

New record in the diet of *Philander andersoni*

Nuevo registro en la dieta de *Philander andersoni*

ALEJANDRA NIÑO-REYES^{1*}, BALTAZAR GONZÁLEZ³, ALEJANDRO NAVARRO-MORALES², ALBEIRO MORENO², ALEXANDER VELÁSQUEZ-VALENCIA², GOVER CAPERA⁴,
AND JUAN CAMILO CEPEDA-DUQUE⁵

¹Centro de Investigación Ambiental y de Estudios Socioeconómicos (AMAZONIAMBIENTAL), Gestión y Evaluación de Proyectos, Universidad de la Amazonia, CP. 180002, Florencia, Caquetá, Colombia. Email: alejandra.vtab@gmail.com (AN-R).

²Centro de Investigación de la Biodiversidad Andino Amazónica (INBIANAM), Universidad de la Amazonia, CP. 180002, Florencia, Caquetá, Colombia. Email: alejandronavarromorales@gmail.com (AN-M), amorenooliveros@gmail.com (AM), alexandervelasquezvalencia@gmail.com (AV-V).

³Centro de Investigaciones Esquel de Montaña y Estepa Patagónica (CIEMEP), CP. 9200, Esquel, Chubut, Argentina. Email: baltazargch@gmail.com (BG).

⁴Junta de acción comunal, Vereda Peregrinos, CP. 184018, Solano, Caquetá, Colombia.

⁵Grupo de investigación en Biología de la Conservación y Biotecnología de la Corporación, Universitaria de Santa Rosa de Cabal, CP. 661020, Risaralda, Colombia. Email: acinonyxjubatus96@gmail.com (JCC-D).

*Corresponding author

Marsupial species of the family Didelphidae comprise the most diverse extant group of Metatherians inhabiting South America and part of North America. This family comprises more than 95 species, among which the members of the subfamilies Didelphinae and Caluromyinae include the largest species (> 150 g). Although widely distributed, information about their feeding habits is relatively scarce, especially for species of the genus *Philander*. Here we present the first record and description of a predatory event on the Tropical Flat Snake (*Siphlophis compressus*) by the Anderson's Four-eyed Opossum (*Philander andersoni*) in the Amazonian region of Colombia. During the predation event, we made *ad libitum* observations for about 12 minutes, using a camera to record the feeding behavior of *P. andersoni*. The event was recorded on October 31, 2018. During a nocturnal survey, we observed one individual adult of *P. andersoni* while consuming a specimen of *S. compressus*. The marsupial bit and pulled the snake body with its premolar dentition and forelimbs respectively to consume the prey's soft parts. This record shows that although *S. compressus* exhibits several antipredator characteristics, such as an aposematic elapid-like colored pattern, elusive behavior and Durvenoy glands, *P. andersoni* was able to feed upon this species in a stereotyped way. To the best of our knowledge this is the first documented consumption event of this snake by a mammal species, yielding new information about the feeding habits of *P. andersoni* and the predators of *S. compressus*.

Key words: Amazonian region; behavior, Colombia; Didelphidae, diet, rainforest.

Las especies de marsupiales de la familia Didelphidae comprenden el grupo más diverso de marsupiales que habitan América del Sur y América del Norte. Esta familia está integrada por más de 95 especies entre las cuales, las pertenecientes a las subfamilias Didelphinae y Caluromyinae son las de mayor tamaño corporal (>150 g). A pesar de su amplia distribución, la información sobre sus hábitos alimenticios es escasa, especialmente para las especies pertenecientes al género *Philander*. Aquí presentamos el primer registro y descripción de un evento de depredación de *Philander andersoni* sobre la serpiente plana tropical *Siphlophis compressus*, en la región Amazónica de Colombia. Por medio de observación *ad libitum* describimos la conducta alimenticia de *P. andersoni* sobre un individuo de *S. compressus*. El evento se registró el 31 de octubre de 2018. Durante un transecto nocturno se observó un individuo adulto de *Philander andersoni* mientras consumía a un espécimen de *Siphlophis compressus*. El marsupial mordió y haló el cuerpo de la serpiente con ayuda de su dentición premolar y sus extremidades anteriores para extraer y consumir las partes blandas del cadáver. Este registro indica que a pesar de que *S. compressus* presenta una serie de mecanismos antidepredatorios, como el patrón aposemático de coloración semejante a los elápidos, las conductas evasivas y las glándulas de Durvenoy, *P. andersoni* tiene la capacidad de consumir a esta serpiente de forma estereotipada. Este es el primer evento de consumo de *S. compressus* por un mamífero y aporta nuevos detalles acerca de los hábitos alimenticios de *P. andersoni*.

Palabras clave: Colombia; comportamiento; Didelphidae; dieta; región Amazónica; selva.

© 2020 Asociación Mexicana de Mastozoología, www.mastozoologiamexicana.org

With slightly more than 100 species, the living South American marsupials (Marsupialia: Metatheria) are one of the most taxonomically and ecologically richest groups of mammals in the Neotropics (Goin *et al.* 2016). Among this group, the family Didelphidae comprises more than 95 species distributed in approximately 19 genera (Voss and Jansa 2009). Within the extant subfamilies, Caluromyinae and Didelphinae contain the largest members of the group (>

150 g), some of them with distinctive morphological traits, such as the presence of colored patches above the eyes, distinctive of the genera *Philander* and *Metachirus* (Voss and Jansa 2009).

Given the highly opportunistic feeding behavior of several species within the didelphid group, the inclusion of animal-related items in their diet is common (Vieira and Moraes 2003). For example, the species of the genus *Philander* are

occasional predators which consume a wide variety of arthropods and, to a lesser extent, vertebrates (Vieira and Moraes 2003; Cáceres 2004; Macedo et al. 2010; Voss et al. 2018).

The genus *Philander* includes eight cursorial or scansorial species with omnivorous habits, mostly inhabiting in primary and secondary rainforests (Voss et al. 2018). The distribution of *Philander* ranges from the Tamaulipas region in the northeastern portion of Mexico to the Atlantic rainforest of southern Brazil (Voss et al. 2018). Information about the natural history, ecology, and behavior of several species within the genus is still scarce (Vieira and Moraes 2003). Regarding their feeding habits, there is some information available about *P. frenatus* (Cáceres 2004) and *P. opossum* (Castro-Arellano et al. 2000; Gómez-Martínez et al. 2008), while for *P. andersoni*, information remains scarce.

Here we report the first documented event of predation and consumption on the Tropical Flat Snake (*S. compressus*) by *P. andersoni* in the Amazonian forests of Solano, Caquetá and discuss some issues related to *P. andersoni* and *S. compressus* in Colombia.

The predation event was recorded on the right margin of the Caquetá river near of vereda Peregrinos (00° 03' 48.8" S, 74° 34' 19.1" W), Solano municipality, at the limit between Putumayo and Caquetá department. The area has a mean elevation of 172 m, a mean annual temperature of 25°C, and a mean annual precipitation of 3,000 mm. The geography consists mainly of low fertility soils that are dry for part of the year but flood during rainy seasons (Cortes-Ávila and Toledo 2013). The vegetation displays features of a stationary flooded rainforest with a high degree of intervention due to logging activities, as well as crop and pasture production (Cortes-Ávila and Toledo 2013). On October 31st 2018, at 18:11h on a nocturnal expedition, both species were observed during an *ad libitum* mammal inventory developed as part of a larger project named "Community agrotourism for the enhancement of economic income, promotion of responsible and sustainable participatory initiatives in a territory with a zero-deforestation approach" in Solano, Caquetá, and was conducted by the University of Amazonia (Colombia).

Given that we were unable to collect the observed individual of *P. andersoni*, we identified the species based on its distribution (Astúa et al. 2016; Patton and da Silva 1997) and external morphology, following Hershkovitz (1997) and Voss et al. (2018). Accordingly, *P. andersoni* can be identified by the presence of a well-marked dorsal stripe and a creamy to creamy-gray colored venter, together with an Amazonian distribution. Regarding the snake identification, we were unable to measure and count the scales to identify the individual. Instead, we based the identification on the coloration and geographic distribution of the species, as described by Aponte-Gutiérrez and Vargas-Salinas (2018). At the moment both individuals were observed, we recorded a video and photos to describe the behavior of *P. andersoni*.

One adult of unknown sex of *P. andersoni* was recorded feeding on a *S. compressus* exhibiting a series of behaviors that we describe herein. At the moment of sighting, the marsupial was attacking the prey at ground level, using its snout and forelimbs to sense and grasp the snake. After being alerted by the investigator's presence, the marsupial took the prey (still alive) in his mouth and transported it to a less-open refuge for subsequent feeding (Figure 1a). After finding refuge, the opossum used repeatedly its snout and forelimbs to explore the long body of the snake, seemingly to locate the cloacal region (Figure 1b). At this time, the snake ceased to move, however the exact moment at which *P. andersoni* killed the snake could not be determined.

The carcass manipulation consisted of an iterated use of the opossum's mouth and forelimbs to identify potential tissues to consume. The opossum smelled the body, grasped the snake's scales with the premolar dentition while grabbing the prey with the forelimbs. During this exploratory phase, *P. andersoni* kept a semi-erect posture (although somewhat more horizontal than vertical), where the weight of the body rested mainly on its hindlimbs and vertebral column (Figure 1b). This phase lasted about 2 minutes, but during this time the opossum stopped several times to sniff the air, which could be caused by the investigator's presence (Figure 1a).

After locating the cloacal region, *P. andersoni* used its premolars and molars to perforate the body while holding the snake firmly with the forelimbs. Subsequently, the opossum used the tongue and incisors to extract the gonads from the carcass, holding the organs with its mouth. Then, by repetitive pulling movements with the head while pushing down the carcass with the forelimbs, *P. andersoni* separated the gonads and ingested them. Next, *P. andersoni* continued to consume the snake's guts in the same way described for the gonads. When necessary, *P. andersoni* also used its premolars and molars for cutting and separating parts of the carcass to ingest. When *P. andersoni* was chewing, it used its forelimbs to hold down the carcass and to lean on the ground at the same time, thus adopting a more quadrupedal position than when exploring the snake carcass (semi-erect position). At one point, *P. andersoni* used one forelimb to grasp the guts of the snake rather than to hold the carcass, as observed earlier. Chewing and consuming events were alternated with exploratory events, in which the opossum used its teeth and mouth rather than the forelimbs to manipulate the carcass. We did not register any grooming behavior during and before the feeding lapse, however our observation time was relatively short (approximately 12 minutes).

Here we presented the first record of *P. andersoni* preying on a *S. compressus* snake. Our report adds to the list of prey items reported for didelphids, and specifically, offers new insights about the diet and feeding behavior of *P. andersoni*.

Although this is a single observation, evidence from other related marsupials when feeding upon snakes (e.g., *Didelphis marsupialis*; Almeida-Santos et al. 2000, and *P.*

a)



b)



Figure 1. Photographs of an Anderson's Four-eyed Opossum (*Philander andersoni*) feeding on a Tropical Flat Snake (*Siphlophis compressus*) at vereda Peregrinos, Solano, Caquetá, Colombia on October 31, 2018, showing: a) alerted watching in-between episodes of feeding; b) manipulative posture and forelimb handling of the snake carcass. Photos by A. Moreno.

opossum; [Gómez-Martínez et al. 2008](#)) suggests that the predation behavior observed is stereotyped rather than random. For example, our observation of a non-attacking behavior by the snake while the opossum fed from the posterior end of it, was registered by [Almeida-Santos et al. \(2000\)](#) when a *Crotalus durissus* was offered to an individual of *D. marsupialis*. Besides, these authors registered that killing the snake by biting his head occurred only when the snake counter-attacked the opossum, which is consistent with our observation: *S. compressus* did not exhibit a defensive behavior towards the opossum while the predation event occurred, and *P. andersoni* did not directly bite or killed the snake by the head. This differs from the observations made by [Emmons 1990](#) of a *P. opossum* feeding upon a coral snake where decapitation of the snake was made, but presumably after the snake counter-attacked.

Regarding the carcass manipulation, *P. andersoni* displayed differences compared to other marsupials' behavior. For example, when feeding upon snakes, *D. marsupialis* sat entirely on its hindlimbs and, during the complete event, manipulated the prey with its forelimbs ([Almeida-Santos et al. 2000](#); see also [Streilein 1982](#)). Rather, we observed *P. andersoni* assuming a quadrupedal position when taking bites of flesh or guts (using its forelimbs for counter-

force) and when chewing (Appendix 1). However, when exploring the carcass, *P. andersoni* sat on its hindlimbs, like *D. marsupialis*. Similar but not identical manipulation behavior has been observed in other marsupials, including *Lestodelphys halli* ([Martin and Udrizar-Sauthier 2011](#)) and *Caenolestes fuliginosus* ([Martin and González-Chávez 2016](#)). In addition, consuming the posterior end of the snake first is consistent with previous evidence about the preference for soft tissues, such as the cloaca ([Almeida-Santos et al. 2000](#)) and the brain ([Martin and Udrizar-Sauthier 2011](#)), we did not record registered any grooming behavior, but it is usual for didelphids to display this type of behavior before and after the feeding ([Martin and Udrizar-Sauthier 2011](#)). Unfortunately, we were unable to record these phases. Future observations should clarify if *P. andersoni* displays stereotyped grooming behaviors as other didelphids.

Several non-venomous snake species display antipredator traits than can be morphological (e.g., aposematic coloration, removable tail), behavioral (e.g., tree-scape reaction, body contortion, raising, coiling into s-shape), and physiological (e.g., segregation of low-concentrated venom and highly repulsive substances; [Greene 1983](#); [De Oliveira et al. 2018](#)). For instance, *S. compressus* can produce and segregate a low-concentrated paralyzing venom with its opisthoglyphous dentition, together with a harassing substance secreted by the Durvenoy's and anal glands, and reddish and black body color pattern ([Solórzano 2004](#); [De Fraga et al. 2013](#)). Yet, as described here, *P. andersoni* was able to feed readily, seemingly unaffected by this type of antipredator traits, upon the snake.

In this sense, it has been established that the aposematic characteristics of these snakes are not usually effective to repel mammals capable of tolerating high concentrations of venom ([Voss and Jansa 2012](#)) or where predators are able to discriminate between lethal and non-lethal snake species ([Buasso et al. 2006](#); [França et al. 2016](#)). Furthermore, species of the genus *Philander* usually feed on carcasses ([Gómez-Martínez et al. 2008](#); [Macedo et al. 2010](#)), which can be related with the ability to tolerate decomposition smells and thus catch and consume preys capable of expelling repulsive substances. Consequently, this report is in some way circumscribed by previous knowledge (i.e., an opossum preying on a non-venomous yet aposematic snake). However, to the best of our knowledge, there is no published evidence of hunting and consumption on *S. compressus* by a Neotropical mammal ([Emmons 1990](#); [Martins et al. 2008](#)) and this report is the first filmed and published evidence of such event.

The lack of information about many Neotropical marsupials can be related to their elusiveness, nocturnal habits, and small size, compared to other mammals ([Voss et al. 2019](#)). This is the case for *P. andersoni* and many other species that although present in local assemblages, few studies exist about their biology. In this sense, information from unrelated projects (as the case of this note) can be useful for augmenting and improving our knowledge of these species and their importance in the areas they inhabit.

Acknowledgements

We wish to thank to the Andean-Amazonian Biodiversity Research Center (INBIANAM) of the Universidad de la Amazonia for the logistics provided during the research development, to Vision Amazonia and Patrimonio Natural for project funding, and the community of vereda Peregrinos for assisting the researchers. To G. Martin who made valuable comments about marsupial behavior on earlier drafts. During this work BGC received economical support of a doctoral grant by the CONICET (Argentina).

Literature cited

- ALMEIDA-SANTOS, S. M., M. M. ANTONIAZZI, O. A. SANTANNA, AND C. JARED.** 2000. Predation by the Opossum *Didelphis marsupialis* on the Rattlesnake *Crotalus durissus*. *Current Herpetology* 19:1-9.
- APONTE-GUTIÉRREZ, A., AND F. VARGAS-SALINAS.** 2018. Geographic distribution of the genus *Siphlophis* Fitzinger, 1843 (Colubridae, Dipsadinae, Serpentes) in Colombia. *Check List* 14:195.
- ASTÚA DE MORALES, D., R. PÉREZ-HERNÁNDEZ, AND L. P. COSTA.** 2016. *Philander andersoni*. The IUCN Red List of Threatened Species 2016: e.T40515A22177040. <http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T40515A22177040.en>. Downloaded on 20 July 2019.
- BUASSO, C. M., G. C. LEYNAUD, AND F. B. CRUZ.** 2006. Predation on snakes of Argentina: effects of coloration and ring pattern on coral and false coral snakes. *Studies on Neotropical Fauna and Environment* 41:183-188.
- CÁCERES, N. C.** 2004. Diet of three didelphid marsupials (Mammalia, Didelphimorphia) in southern Brazil. *Mammalian Biology* 69:430-433.
- CASTRO-ARELLANO, I., H. ZARZA, AND R. A. MEDELLÍN.** 2000. *Philander opossum*. *Mammalian Species* 368:1-8.
- CORTES-ÁVILA, L., AND J. J. TOLEDO.** 2013. Estudio de la diversidad de serpientes en áreas de bosque perturbado y pastizal en San Vicente del Caguán (Caquetá), Colombia. *Actualidades Biológicas* 35:185-197.
- DE FRAGA, R., A. P. LIMA, A. L. DA COSTA, AND W. MAGNUSSON.** 2013. Guide to the snakes of the Manaus Region-Central Amazonia. Instituto Nacional de Pesquisas da Amazônia Press. Manaus, Brazil.
- DE OLIVEIRA, P. V., A. W. DOS SANTOS, A. D. ABEGG, AND F. DE ALCANTARA MENEZES.** 2018. Repertoire of antipredator displays in *Siphlophis longicaudatus* (Serpentes: Dipsadidae). *Herpetology Notes* 11:157-160.
- EMMONS, L. H.** 1990. Neotropical Rainforest Mammals. The University of Chicago Press. Chicago, U.S.A.
- FRANÇA, F. G. R., E. D. S. BEZERRA, R. C. DE FRANÇA, AND I. M. M. DE CARVALHO PEDROSA.** 2016. Predation in different phenotypes of venomous snakes in Atlantic Forest of Paraíba, Northeast Brazil. *Revista Nordestina de Biología* 24:19-28.
- GOIN, F. J., M. O. WOODBURN, A. N. ZIMICZ, G. M. MARTIN, AND L. CHORNOGUBSKY.** 2016. South American Living Metatherians: Physiological Ecology and Constraints. In *A Brief History of South American Metatherians*. Pp. 37-75 in *Evolutionary Contexts and Intercontinental Dispersals* (Goin, F. J., M. O. Woodburne, A. M. Zimicz, G. M. Martin, and L. Chornogubsky, eds.). Springer. Dordrecht, Netherlands.
- GÓMEZ-MARTÍNEZ, M. J., A. GUTIERREZ, AND F. DECLERCK.** 2008. Four-eyed Opossum (*Philander opossum*) Predation on a Coral Snake (*Micrurus nigrocinctus*). *Mammalia* 72:350-351.
- GREENE, H.** 1983. Antipredator Mechanisms in Reptiles. Pp. 3-70 in *Biology of the Reptilia* (Gans, C., ed.). No. 16, Branta Books. The University of Michigan. Ann Arbor. Michigan, U.S.A.
- HERSHKOVITZ, P.** 1997. Composition of the family Didelphidae Gray, 1821 (Didelphoidea: Marsupialia), with a review of the morphology and behavior of the included four eyed opossums of the genus *Philander* Tiedemann, 1808. *Fieldiana Zoology* 86:1-103.
- MACEDO, L., F. A. FERNANDEZ, AND J. L. NESSIMIAN.** 2010. Feeding ecology of the marsupial *Philander frenatus* in a fragmented landscape in Southeastern Brazil. *Mammalian Biology* 4:363-369.
- MARTIN, G., AND D. UDRIZAR-SAUTHIER.** 2011. Observations on the captive behavior of the rare Patagonian opossum *Lestodelphys halli* (Thomas, 1921) (Marsupialia, Didelphimorphia, Didelphidae). *Mammalia* 75:568-575.
- MARTIN, G., AND B. GONZÁLEZ-CHÁVEZ.** 2016. Observations on the behavior of *Caenolestes fuliginosus* (Tomes, 1863) (Marsupialia, Paucituberculata, Caenolestidae) in captivity. *Journal of Mammalogy* 97:568-575.
- MARTINS, M., O. A. MARQUES, AND I. SAZIMA.** 2008. How to be arboreal and diurnal and still stay alive: microhabitat use, time of activity, and defense in Neotropical forest snakes. *South American Journal of Herpetology* 3:58-67.
- PATTON, J. L., AND M. N. F. DA SILVA.** 1997. Definition of species of pouched four-eyed opossums (Didelphidae, *Philander*). *Journal of Mammalogy* 78:90-102.
- SOLÓRZANO, A.** 2004. Serpientes de Costa Rica: distribución, taxonomía e historia natural. Snakes of Costa Rica: distribution, taxonomy, and natural history, first edition. Instituto Nacional de Biodiversidad Press. San José, Costa Rica.
- STREILEIN, K. E.** 1982. Behavior, ecology and distribution of South American marsupials. Pp. 231-250 in *Mammalian Biology in South America* (Mares, M. A., and H. H. Genoways, eds.). Special Publications No. 6, Pymatuning Laboratory of Ecology, University of Pittsburgh, Linesville. Pennsylvania, U.S.A.
- VIEIRA, E. M., AND D. A. DE MORAES.** 2003. Carnivory and insectivory in Neotropical marsupials. Pp. 271-284 in *Predators with pouches: the biology of carnivorous marsupials* (Jones, M., C. Dickman, and M. Archer, eds.). CIRSRO publishing. Collingwood, Australia.
- VOSS, R. S., AND S. A. JANSÁ.** 2009. Phylogenetic relationships and classification of didelphid marsupials, an extant radiation of New World metatherian mammals. *Bulletin of the American Museum of Natural History* 322:1-177.
- VOSS, R. S., AND S. A. JANSÁ.** 2012. Snake-venom resistance as a mammalian trophic adaptation: lessons from didelphid marsupials. *Biological Reviews* 87:822-837.
- VOSS, R. S., J. F. DÍAZ-NIETO, AND S. A. JANSÁ.** 2018. A revision of *Philander* (Marsupialia: Didelphidae), Part 1: *P. quica*, *P. canus*, and a new species from Amazonia. *American Museum Novitates* 3891:1-71.
- VOSS, R. S., D. W. FLECK, AND S. A. JANSÁ.** 2019. Mammalian diversity and Matses Ethnomammalogy in Amazonian Peru. Part 3: Marsupials (Didelphimorphia). *Bulletin of the American Museum of Natural History* 432:1-26.

Associated editor: Tamara M. Rioja

Submitted: December 18, 2019; Reviewed: March 20, 2020.

Accepted: March 27, 2020; Published on line: April 3, 2020.

Appendix 1

Video of an Anderson's Four-eyed Opossum (*Phylander andersoni*) feeding on a Tropical Flat Snake (*Siphlophis compressus*) at vereda Peregrinos, Solano, Caquetá, Colombia.

<https://drive.google.com/file/d/1lgJzwMIKvhMoGFfgV5unjfhfKShl8ern/view?usp=sharing>