced occurrences are considered, most commonly ring-tailed coatis self-anointed individually, i.e., in only 14 out of 49 self-anointing behaviors, there was more than one animal performing this behavior at the same time. One case occurred in during a spontaneous event.

Table 1

Number and description of all spontaneous and induced anointing behavior events (self and allo-performed) observed during two single-day field campaigns in ring-tailed coatis on Ilha do Campeche, State of Santa Catarina, Brazil.

			Spontaneous	Induced
Self (allo) anointing events	Number	Oct 11th	4	15
		Nov 8th	11 (2)	31 (10)
		Total	15	46
	Time	Behavior duration (s)	4 – 188	2 – 295
		Period of the fieldwork (h)	10:27 – 14:25	09:50 – 14:44
Items	Offered		None	Toilet and pieces of ash-soap, bailer of soapy water
	Used		A small rock*, toilet and degreasing soap	Pieces of soap and suds/foam acquired from others body
Part of the body	Being anointed	Genital area	6	33
		Tail	10	21
		Other parts	1	9
	Used to rub	Mouth / Nose	11	40
		Paws	12	40
Subjects	Into the recreational area	Number	2 – 10	1 – 12
		Age	juvenile, subadult and adult	juvenile, subadult and adult
		Sex	male and female	male and female
	Performing anointing	Self	0 – 2	0 – 3
		Some other	0 – 1	0 – 2

*It was a particular case of spontaneous use of a rock, during a balier of soapy water and ash-soap experimental session. A subadult in a group of other 3 individuals, found a rock on the ground and anointed it throughout its tail using paws, nose and mouth. It lasted 1 min.

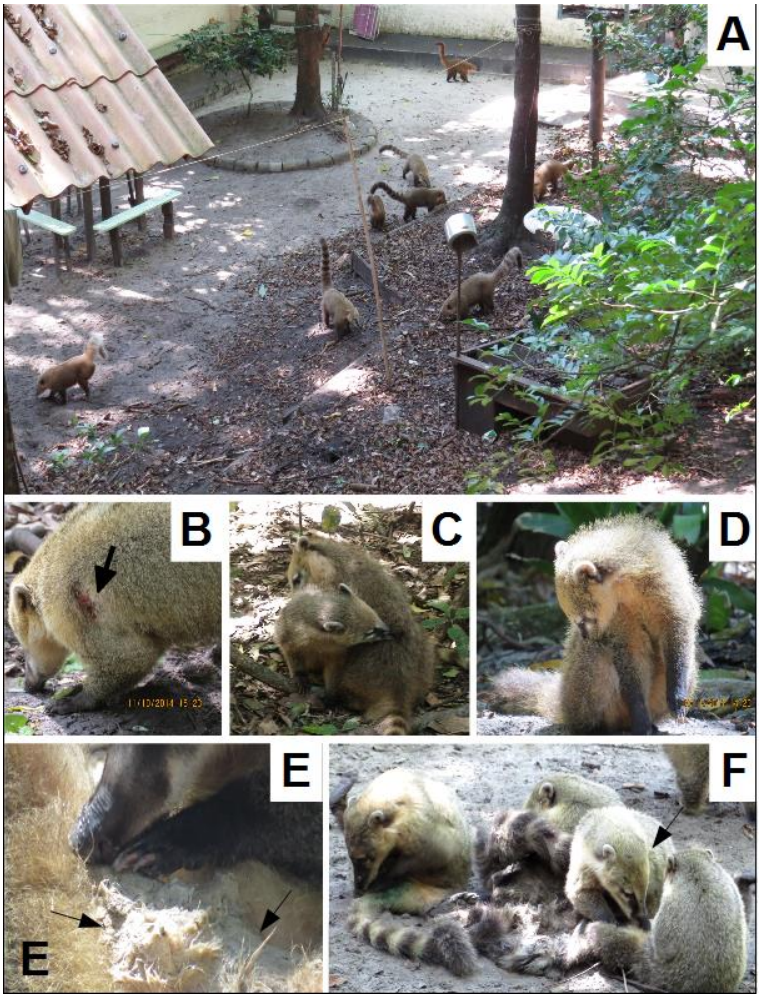

Figure 2. Nasua nasua on Ilha do Campeche (State of Santa Catarina, Brazil). A: group of ring-tailed coatis at the recreational area of *Enseada* Beach; B: an adult individual parasitized by ticks (arrow). From C to F, the behavioral categories of C: allogrooming; D: self-grooming; E: self-anointing, photo in close proximity showing the nose and paws of a ring-tailed coati rubbing his genital area plenty of suds (arrows); F: three self- and one allo-anointing behavior (the animal indicated by the arrow rubs the other that is self-anointing) in close social proximity. Photos by ADCG.

Anointing was usually performed by both paw and mouth/nose (sometimes it was possible to see the teeth rubbing the fur; see Figures 1B and 2E). It lasted from a few seconds to almost five minutes. It was performed by all age classes, but as the number of animals per class is not equal, this ratio was not possible to calculate. Whenever the subject's sex could be identified there was an equal number of males and females (10 females, 9 males) involved. The individual self-directed act commonly started with one or a few individuals approaching and sniffing the deposited items independently, coming from different directions, and taking a piece of soap, holding it between its paws, biting and even chewing on it for a few minutes without body contact. The mixture of chewed-up soap and saliva formed suds that were then applied to the body. The genital area (see Figure 2E) and tail were the most frequently rubbed parts, occurring in 39 and 31 events, respectively. It was applied less frequently to the inner legs and sides of the body (8 events). It is worth noting that the genitals were most commonly anointed by males whereas females mostly rubbed their tails. Ring-tailed coatis would leave the place where they found soap and move to another location, even jumping into the trees, continuing to self-anoint without taking more soap but using what was already on their fur. Animals that arrived latter would take foam

or suds from the body of a wet animal and pass it over their own body. Ring-tailed coatis were seen sharing soap. Soap defense occurred in just 3 out of the 116 total behavioral events, twice in induced sessions. In one of the spontaneous events, there were two animals, a sub-adult and an adult, that stared at each other, jumped and called in an agonistic manner while one had a piece of soap supposedly desired by the other. Carrying soap in the mouth and moving away from another individual was also interpreted as soap defense. Nevertheless, sharing soap was more frequent than fighting for it, although we could not completely quantify this.

Concerning the behavior's structure, special attention was given to other self-cleaning behaviors in order to distinguish them from anointing. We have identified and counted 21 grooming behaviors (see Figures 2C-D) performed by sub-adults and adults of both sexes, 16 of them in spontaneous events. During self-grooming (see Figure 2D), the individual nibbled and scratched some parts of its body alternating the paws and did so repeatedly for 5 to 53 s. This was usually focused on the same part of the body, mostly the tail, but also the genitals, nose, the side of the body and ears. There were also 10 allogrooming behaviors (see Figure 2C) and all except one was performed in the absence of any cleaning product and always directed from older animals to younger ones (i.e., a sub-adult grooming a juvenile or an adult grooming a sub-adult). Self-grooming was performed for longer durations than allogrooming and it was performed without vocalizing. During allogrooming, affiliative calls were emitted. Greeting calls preceded allogrooming, since this call is emitted when joining others in a group (Gasco & Monticelli, unpublished data).

Anointing behavior differed from grooming in several key ways that reflected both the substance used and the how the body area is covered by rubbing. Anointing is not just scratching the body in response to itch. The rubbed area in anointing is large in surface area: When it focused on the tail, animals usually rub soap all over the tail, anus and surroundings. If it is focused on the genitals, all of the under belly becomes soapy. Self-grooming is usually faster and directed to a focused part of the body, which does not require an external tool or substance. For instance, in one event a juvenile male rubbed suds along his abdomen, genitals, and tail (see Supplementary Material). Once his body was covered in suds and his fur was obviously wet, he bit off more of the soap that he was holding near him and repeated the process until the soap was completely used up. When he ran out of soap, he returned to the area where soap was deposited, picked up another piece, and repeated the process, anointing himself on other parts of his body. Similar behavioral sequences were performed by 10 other individuals and each lasted for almost 5 min. Only sub-adults exhibited allo-anointing, mostly on other animals of the same age but once towards a juvenile.

Discussion

Ring-tailed coatis living on Ilha do Campeche rubbed cleaning substances onto their fur, preferentially on the tail and genitals, using both paws and nose/mouth for longer periods of time and on a wider area of the body than when they groomed themselves. It was not specific to any age-sex class and may have a social component, as in primate anointing and allogrooming behaviors (e.g., Meunier et al., 2008). Members together in a social group were more prone than single individuals to visit the recreational area and self-anoint when cleaning or laundry products were available, suggesting social facilitation and a self-reinforcing mechanism that gives pleasure and strengthens important affiliative bonds. Self-anointing was much more common than allo-anointing, and the latter was performed more by older individuals onto younger ones. Sharing or fighting for scarce soap seemed to be related to social bonding and hierarchical relationships.

Self-medication and the topical application of products have already been described for many mammals including white-nosed coatis *Nasua narica* (for a general review see Engel, 2002; for primates, see Huffman, 2011, and for an extensive discussion about the evolutionary functionality of antibiotic chemicals in fruits eaten

by mammals, see Janzen, 1978). Free-ranging ring-tailed coatis and several primate species rub millipedes and other noxious arthropods substances over their bodies (Weldon, 2004; Weldon et al., 2006) and the expunged secretions obtained through prey-rolling repels mosquitoes and ticks (Carroll et al., 2005; Weldon, 2004). There are also reports of isolated cases of ring-tailed coatis anointing themselves with a non-identified substrate of an unknown arboreal species (W. U. Mesquita, personal communication, September 9, 2014) at *Parque das Mangabeiras* (State of Minas Gerais), using car grease (reported to us by a third person about D. S. Stein's observation, December 10, 2015) at *Parque da Serra dos Órgãos* (State of Rio de Janeiro), using putrid matter and ink at *Parque Ecológico do Tietê* (State of Sao Paulo; A. D. C. Gasco, personal observation, November 18, 2011). Gompper and Hoylman (1993) reported the use of tree resin from *Trattinnickia aspera* by white-nosed coatis at Barro Colorado Island in Panama. It is evident that anointing behavior is commonly displayed by *Nasua* spp. The resin of *T. aspera* and plant juices and insect secretions used for anointing by primates and white-nosed coatis, have been suggested to possibly deter ectoparasites. If animals do use them to benefit from their pharmaceutical properties, then probably this is a case of zoopharmacognosy (Rodriguez & Wrangham, 1993) or self-medication (animals may also medicate others, improving their own fitness, for example see Lefévre et al., 2010).

The novel finding of this report is the adoption of human cleaning products for anointing by ring-tailed coatis. As far as we know, after seven years of studying ring-tailed coatis at different sites across the country, it is a peculiarity of the Ilha do Campeche population that they are using cleaning products. Showing that the behavior involves the external application of chemical compounds is only one of the four conditions necessary to conclude definitively that such a behavior is an adaptive form of therapeutic medication (Huffman, 1997; 2011). We must still test if the behavior increases individual or inclusive fitness of an infected animal and if it is costly enough such that uninfected subjects do not display this behavior. Soap-anointing behavior may be relevant in the natural environment as these animals are infected by ticks (see Figure 2B) and could be susceptible to zoonoses (further studies are needed to confirm zoonotic risk). The close proximity to humans could lead to higher frequencies of soap-anointing behavior and the cleaning products adopted on Ilha do Campeche contain chemicals with known deterrent effects (benzoquinones). We hypothesize at the proximate level that some chemicals present in the soap may have a deterrent effect against ectoparasites (including microorganisms that become lodged in the fur). The literature is filled with examples of animals that rub substances from plants and insects onto their body, such as the benzoquinones of the millipedes with a demonstrated repellent effect toward ticks and mosquitoes (Caroll et al., 2005; Weldon, Aldrich, Klun, Oliver, & Debboun, 2003; Weldon et al., 2011). Conventional synthetic chemical products featuring bactericidal activity of disinfectants and chemical antiseptics are composed of quinones, derived from the oxidation of aromatic alcohols (phenols; Drebes, 2014). One of the major groups of quinones is the benzoquinones (Drebes, 2014), with toxicity that has the potential to offer protection against ticks afforded by anointing with soap or disinfectant (Carroll et al., 2005). It is not possible to infer nutritional gain as neither the soap or other items used in fur rubbing where frequently eaten (there was just two events of eating soap). Huffman (1997) points out alternative medicinal functions of fur rubbing with insects such as topical skin treatment for fungal and bacterial infections. The most anointed body parts of ring-tailed coatis from Ilha do Campeche were the tail and genitals, moist and warm areas that are ideal for bacteria and fungi development. We propose that soap-anointing helps in preventing both micro-organism infection and in repelling ticks. Additionally, there may also been a soothing effect from the soaps which could alleviate irritation caused by any of these infections.

How did this behavior emerge in the population? It may have been brought about by the opportunities provided by close interactions with humans and the ring-tailed coatis' behavioral plasticity and motivation to explore novel situations. Human-introduced substances (e.g., tobacco, eau de cologne, pepper, laundry soap, ammonia, oil of lavender, orange juice, onions) have been used by free-ranging capuchins living in natural environments highly frequented by humans and in captivity (Alfaro et al., 2012). Coatis all over the Americas often interact with human beings, who become a source of easily-collected food. On Ilha do Campeche, ring-

tailed coatis are clearly accustomed to residents and tourists: they visit the area around restaurants and respond to a person with their hand on their pocket by standing up in front of the person in anticipation of receiving food. The development of such behaviors could be a combination of both innate behavioral propensities and an innovated use acquired through social learning (Huffman, 1997; Huffman and Hirata, 2004; Huffman, Spiezio, Sgaravatti & Leca, 2010). Becoming accustomed to humans and the soap left by tourists creates the circumstances allowing for the selection and use of such substances with medicinal properties for the prevention or treatment of disease (Huffman, 1997; Huffman & Hirata, 2004; Huffman et al., 2010). The learning component may be in the observation and imitation of others (socially-mediated observational learning). In such a social and long-lived species, this learning may easily be transmitted across generations (Lefebvre, 2013). In the artificial conditions created by humans, ring-tailed coatis have been spontaneously anointing themselves with soap and disinfectant for almost a decade now, which is consistent with our hypothesis that social learning and cross-generational transmission of this behavior is taking place.

Ring-tailed coatis are comparable to capuchins (Alfaro et al., 2012) with respect to their cooperative sociality, long life-span, and behavioral plasticity (Romero & Aureli, 2008). All of these aspects should favor cultural transmission (Arsznov & Sakai, 2013; Kawai, 1965; MacLean et al., 2012; Romero & Aureli, 2008; Van Schaik et al., 2003). For years, the literature has focused on primate abilities and the Procyonidae family may be a good outlying group for comparison with primates in social aspects of behavior (Romero & Aureli, 2008), offering insights about the selective pressures for such complex and plastic behaviors as those involved in self-medication.

Sometimes, pieces of soap were shared, leading to social anointing or anointing in close proximity with others. However, as in foraging, competition can also occur when the resource is scarce. Occasionally the owner of a piece of soap threatened and in some instances physically attacked another individual that tried to take a piece of the soap from it. We found that support in aggressive conflicts is a common feature in ring-tailed coatis and that this behavior is reciprocally exchanged in a manner similar to primates (Hirsch, Stanton & Maldonado, 2012). Given that reciprocity correlations persisted after controlling for the effect of spatial association and subunit membership, some level of scorekeeping may be involved. It may have been that the scenarios produced improved other cognitive abilities, since a juvenile was seen opening a bottle of degreasing agent it first dropped to the ground. After opening the contents of the bottle onto the wet floor, the juvenile produced a foam that was then rubbed against its body.

This unique form of self-anointing behavior may disappear if this population of ring-tailed coatis is removed from the island. The ring-tailed coatis were first introduced to Ilha do Campeche for hunting activities. Over the last decade, they have been subjected to removal or neutering, as part of the island's management plans. This conflict between humans and other animals as abundant as ring-tailed coatis and capuchins occurs when they are labeled as pests, even where they are native to the habitat (Alfaro, Izar, & Ferreira, 2014). Labeling them as a pest ignores the real problems behind the conflict, which is the mismanagement of organic waste and the habit of tourists to provide food, which encourages coatis to approach human facilities and interact with people and their refuse. There is much to do before the Ilha do Campeche coati population should be removed. The studies on African great apes that provided supportive evidence for the hypotheses of self-medication as a behavioral adaptation for the control of parasites documented the response of individuals to parasite infection. In the case of ring-tailed coatis, systematic, seasonal monitoring of individuals behavior in response to fluctuating levels of external parasite infection (i.e., grooming or anointing behavior) is needed. This should include detailed analysis of activity budgets and systematic inspection and recording of health in order to identify the type and severity of illness experienced as well as the effectiveness of self-anointing for the removal or control of these external parasites or other possible diseases potentially being treated by this behavior (Huffman, 1997). This effort requires a multi-disciplinary approach to fully understand the implications of this proposed self-medication behavior by ring-tailed coatis using human cleaning products.

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Supplementary Material

Please see 8 min 9 s video of selected anointing behaviors with soap of several ring-tailed coatis *Nasua nasua* on Ilha do Campeche (Brazil) in YouTube or check the supporting material.

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