
SHORT COMMUNICATION

Armadillo consumption by a tiger shark: an ethnozoological contribution

MÁRCIO LUIZ VARGAS BARBOSA-FILHO^A, ERALDO MEDEIROS COSTA-NETO^B, PAULO RIBEIRO^{A,1}, MARTÍN R. ALVAREZ^A AND RÔMULO ROMEU NÓBREGA ALVES^C

^APrograma de Pós Graduação em Zoologia, Universidade Estadual de Santa Cruz – UESC, Rodovia Ilhéus–Itabuna, Salobrinho, CEP 45662-900, Ilhéus, BA, Brazil

^BDepartamento de Ciências Biológicas, Universidade Estadual de Feira de Santana – UEFS, Av. Transnordestina, s/n, Novo Horizonte, CEP 44036-900, Feira de Santana, BA, Brazil

^CDepartamento de Biologia, Universidade Estadual da Paraíba, Avenida das Baraúnas, 351, Bodocongó, Campina Grande, CEP 58109-753, Paraíba, Brazil

¹ Corresponding author. E-mail: phpinheiro@yahoo.com.br

Abstract This work is a case report of the consumption of an armadillo (*Dasyplus novemcinctus*) by a tiger shark (*Galeocerdo cuvier*), which was reported by fishermen and confirmed by an image showing the armadillo in the digestive tract of the gutted shark. The shark was captured by fishermen in Pedras de Una, Bahia State, Brazil. Two hypotheses are suggested: (1) the armadillo was eaten while crossing an estuarine region, or (2) during a rainstorm the animal was washed into the sea and the shark consumed the carcass. This is the first scientific record of the consumption of an armadillo by a shark.

Keywords: *Dasyplus novemcinctus*, ecology, feeding habits, *Galeocerdo cuvier*

Consumo de tatu por tubarão tigre: uma contribuição da etnozoologia

Resumo Aqui apresentamos um relato de caso onde houve o consumo de tatu (*Dasyplus novemcinctus*) por um tubarão-tigre (*Galeocerdo cuvier*). O consumo foi relatado por pescadores e comprovado por fotos onde o tatu aparece no trato digestivo de um tubarão eviscerado. O tubarão foi capturado por pescadores em Pedras de Una, Bahia, Brasil. Duas hipóteses foram assumidas: a primeira, o tatu foi predado ao cruzar região estuarina e, na segunda, o animal foi arrastado pela chuva até o mar, onde o tubarão consumiu sua carcaça. Esta é a primeira vez que o consumo de tatu por tubarões foi registrado na ciência.

Palavras chave: *Dasyplus novemcinctus*, ecologia, *Galeocerdo cuvier*, hábitos alimentares

Armadillos are terrestrial mammals that belong to the order Cingulata. They exhibit a semifossorial habit and differ from other mammals because they have ossified dermal scutes (McBee & Baker, 1982). Among Cingulata, *Dasyplus* is the genus with the largest number of species (nine) (Feijó & Cordeiro-Estrela, 2016), and is represented

by armadillos with an elongated snout, long tail, and carapace formed by six to 11 movable bands (Wetzel *et al.*, 2008). Despite being exclusively terrestrial, species of *Dasyplus* are found near (Taulman & Robbins, 1996) and sometimes cross water courses.

Galeocerdo cuvier (order Carcharhiniformes) is one of the largest extant shark species. It exhibits a high growth rate and is widely distributed in

tropical and temperate regions worldwide (Meyer *et al.*, 2014). It is currently listed by the IUCN as Near Threatened (Simpfendorfer, 2009), and is well-known scientifically, including studies about feeding habits (Bornatowski *et al.*, 2007, 2012), habitat use (Heithaus *et al.*, 2002), movement patterns (Meyer *et al.*, 2009), behavior (Tricas *et al.*, 1981), and even interspecific interactions (Wirsing *et al.*, 2007; Fitzpatrick *et al.*, 2012). Tiger sharks prefer murky coastal waters, such as near beaches, coral areas, harbors, and estuaries (Heithaus *et al.*, 2007), primarily because most of their prey inhabit these environments. *Galeocerdo cuvier* is one of the most generalist predators among fish of tropical ecosystems (Gallagher *et al.*, 2011). In fact, its diet is the most varied diet among shark species (Lowe *et al.*, 1996), consisting of bony fish, marine reptiles, birds, turtles, marine and terrestrial mammals (including humans), invertebrates, carcasses, and a variety of anthropogenic “garbage” (Heithaus, 2001). Qualitative studies about the diet of *G. cuvier* have been conducted more frequently compared to all other shark species (Lowe *et al.*, 1996).

In Brazil, *G. cuvier* is most commonly found in the Northeast Region; however, it occurs throughout the coast of the country (Bornatowski *et al.*, 2012). In addition, *G. cuvier* is the shark with the greatest cultural importance among Bahian fishermen (Barbosa-Filho *et al.*, 2014) because it lives on the coast and often attacks humans (Caldicott *et al.*, 2001).

This paper describes an episode where a tiger shark was caught by artisanal fishermen and had an armadillo in its digestive tract, and also discusses

relevant ethnozoological studies that contain information about the ecology and biology of these species.

In 2012 semi-structured interviews were conducted (using a form about shark fishing) with 65 fishermen from the municipalities of Canavieiras, Una and Ilhéus, in southern Bahia State, Brazil. All the fishermen selected had more than 15 years of experience catching sharks, thus forming a native expert fishermen network (Marques, 2001). Among these individuals, eight (12.3%) (Barbosa-Filho & Costa-Neto, 2016) independently reported the episode related here, in which a shark was captured with an armadillo in its digestive tract (FIG. 1).

According to the fisherman that captured the shark, the event occurred in 2009 in the vicinity of the Pedras de Una community (Una municipality). The specimen was captured by a longline, which was installed about eight miles from the coast and 55 m deep. The shark was a male, about 3 m long, and weighed 252 kg (headless and gutted). Some of the fishermen on the boat noticed an unusual form in the stomach of the animal so the shark arrived at the port with its gut intact. The removal of the armadillo was witnessed by over 80 curious community dwellers who were at the landing. The armadillo was identified as an adult *Dasypus novemcinctus* because of its elongated rostrum shape, long tail and weight (>3 kg). The only other *Dasypus* species present in Bahia State is *D. septemcinctus*, which is considerably smaller than the individual described here.



FIGURE 1. Armadillo (*Dasypus novemcinctus*) found in *Galeocerdo cuvier* viscera in Pedras de Una in 2009. Photograph courtesy of a fisherman whose identity is not disclosed.

Armadillos are components of various animal diets, especially terrestrial mammals, such as felids (Moreno *et al.*, 2006; Foster *et al.*, 2010; Bianchi *et al.*, 2011), canids (Bueno *et al.*, 2002; Rocha *et al.*, 2004), and even semi-aquatic mammals, such as *Lontra longicaudis* (Quintela & Gatti, 2009). This is the first record of a *D. novemcinctus* being consumed by *G. cuvier*.

Among our expert fishermen network, four men said that they had seen armadillos swimming in areas of an estuary and the mouth of a river (*bocas de barra*), where they were crossing between riverbanks. One of them reported that he killed an armadillo with a paddle while the animal was swimming, and another reported that he caught an armadillo in a trammel net that was on the Pedra de Una River. The hypothesis that the armadillo was crossing the river when it was eaten is quite plausible because these animals can easily cross rivers and streams. In addition, fishermen from Roviana Lagoon, in the Solomon Islands, report that tiger sharks enter rivers during high tide to feed (Aswani & Vaccaro, 2008). One of the names used by fishermen from southern Bahia for *G. cuvier* is *cação-boca-de-barra* (river mouth shark). This is derived from the local perception that the species has the habit of waiting in river mouths for food from the mainland (Barbosa-Filho *et al.*, 2014).

It is interesting to note that during the interviews the participants pointed out that they have caught tiger sharks that had pieces of other terrestrial animals in their digestive tracts, such as cattle, sheep and even whole chickens, which probably washed into the sea during floods. Based on this, another hypothesis proposed by the fishermen is that the water level of local rivers rose during heavy rains, flooding the burrow of the armadillo and washing the animal into the river and then the sea, where it was then scavenged by the shark.

The consumption of an armadillo by a shark has not been recorded previously, and could be relevant in understanding ecological aspects (*e.g.*, movement and habitat use) of both species in the study area, assuming this is not an isolated record. Regardless, this type of food interaction is a classic example of how rare information can be obtained from collaboration with local communities. For example, through stomach content analysis, Marques (1991) confirmed (based on information from fishermen from Alagoas, Brazil) that the catfish *Arius herzbergii* feeds on terrestrial insects (Ephemeroptera). Likewise, Costa *et al.* (2012) confirmed a peculiar feeding behavior (which had not been described in the scientific literature) of the dolphin *Sotalia guianensis* that was first reported by local inhabitants.

Such cases exemplify the value of ethnozoological knowledge, which directly contributes to a better

understanding of the biology and ecology of animal species and also helps in the development of new scientific hypotheses (Hind, 2014). Ethnozoological studies can be particularly useful in extremely biologically and culturally diverse countries, such as Brazil (Santos-Fita & Costa-Neto, 2007; Alves & Souto, 2010), where ethnozoological interactions are frequent. Moreover, this method has the advantages of being low cost and non-lethal (Alves & Souto, 2015).

Even though rivers may not be a geographical barrier for armadillos, observations of them crossing rivers are not common (Taulman & Robbins, 1996). Thus, the consumption of armadillos by tiger sharks is most likely a very rare interaction. The photos, although historical, confirm our report and give credibility to the knowledge and experience of the fishermen, who are in daily contact with these species.

ACKNOWLEDGEMENTS

We would like to thank the biologist Melina Oliveira Melito for reviewing the manuscript and editing the text in English. A special thanks to Denival Bugarí for his friendship and the valuable information provided. This study was approved (before fieldwork) by the Committee of Ethics in Research with Human Beings of the State University of Santa Cruz (CEP/UESC 25275).

REFERENCES

- Alves, R. R. N. & W. M. S. Souto. 2010. Panorama atual, avanços e perspectivas futuras para etnozoologia no Brasil. Pp. 41–56 in: *Etnozoologia no Brasil: importância, status atual e perspectivas* (R. R. N. Alves, W. M. S. Souto & J. S. A. Mourão, eds.). NUPEEA, Recife.
- Alves, R. R. N. & W. M. S. Souto. 2015. Ethnozoology: a brief introduction. *Ethnobiology and Conservation* 4: 1–13. <https://doi.org/10.15451/ec2015-1-4.1-1-13>
- Aswani, S. & I. Vaccaro. 2008. Lagoon ecology and social strategies: habitat diversity and ethnobiology. *Human Ecology* 36: 325–341. <https://doi.org/10.1007/s10745-007-9159-9>
- Barbosa-Filho, M. L. V., A. Schiavetti, D. T. Alarcon & E. M. Costa-Neto. 2014. “Shark is the man!”: ethno knowledge of Brazil’s South Bahia fishermen regarding shark behaviors. *Journal of Ethnobiology and Ethnomedicine* 10: 54.
- Barbosa-Filho, M. L. V. & E. M. Costa-Neto. 2016. Conhecimento ecológico local de pescadores artesanais do sul da Bahia, Brasil, sobre as interações tróficas de tubarões. *Biotemas* 29: 41–52. <https://doi.org/10.1186/1746-4269-10-54>

- Bianchi, R. D. C., A. F. Rosa, A. Gatti & S. L. Mendes. 2011. Diet of margay, *Leopardus wiedii*, and jaguarundi, *Puma yagouaroundi* (Carnivora: Felidae) in Atlantic Rainforest, Brazil. *Zoologia* 28: 127–132. <https://doi.org/10.1590/S1984-46702011000100018>
- Bornatowski, H., M. R. Heithaus, C. M. P. Batista & R. Mascarenhas. 2012. Shark scavenging and predation on sea turtles in northeastern Brazil. *Amphibia-Reptilia* 33: 495–502. <https://doi.org/10.1163/15685381-00002852>
- Bornatowski, H., M. C. Robert & L. Costa. 2007. Dados sobre a alimentação de jovens de tubarão-tigre, *Galeocerdo cuvier* (Péron & Lesueur) (Elasmobranchii, Carcharhinidae), do sul do Brasil. *Pan-American Journal of Aquatic Sciences* 2: 10–13.
- Bueno, A. D. A., S. C. D. S. Belentani & J. C. Motta-Junior. 2002. Feeding ecology of the maned wolf, *Chrysocyon brachyurus* (Illiger, 1815) (Mammalia: Canidae), in the ecological station of Itirapina, São Paulo State, Brazil. *Biota Neotropica* 2: 1–9. <https://doi.org/10.1590/S1676-06032002000200007>
- Caldicott, D., R. Mahajani & M. Kuhn. 2001. The anatomy of a shark attack: a case report and review of the literature. *Injury – International Journal of the Care of the Injured* 32: 445–453.
- Costa, M. E., Y. Le Pendu & E. M. Costa-Neto. 2012. Behaviour of *Sotalia guianensis* (van Beneden, 1864) (Cetacea, Delphinidae) and ethnoecological knowledge of artisanal fishermen from Canavieiras, Bahia, Brazil. *Journal of Ethnobiology and Ethnomedicine* 8: 1–19. <https://doi.org/10.1186/1746-4269-8-18>
- Feijó, A. & P. Cordeiro-Estrela. 2016. Taxonomic revision of the *Dasyypus kappleri* complex, with revalidations of *Dasyypus pastasae* (Thomas, 1901) and *Dasyypus beniensis* Lönnberg, 1942 (Cingulata, Dasypodidae). *Zootaxa* 4170: 271–297. <https://doi.org/10.11646/zootaxa.4170.2.3>
- Fitzpatrick, R., M. Thums, I. Bell, M. G. Meekan, J. D. Stevens & A. Barnett. 2012. A comparison of the seasonal movements of tiger sharks and green turtles provides insight into their predator-prey relationship. *PLoS ONE* 7: e51927. <https://doi.org/10.1371/journal.pone.0051927>
- Foster, R. J., B. J. Harmsen & C. P. Doncaster. 2010. Sample-size effects on diet analysis from scats of jaguars and pumas. *Mammalia* 74: 317–321. <https://doi.org/10.1515/mamm.2010.006>
- Gallagher, A. J., T. Jackson & N. Hammerschlag. 2011. Occurrence of tiger shark (*Galeocerdo cuvier*) scavenging on avian prey and its possible connection to several large-scale bird die-offs in the Florida Keys. *Florida Scientist* 74: 264–269.
- Heithaus, M. R. 2001. The biology of tiger sharks, *Galeocerdo cuvier*, in Shark Bay, Western Australia: sex ratio, size distribution, diet, and seasonal changes in catch rates. *Environmental Biology of Fishes* 61: 25–36. <https://doi.org/10.1023/A:1011021210685>
- Heithaus, M., L. Dill, G. Marshall & B. Buhleier. 2002. Habitat use and foraging behavior of tiger sharks (*Galeocerdo cuvier*) in a seagrass ecosystem. *Marine Biology* 140: 237–248. <https://doi.org/10.1007/s00227-001-0711-7>
- Heithaus, M. R., A. J. Wirsing, L. M. Dill & L. I. Heithaus. 2007. Long-term movements of tiger sharks satellite-tagged in Shark Bay, Western Australia. *Marine Biology* 151: 1455–1461. <https://doi.org/10.1007/s00227-006-0583-y>
- Hind, E. J. 2014. A review of the past, the present, and the future of fishers' knowledge research: a challenge to established fisheries science. *ICES Journal of Marine Science* 72: 341–358. <https://doi.org/10.1093/icesjms/fsu169>
- Lowe, G. L., B. M. Wetherbee, G. L. Crow & A. L. Tester. 1996. Ontogenetic dietary shifts and feeding behavior of the tiger shark, *Galeocerdo cuvier*, in Hawaiian waters. *Environmental Biology of Fishes* 47: 203–211. <https://doi.org/10.1007/BF00005044>
- Marques, J. G. W. 1991. Aspectos ecológicos na etnoecologia dos pescadores do complexo estuarino-lagunar Mundaú-Manguaba, Alagoas. PhD Thesis, Universidade Estadual de Campinas, Campinas. 280 pp.
- Marques, J. G. W. 2001. Pescando pescadores: Etnoecologia abrangente no baixo São Francisco Alagoano. 2nd edition. NUPAUB/USP, São Paulo. 285 pp.
- McBee, K. & R. J. Baker. 1982. *Dasyypus novemcinctus*. *Mammalian Species* 162: 1–9. <https://doi.org/10.2307/3503864>
- Meyer, C. G., T. B. Clark, Y. P. Papastamatiou, N. M. Whitney & K. N. Holland. 2009. Long-term movement patterns of tiger sharks *Galeocerdo cuvier* in Hawaii. *Marine Ecology Progress Series* 381: 223–235. <https://doi.org/10.3354/meps07951>
- Meyer, C. G., J. M. O'Malley, Y. P. Papastamatiou, J. J. Dale, M. R. Hutchinson, J. M. Anderson, M. Royer & K. N. Holland. 2014. Growth and maximum size of tiger sharks (*Galeocerdo cuvier*) in Hawaii. *PLoS ONE* 9: e84799. <https://doi.org/10.1371/journal.pone.0084799>

- Moreno, R. S., R. W. Kays & R. Samudio-Junior. 2006. Competitive release in diets of ocelot (*Leopardus pardalis*) and puma (*Puma concolor*) after jaguar (*Panthera onca*) decline. *Journal of Mammalogy* 87: 808–816. <https://doi.org/10.1644/05-MAMM-A-360R2.1>
- Quintela, F. M. & A. Gatti. 2009. Armadillo (Cingulata: Dasypodidae) in the diet of the neotropical otter *Lontra longicaudis* in Southern Brazil. *IUCN Otter Specialist Group Bulletin* 26: 78–81.
- Rocha, V. J., N. R. D Reis & M. L. Sekiama. 2004. Dieta e dispersão de sementes por *Cerdocyon thous* (Linnaeus) (Carnivora, Canidae), em um fragmento florestal no Paraná, Brasil. *Revista Brasileira de Zoologia* 21: 871–876. <https://doi.org/10.1590/S0101-81752004000400022>
- Santos-Fita, D. & E. M. Costa-Neto. 2007. As interações entre os seres humanos e os animais: a contribuição da etnozootologia. *Biotemas* 20: 99–110.
- Simpfendorfer, C. 2009. *Galeocerdo cuvier*. The IUCN Red List of Threatened Species. Version 2014.2. <<http://www.iucnredlist.org>>. Downloaded on 25 September 2014.
- Taulman, J. F. & L. W. Robbins. 1996. Recent range expansion and distributional limits of the nine-banded armadillo (*Dasypus novemcinctus*) in the United States. *Journal of Biogeography* 23: 635–648. <https://doi.org/10.1111/j.1365-2699.1996.tb00024.x>
- Tricas, T. C., L. R. Taylor & G. Naftel. 1981. Diel behavior of the tiger shark, *Galeocerdo cuvier*, at French Frigate Shoals, Hawaiian Islands. *Copeia* 1981: 904–908. <https://doi.org/10.2307/1444199>
- Wetzel, R. M., A. L. Gardner, K. H. Redford & J. F. Eisenberg. 2008. Order Cingulata. Pp. 128–157 in: *Mammals of South America. Volume 1: marsupials, xenarthrans, shrews, and bats* (A. L. Gardner, ed.). University of Chicago Press, Chicago.
- Wirsing, A. J., M. R. Heithaus & L. M. Dill. 2007. Fear factor: do dugongs (*Dugong dugon*) trade food for safety from tiger sharks (*Galeocerdo cuvier*)? *Oecologia* 153: 1031–1040. <https://doi.org/10.1007/s00442-007-0802-3>

Received: 16 October 2016; Accepted: 14 November 2016