Food Webs 36 (2023) e00291

Contents lists available at ScienceDirect

Food Webs

journal homepage: www.elsevier.com/locate/fooweb

Sloths strike back: Predation attempt by an ocelot (*Leopardus pardalis*) on a Linnaeus's two-toed sloth (*Choloepus didactylus*) at a mineral lick in Western Amazonia, Ecuador

María Camila Bastidas-Domínguez [a,b,*], Andrés Link [a,b,d], Anthony Di Fiore [c,d], Diego Mosquera [e]

[a] *Fundación Proyecto Primates, Bogotá D.C., Colombia*
[b] *Department of Biological Sciences, Universidad de los Andes, Bogotá D.C., Colombia*
[c] *Department of Anthropology, University of Texas, Austin, TX, United States*
[d] *Tiputini Biodiversity Station, College of Biological and Environmental Sciences, Universidad San Francisco de Quito - USFQ, Quito, Ecuador*
[e] *Tandayapa Cloud-Forest Station, College of Biological and Environmental Sciences, Universidad San Francisco de Quito - USFQ, Quito, Ecuador*

ARTICLE INFO

Keywords:
Ocelot
Predation
Mineral lick
Sloth
Behavior
Amazonia

ABSTRACT

Two-toed sloths (genus *Choloepus)* are almost exclusively arboreal. However, they often descend to the ground in places known as mineral licks or "saladeros" and feed from soil, which presumably enhances their digestion of toxins and helps them obtain minerals not readily available in their diet. Mineral licks are risky areas which may increase their visitors' vulnerability to predators. Here, we report a predation attempt on an adult Linnaeus two-toed sloth (*Choloepus didactylus*) by an adult ocelot (*Leopardus pardalis*) at a mineral lick at the Tiputini Biodiversity Station in the Ecuadorian Amazon. Predation events are rarely recorded in camera traps, and this particular predation event can be considered unusual, given that sloths usually come down to mineral licks during the night. Also, it is not clear how ocelots are able to capture sloths, and other arboreal animals and this record evidence that predation of arboreal vertebrates by ocelots may also take place in the ground. Finally, the anti-predatory behavior displayed by the two-toed sloth demonstrates that there are intrinsic risks for predators while attempting to capture prey.

Mineral licks or "saladeros" are specific areas within forests – and other ecosystems – where several species of mammals and birds frequently feed on soil directly from the ground (Griffiths et al., 2020; Matsubayashi et al., 2007). In the lowland forests of Western Amazonia, mineral licks are often found on the forest floor, in caves, and on the side of exposed dirt walls in river banks (Lee et al., 2010; Mosquera et al., 2019). Most animals visiting mineral licks have a plant-based diet, and geophagy has been proposed to be a nutritional strategy that provides animals with access to minerals that are relatively scarce in other components of the diet (Kreulen, 1985). Several studies have documented the temporal patterns of mineral lick visitation by forest mammals (Blake et al., 2013; Montenegro, 2004) and a few of them have highlighted behavioral responses of animals to a higher perception of predation risk at mineral licks (Brightsmith, 2004; Link and Di Fiore, 2013).

Predation is one of the most influential ecological interactions shaping both the behavioral ecology and evolution of both predators and prey. In Amazonia, many species visit mineral licks frequently (Blake et al., 2013; Griffiths et al., 2021; Macas-Pogo and Sánchez, 2021). Large species such as the lowland tapir (*Tapirus terrestris*) and the white-lipped peccary (*Tayassu pecari*) can travel large distances to visit mineral licks (Tobler, 2008), making them ideal hunting areas for human and non-human predators. In fact, some studies have estimated that almost a third of all prey (using biomass as a proxy) captured by local human communities takes place at mineral licks (Mayor et al., 2017; Montenegro, 2004).

For arboreal mammals and birds, mineral licks can represent areas of relatively high predation risk from terrestrial predators, as they are some of the only sites where these animals come down to the forest floor (e.g., howler monkeys and spider monkeys: Link et al., 2011; porcupines: Griffiths et al., 2020; sloths: Mosquera et al., 2019). There is ample evidence suggesting that mineral licks may be visited by large and medium-sized felids presumably in search of prey (Matsuda and Izawa, 2008; Montenegro, 2004). For example, in Macarena-Tinigua National

* Corresponding author at: Fundación Proyecto Primates, Bogotá D.C., Colombia.
E-mail address: m.bastidasd@uniandes.edu.co (M.C. Bastidas-Domínguez).

https://doi.org/10.1016/j.fooweb.2023.e00291
Received 14 December 2022; Received in revised form 14 April 2023; Accepted 27 May 2023
Available online 24 June 2023
2352-2496/

Park, Colombia, a jaguar (*Panthera onca*) was observed to prey on a spider monkey on the forest floor, and a puma was observed attempting to prey on a spider monkey at a mineral lick (Matsuda and Izawa, 2008). A recent study also documented – with the aid of camera traps – the predation of a porcupine (*Coendou prehensilis*) at a mineral lick in Maijuna-Kichwa Regional Conservation Area, Peru (Griffiths et al., 2020), and at Tiputini Biodiversity Station one of us directly observed the predation of a deer (*Mazama americana*) by a puma (*Puma concolor*) at a mineral lick (Mosquera, 2011, personal observation).

Here, we describe an attempt of predation event by an adult ocelot (*Leopardus pardalis*) on an adult Linnaeus's two-toed sloth (*Choloepus didactylus*) captured by a camera trap placed at a mineral lick at the Tiputini Biodiversity Station research site, which is located in the Provincia de Orellana within the Yasuní Biosphere Reserve in eastern Ecuador (76° 08.992 W, 00° 38.221 S,). The station is adjacent to Yasuní National Park, a ~ 982,000 ha protected area in the Ecuadorian Amazon comprising relatively undisturbed tropical rainforests that includes regions of both terra firme and seasonally flooded forest (Bass et al., 2010).

Ocelots are opportunistic hunters and are highly carnivorous, feeding on a wide variety of animals such as small and medium-sized mammals, iguanas, snakes, turtles, frogs, crabs, beetles, and birds (Nowell and Jackson, 1996). They are predominantly solitary and nocturnal but can be active at any time of day (Dillon, 2005). While mainly terrestrial, they are also very good climbers (Tirira, 2007). A large proportion of their diet consists of prey weighing <1 kg, but they also feed on larger mammals such as agoutis, capybaras, monkeys, deer, collared peccaries, and sloths (Griffiths et al., 2020; Moreno et al., 2006; Murray and Gardner, 1997; Wang, 2002).

Linnaeus's two-toed sloth (*Choloepus didactylus*) is a medium-sized, arboreal, herbivorous mammal with mainly nocturnal habits (Stewart et al., 2022). It feeds on a wide variety of leaves in the canopy, where it prefers to forage in high areas between 24 and 30 m (Tirira, 2007). Very few studies on the natural history of sloths are available (e.g., Plese et al., 2016), and information on their biology, activity patterns, and behavior is still scant (Chiarello, 2008; Mosquera et al., 2019; Peery and Pauli, 2012). However, previous studies have shown that two-toed sloths exhibit temporal variation in their visits to mineral licks, over both hourly and monthly scales (Mosquera et al., 2019).

On 2022-08-29, a series of three 20 s videos of an attempted predation on a two-toed sloth by an ocelot were captured during a long-

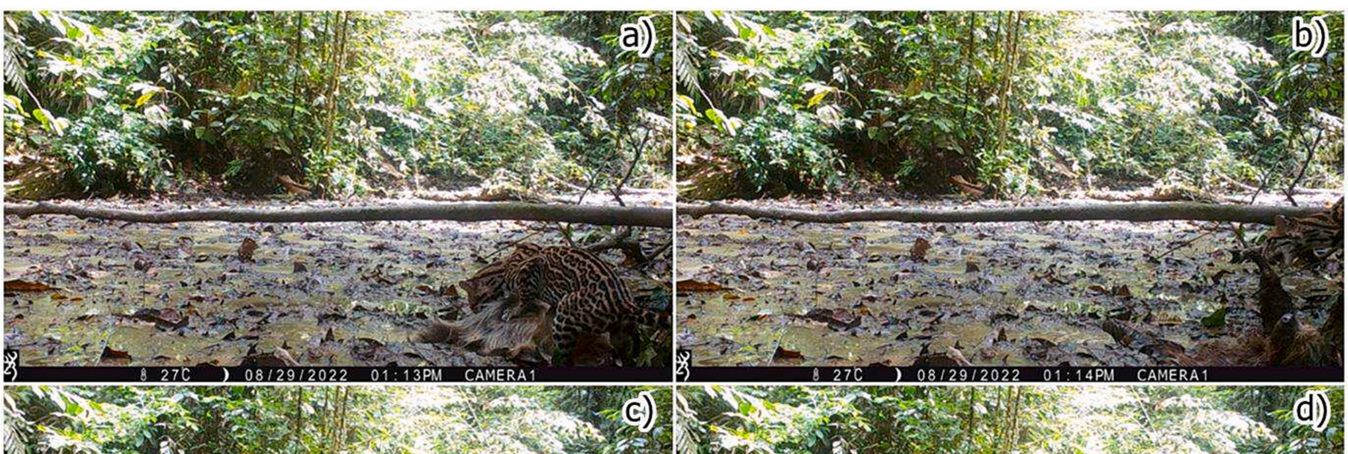

Fig. 1. a-b) An adult ocelot (*Leopardus pardalis*) is observed pouncing on an adult two-toed sloth (*Choloepus didactylus*) on the ground of the mineral lick and attempting to bite the sloth's neck and claws. c-d) The sloth hangs below a small fallen tree that crosses the mineral lick, defends itself from the ocelot's attacks, and moves quickly. e-f) The ocelot crosses the log in the opposite direction and then waits for the sloth, which also moves in the same direction.

term video-trapping survey of spider monkey demography and mineral lick visitation patterns. We had installed a Browning BTC-5HDX camera trap in a large mineral lick aimed at a specific location where spider monkeys frequently come down to the ground to either cross the lick or feed on soils. The three videos, filmed over a total of ~4 min, show several biting attempts by the ocelot and the sloth fiercely defending itself. After the third video we could not determine if the predation attempt was successful, or if the sloth escaped. However, on 2022-08-31, two days after the predation attempt, we went back to the area to search for possible evidence of a successful predation attack (e.g., bones, hair) in an area of approximately 200 m around to where the attack took place, but no remains were found.

The first video (13:13) (Fig. 1 a-b) starts with the two-toed sloth lying on the muddy floor of the mineral lick. Soon thereafter, an ocelot appears in the frame and jumps on its back trying to bite its neck. The sloth defends itself by twisting its body and turning down-side up and aiming to trap the ocelot with its claws. The ocelot tries to bite the sloth in the neck and is rebuffed by a sudden move of the sloths' arms. The ocelot then makes several attempts to bite the sloth's hands, while the sloth swings its arms defending itself. The second video (13:15) (Fig. 1 c-d) shows the sloth trying to escape at a considerably high speed (for a sloth) by inverted quadrupedal locomotion along a horizontal fallen tree lying across the mineral lick at a height of ~30 cm above the ground. The ocelot tries to bite the sloth's hands and slowly follows it on top of the branch. The third video (13:16) (Fig. 1 e-f) shows the sloth now moving in the opposite direction under the same fallen tree, while the ocelot is waiting on top, until it disappears from the frame.

The predation attempt documented in this study is extremely unusual, given the limited number of records of two-toed sloths (*Choloepus didactylus*) visiting mineral licks. For instance, Blake et al. (2011) reported only one visit in four mineral licks assessed in the same area over almost 4000 trap/nights. It is worth noting that sloths are mostly spotted in mineral licks at night, as stated by Mosquera et al. (2019) in a previous study conducted in the same area. In that study, 45 independent events of sloths visiting a mineral lick located on a vertical bank near the river were recorded during one year. Sloths visited the lick between 19:00 and 03:30, with a single daytime observation recorded at 06:00, when it was still relatively dark. In addition, peak activity was recorded at 22: 00. In a larger study, Stewart et al. (2022) found a higher overall frequency of visits by two-toed sloths at one mineral lick that accounted for 89.6% of *Choloepus* records among 53 mineral licks surveyed. In that study, activity patterns were similar: without activity occurring during daylight hours and activity peaking at 22:00. Interestingly, although similar mineral licks are present along other small drainages at TBS, sloths have rarely been recorded at such licks (Blake et al., 2011).

Finally, although ocelots are quite abundant in the area, records of them visiting the core area of mineral licks are scarce. For example, Blake et al. (2011) recorded a visitation rate by ocelots of only 0.002 photographs/trap nights at the same mineral lick during a large sampling effort of 1006 trap/nights. The fact that two species that usually require very high camera trap sampling efforts to be recorded at mineral licks were detected by our camera at the same time and during the day is unusual. Mineral licks are characterized for retaining water even in times of severe droughts (dry season between mid-November through late February) and therefore activity in such places increases when there is lack of rain for several days or weeks (Mosquera, 2011, personal observation).

Although most prey included in ocelot's diet are relatively small (>0.1 kg), it is well known they can also prey on medium-sized (0.1–1.0 kg) and even larger prey (Abreu et al., 2008 and references therein). Records of predation of ocelots on animals as large as deer remain to be validated as they may feed from carcasses killed by larger predators or that died independent of the interaction with ocelots. Nonetheless, ocelots are known to prey on many rodents and marsupials, armadillos, birds and reptiles (Abreu et al., 2008; Chinchilla, 1997; Emmons, 1988; Wang, 2002). Although many studies have suggested ocelots are mostly terrestrial predators (Emmons, 1988), a number of other studies do record arboreal mammals, birds, and reptiles in their diet, suggesting that ocelots are occasionally able to successfully capture arboreal prey. For example, other studies have recorded evidence of large arboreal mammals in their diets, including howler monkeys (*Alouatta*: Ximenez, 1982; Bianchi and Mendes, 2007), capuchins (*Cebus apella*: Bianchi and Mendes, 2007; Miranda et al., 2005), anteaters (*Tamandua mexicana*: Konecny, 1989), and three-toed sloths (*Bradypus variegatus*: Wang, 2002). The hunting strategies of ocelots that allow them to capture arboreal animals might include their ability to climb and hunt in the canopy or to opportunistically capture prey when they descend to the ground, e.g., when they visit mineral licks. In fact, a recent study recorded an ocelot preying upon an arboreal porcupine in a mineral lick in Peru (Griffiths et al., 2020).

The dietary presence of sloths in the American tropics has been extensively documented, with the three-toed sloth being consumed in larger proportion than the two-toed sloth in Panama, as reported by Moreno et al. (2006) (18.5% and 1.4%, respectively). Records from Brazil have also confirmed consumption of three-toed sloths but not of their two-toed counterparts (Wang, 2002). Previous studies, such as that of Voirin et al. (2009), have suggested that three-toed sloths are more vulnerable to predation due to their lower metabolism and are preyed upon by a wider range of predators. Nevertheless, as this event clearly shows, predation is not necessarily easy for the predator despite the slow movements and metabolism of sloths. These opportunistic recordings of a predation attempt by an ocelot on a two-toed sloth at a mineral lick provided further evidence of the relatively high predation risk that these frequently visited resources may pose for the animals that visit them.

Declaration of Competing Interest

None.

Acknowledgments

We would like to thank the staff at Tiputini Biodiversity Station and also Javier Portilla Chalparizan, whose support in the field was key to obtaining this record.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fooweb.2023.e00291.

References

Abreu, K.C., Moro-Rios, R.F., Silva-Pereira, J.E., Miranda, J.M.D., Jablonski, E.F., Passos, F.C., 2008. Feeding habits of ocelot (*Leopardus pardalis*) in Southern Brazil. Mamm. Biol. 73 (5), 407–411. https://doi.org/10.1016/j.mambio.2007.07.004.

Bass, M.S., Finer, M., Jenkins, C.N., Kreft, H., Cisneros-Heredia, D.F., McCracken, S.F., Pitman, N.C.A., English, P.H., Swing, K., Villa, G., Di Fiore, A., Voigt, C.C., Kunz, T. H., 2010. Global conservation significance of Ecuador's Yasuní National Park. PLoS One 5 (1). https://doi.org/10.1371/journal.pone.0008767.

Bianchi, R.D.C., Mendes, S.L., 2007. Ocelot (*Leopardus pardalis*) predation on primates in Caratinga Biological Station, Southeast Brazil. Am. J. Primatol. 69 (10), 1173–1178. https://doi.org/10.1002/AJP.20415.

Blake, John G., Mosquera, D., Guerra, J., Loiselle, B.A., Romo, D., Swing, K., 2011. Mineral licks as diversity hotspots in lowland forest of eastern Ecuador. Diversity 3 (2), 217–234. https://doi.org/10.3390/D3020217.

Blake, J.G., Mosquera, D., Salvador, J., 2013. Use of mineral licks by mammals and birds in hunted and non-hunted areas of Yasuní National Park, Ecuador. Anim. Conserv. 16 (4), 430–437. https://doi.org/10.1111/acv.12012.

Brightsmith, D.J., 2004. Effects of weather on parrot geophagy in Tambopata, Peru. Wilson Bull. 116 (2), 134–145. https://agris.fao.org/agris-search/search.do?recordID=US201600047140.

Chiarello, A.G., 2008. Sloth ecology: An overview of field studies. In: Vizcaino, S.F., Loughry, W. (Eds.), The Biology of the Xenarthra. University Press of Florida. https://www.researchgate.net/publication/313343711_Sloth_Ecology_an_overview_of_field_studies.

Chinchilla, F.A., 1997. La dieta del jaguar (*Panthera onca*), el puma (*Felis concolor*) y el manigordo (*Felis pardalis*) (Carnivora: Felidae) en el Parque Nacional Corcovado, Costa Rica. Rev. Biol. Trop. 45 (3), 1223–1229. https://revistas.ucr.ac.cr/index.php/rbt/article/view/21416.

Dillon, A., 2005. Ocelot Density and Home Range in Belize, Central America: Camera-Trapping and Radio Telemetry. MSc. Dissertation. Virginia Polytechnic Institute and State University.

Emmons, L.H., 1988. A field study of ocelots (*Felis pardalis*) in Peru. Rev. Ecol. (Terre Vie) 43, 133–157.

Griffiths, B.M., Gilmore, M.P., Bowler, M., 2020. Predation of a Brazilian porcupine (*Coendou prehensilis*) by an ocelot (*Leopardus pardalis*) at a mineral lick in the Peruvian Amazon. Food Webs 24. https://doi.org/10.1016/j.fooweb.2020.e00148.

Griffiths, B.M., Cooper, W.J., Bowler, M., Gilmore, M.P., Luther, D., 2021. Dissimilarities in species assemblages among Amazonian mineral licks. Biotropica 53 (5), 1255–1260. https://doi.org/10.1111/BTP.13012.

Konecny, M.J., 1989. Movement patterns and food habits of four sympatric carnivore species in Belize, Central America. Adv. Neotrop. Mammal. 243–264.

Kreulen, D.A., 1985. Lick use by large herbivores: a review of benefits and banes of soil consumption. Mammal Rev 15 (3).

Lee, A.T.K., Kumar, S., Brightsmith, D.J., Marsden, S.J., 2010. Parrot claylick distribution in South America: Do patterns of "Where" help answer the question "Why"? Ecography 33 (3), 503–513. https://doi.org/10.1111/j.1600-0587.2009.05878.x.

Link, A., Di Fiore, A., 2013. Effects of predation risk on the grouping patterns of white-bellied spider monkeys (*Ateles belzebuth belzebuth*) in Western Amazonia. Am. J. Phys. Anthropol. 150 (4), 579–590. https://doi.org/10.1002/ajpa.22230.

Link, A., Galvis, N., Fleming, E., Di Fiore, A., 2011. Patterns of mineral lick visitation by spider monkeys and howler monkeys in Amazonia: are licks perceived as risky areas? Am. J. Primatol. 73 (4), 386–396. https://doi.org/10.1002/ajp.20910.

Macas-Pogo, P., Sánchez, M.C.O., 2021. Use of mineral licks by mammals in areas of the Amazonia with no hunting pressure. Therya 12 (3), 599–607. https://doi.org/10.12933/THERYA-21-1086.

Matsubayashi, H., Lagan, P., Majalap, N., Tangah, J., Sukor, J.R.A., Kitayama, K., 2007. Importance of natural licks for the mammals in Bornean inland tropical rain forests. Ecol. Res. 22 (5), 742–748. https://doi.org/10.1007/s11284-006-0313-4.

Matsuda, I., Izawa, K., 2008. Predation of wild spider monkeys at La Macarena. Colombia. *Primates* 49 (1), 65–68. https://doi.org/10.1007/s10329-007-0042-5.

Mayor, P., El Bizri, H., Bodmer, R.E., Bowler, M., 2017. Assessment of mammal reproduction for hunting sustainability through community-based sampling of species in the wild. Conserv. Biol. 31 (4), 912–923. https://doi.org/10.1111/COBI.12870.

Miranda, J.M.D., Bernardi, I.P., Abreu, K.C., Passos, F.C., 2005. Predation on *Alouatta Guariba* clamitans Cabrera (Primates, Atelidae) by *Leopardus pardalis* (Linnaeus) (Carnivora, Felidae). Revista Brasileira de Zoologia 22 (3), 793–795. https://doi.org/10.1590/S0101-81752005000300043.

Montenegro, O.L., 2004. Natural Licks as Keystone Resources for Wildlife and People in Amazonia. University of Florida.

Moreno, R.S., Kays, R.W., Samudio, R., 2006. Competitive release in diets of ocelot (*Leopardus pardalis*) and puma (*puma concolor*) after jaguar (*Panthera onca*) decline. In *source*. J. Mammal. 87 (4).

Mosquera, D., 2011. Estimación de densidades de ocelotes (*Leopardus pardalis*) en la Amazonía ecuatoriana a través de análisis captura-recaptura, trampas cámara y Sistemas de Información Geográfica. MSc. Dissertation. Universidad San Francisco de Quito.

Mosquera, D., Vinueza-Hidalgo, G., Blake, J.G., 2019. Patterns of mineral lick visitation by Linnaeus's two-toed sloth *Choloepus didactylus* (Pilosa, Megalonychidae) in eastern Ecuador. Notas Sobre Mamíferos Sudamericanos 1 (1), 001–011. https://doi.org/10.31687/SAREMNMS.19.0.07.

Murray, J.L., Gardner, G., 1997. *Leopardus pardalis*. Mammalian Species, 548, pp. 1–10. http://www.bio-nica.info/Mammalia/Leopardus_pardalis.pdf.

Nowell, K., Jackson, P., 1996. In: Nowell, K., Jackson, P. (Eds.), Wild Cats' Status Survey and Conservation Action Plan. International Union for Conservation of Nature and Natural Resources IUCN. https://portals.iucn.org/library/sites/library/files/documents/1996-008.pdf.

Peery, M.Z., Pauli, J.N., 2012. The mating system of a "lazy" mammal, Hoffmann's two-toed sloth. Anim. Behav. 84 (3), 555–562. https://doi.org/10.1016/J.ANBEHAV.2012.06.007.

Plese, T., Reyes-Amaya, N., Castro-Vásquez, L., Giraldo, S., Feliciano, O., 2016. Distribution and current state of knowledge of Hoffmann's two-toed sloth (*Choloepus hoffmanni*) in Colombia, with comments on the variations of its external morphological traits. Therya 7 (3), 407–431. https://doi.org/10.12933/THERYA-16-412.

Stewart, H.D., Tighe, E., Griffiths, B.M., 2022. Patterns of visitation of the Linnaeus's two-toed sloth (*Choloepus didactylus*) at Amazonian mineral licks. Eur. J. Wildl. Res. 68 (2) https://doi.org/10.1007/s10344-022-01573-y.

Tirira, D., 2007. Mamíferos del Ecuador - Guía de Campo, 576.

Tobler, M.W., 2008. The Ecology of the Lowland Tapir in Madre de Dios. Using new Technologies to Study Large Rainforest Mammals, Peru. https://www.researchgate.net/publication/41015431.

Voirin, J.B., Kays, R., Lowman, M.D., Wikelski, M., 2009. Evidence for three-toed sloth (Bradypus variegatus) predation by spectacled owl (Pulsatrix perspicillata). Edentata 2009 (10), 15–20.

Wang, E., 2002. Diets of ocelots (*Leopardus pardalis*), margays (*L. wiedii*), and oncillas (*L. tigrinus*) in the Atlantic rainforest in Southeast Brazil. Stud. Neotropical Fauna Environ. 37 (3), 207–212. https://doi.org/10.1076/snfe.37.3.207.8564.

Ximenez, A., 1982. Notas sobre félidos neotropicales VIII. Observaciones sobre el contenido estomacal y el comportamiento alimentar de diversas especies de felinos. *Revista Nordestina de.* Biologia 5 (1), 89–91.