ECOLOGICAL INTERACTIONS AND PREDATION DYNAMICS BETWEEN JAGUARS AND ARAGUAIA RIVER DOLPHINS

Silveira, Leandro[a]; Jácomo, Anah Tereza de Almeida[a]; Jácomo, Tiago[a]; Alves, Giselle Bastos[a]; Santos, Douglas[b]; de Moraes, Cristiane Gonçalves[c]; Miranda, Everton[d].

[a] Jaguar Conservation Fund/Instituto Onça-Pintada, Mineiros, Goiás, Brazil

[b] Associação Guardiões do Cerrado

[c] Universidade Evangélica de Goiás - UniEVANGÉLICA, Brasil.

[d] *Macroecology Lab, Tohoku University, Sendai, Japan*.

CORRESPONDENCE: Leandro Silveira (l.silveira@jaguar.org.br*)*

River dolphins diverged from their marine relatives approximately 18 million years ago (Rice 1998; Reeves and Martin 2009). Only three genera (*Inia*, *Lipotes*, and *Platanista*) exclusively inhabit freshwater environments, with *Inia* being the only genus found in South America (Hamilton et al. 2001; da Silva et al. 2023). Based on mitochondrial DNA, Hrbek et al. (2014) suggested that the dolphins of the Tocantins-Araguaia River Basin belong to a genetically distinct lineage, *Inia araguaiaensis*, known as the Araguaian river dolphin.

Their populations are classified as Vulnerable to extinction (ICMBio 2022), primarily due to anthropogenic pressures such as habitat degradation, population fragmentation, and declining fish stocks (da Silva et al. 2018; Paschoalini et al. 2020; de Moraes et al. 2024). Moreover land use changes and altered river flow regimes reduce fish availability, impacting the dolphin's feeding behavior and increasing conflicts with fishermen (Dewhurst-Richman et al. 2020; Campbell et al. 2022; de Moraes et al. 2025).

River dolphins feed on a wide variety of fish species and are recognized as top predators in aquatic ecosystems, playing a crucial role in regulating trophic networks and serving as indicators of environmental health (Gomez-Salazar et al. 2012; Das et al. 2022). In the Araguaia, the animals exhibit a locally known behavior called "*estouro do boto*," in which it drives schools of fish into shallow waters to increase capture efficiency (Dalpaz and Simões-Lopes 2025), a strategy similar to that observed in some marine dolphin species (Santos et al. 2010). Despite their top-predator status, these cetaceans are also subject to predation by jaguars (*Panthera onca*) (Silveira et al., 2004) and black caimans (*Melanosuchus niger*).

As apex predators, river dolphins regulate trophic networks and serve as indicators of ecosystem health (Gomez- Salazar et al. 2012; Das et al. 2022). They feed on a wide range of fish species and exhibit a behavior locally known as "*estouro do boto*", in which they drive fish into shallow waters to increase capture efficiency (Dalpaz and Simões-Lopes, 2025), similar to strategies observed in some marine dolphins (Santos et al. 2010).

Jaguars are opportunistic predators that hunt a diverse array of vertebrates (Hayward et al. 2016), being mostly dependent of peccaries over most of its distribution Miranda et al. (2016). Among *Panthera* species, they are the single species to be able to forage over semi-aquatic and aquatic prey as the bulk of its diet. These jaguar prey can comprise capybaras, caimans and fish in Pantanal (Eriksson et al. 2022), and crocodiles in Mexico (Pérez-Flores 2018). I the coastal sections of central America, a few jaguar populations are known to prey over nesting sea turtles (Fonseca et al. 2020). While some of these species are clumsy on

land and may represent easy prey, jaguars can handle and capture prey such as caimans and capybaras underwater.

All known records of jaguars feeding on river dolphins have been photographic or video evidence captured by researchers and other citizens, typically showing individuals feeding on beaches or riverbanks. This paper aims to provide the first material evidence of jaguar predation on river dolphins through the analysis of physical remains, including dolphin skulls bearing diagnostic bite marks. While previous reports of jaguar attacks on river dolphins have relied exclusively on photographic and video records, material evidence has been lacking. By documenting and analyzing these physical remains, we seek to strengthen understanding of jaguar feeding ecology in aquatic environments and to expand knowledge of predator-prey interactions involving river dolphins. This evidence also contributes to broader discussions of apex predator roles within Amazonian aquatic ecosystems, and highlights the ecological versatility of jaguars in exploiting aquatic prey.

The Tocantins-Araguaia Basin covers approximately 384,000 km², with sandy riverbeds and turbid waters (Aquino et al. 2005). The tropical climate features a rainy season from October to March and a dry season from April to September (Lininger and Latrubesse 2016). During the dry season, the river channel narrows, forming sandbanks used for recreational fishing (Latrubesse et al. 2019). Floods during the wet season increase system productivity, providing shelter and food for fish and dolphins (Junk 2013).

Jaguar Predation on the Araguaia River Dolphin

Event 1:

The first record predation event occurred in the afternoon on the March 2024 in the left bank of the Araguaia River, close to the São Felix do Araguaia city. Although the attack was not directly observed, fresh tracks in the sand showed that the dolphin was dragged approximately 30 meters from the water into the gallery forest. A camera trap placed near the carcass recorded a female jaguar and her cub feeding on the remains for two consecutive days. Bite marks on the skull indicated the characteristic canine punctures of a jaguar's killing bite (Figure 1a).

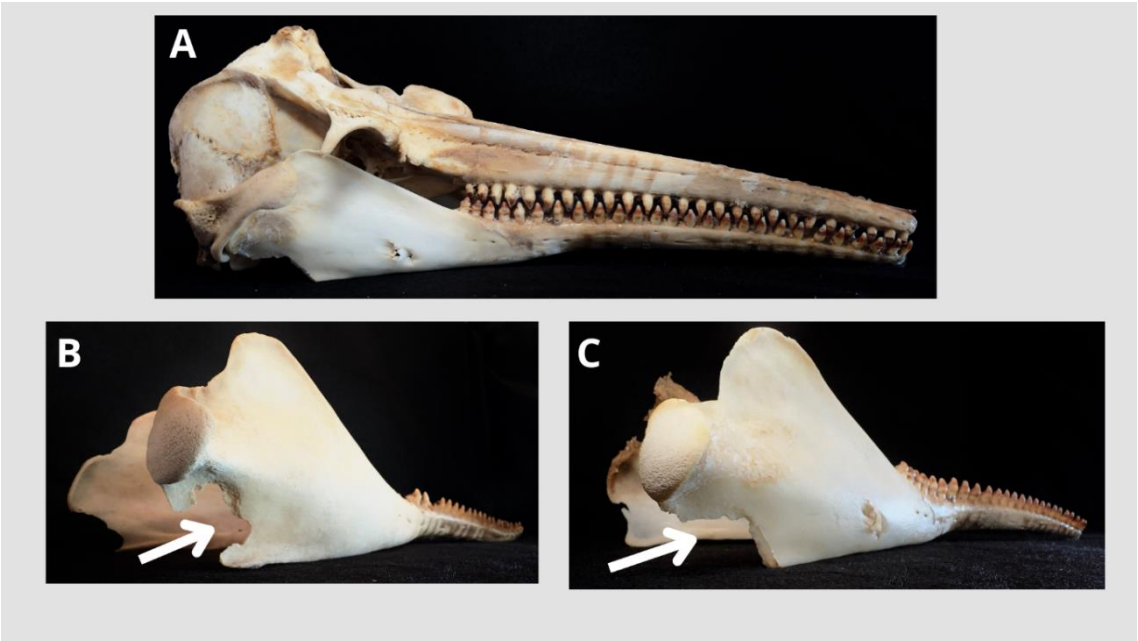

Figure 1. River Dolphin (*Inia araguaiaensis*) skulls with jaguar (*Panthera onca*) bite marks indicating the characteristic canine punctures of a jaguar's deadly bite A) skull found in the left bank of the Araguaia River, close to the São Felix do Araguaia city; B) and C) skull found of the Araguaia River, close to the Luiz Alves city.

Event 2:

The second event was witnessed by a local guide and fisherman around 9:00 a.m., of the Araguaia River, close to the Luiz Alves city (12°56'21.70"S 50°31'38.13"W). A professional fisherman who also acts as fishing guide observed a jaguar patrolling the beach, which fixated on a dolphin herding fish in shallow water, with part of its back exposed. The jaguar ran a few meters along the shallows, leapt onto the dolphin, bit its melon, and carried it about 40 meters from the water's edge (Figure 1b and c).

Informal interviews conducted by some co-authors with local riverine communities suggest that such events may be more frequent than previously documented. Dolphins often herd fish into shallow areas, splashing and partially exposing their bodies—behavior that may attract jaguars patrolling the riverside in search of prey like caimans and capybaras. The river's geomorphology, characterized by a deep main channel bordered by shallow waters, further facilitates these encounters. Both skulls exhibit the characteristic "lethal bite" pattern of jaguars, where their canine teeth pierce the jawbone (Figures 1).

Jaguars possess a bite force of approximately 4,939 N (503.57 kg-force) (Hartstone-Rose et al. 2012), strong enough to puncture a tapir's skull and crush tortoise shells up to 5 cm thick (Schaller and Vasconcelos 1978; Emmons 1989). Given this capacity and their ability to handle aquatic prey underwater,

that jaguars could prey on river dolphins (*Inia geoffrensis*). Silveira et al. (2004) reported 13 documented cases of jaguar predation on river dolphins along the Araguaia River, highlighting that such predator-prey interactions might have been occurring frequently and for longer than previously recognized. However, the circumstances under which such predation occurred remained poorly understood. The jaguar's current distribution overlaps entirely with that of South American freshwater dolphins, yet despite extensive research on both taxa, no detailed material evidence of predation had previously been documented. Here we present physical evidence confirming jaguar attacks on river dolphins (Figure 1a, 1b and 1c), highlighting an interaction crucial for understanding jaguar ecology and broader predation dynamics within Amazonian aquatic systems.

The rarity of documented cases might be explained by infrequent encounters between jaguars and dolphins. Furthermore, dolphins' lack of hair makes their detection challenging through traditional jaguar diet analyses, such as hair identification in scats, limiting documentation primarily to carcasses (Negroes et al. 2011). Closer examination of this ecological interaction reveals a combination of factors that facilitate such predation events. A key landscape feature enabling this interaction is the river's structure itself. The Araguaia River, within the dolphins' distribution range, is relatively shallow during the dry season. Dolphins commonly fish by herding fish schools into shallow areas, frequently exposing their bodies above water.

Jaguars, known to patrol riverbanks and beaches hunting semi-aquatic prey such as caimans, turtles, and capybaras, are naturally attracted by the splashes dolphins produce when hunting. Indeed, local residents along the Araguaia River report jaguars emerging from forests specifically in response to such splashes, anticipating dolphin presence (Silveira L. unpublished data).

Significant landscape alterations, such as deforestation, dam construction, and subsequent fragmentation of aquatic ecosystems, profoundly impact the availability and distribution of food resources for river dolphins. These environmental changes modify dolphin foraging behavior, frequently forcing them into more restricted and shallow habitats, thereby increasing their exposure to predation risk by jaguars (Dewhurst-Richman et al. 2020; Campbell et al. 2022; Ferreira et al. 2022; de Moraes et al. 2025).

Consequently, such environmental modifications may enhance opportunities for jaguars to exploit dolphins as prey, directly influencing predation dynamics and altering trophic relationships in Amazonian aquatic ecosystems. Jaguars are well-documented aquatic predators and opportunistic scavengers, also observed feeding on marine dolphin carcasses (Da Silveira et al. 2010; Castañeda et al. 2013; Dias et al. 2025)

On the northern coast of Honduras, two male jaguars scavenged a dolphin carcass washed ashore, dragging it inland and consuming it over several days, demonstrating behaviors such as sniffing and rolling on remains (Castañeda et al. 2013). Similarly, at Maracá-Jipioca Ecological Station off Brazil's Amapá State, a female jaguar and her cub scavenged a Guiana dolphin (*Sotalia guianensis*) carcass, likely a bycatch from illegal fishing, defending it against vultures and repeatedly feeding on it (Dias et al. 2025). These observations suggest jaguars may opportunistically learn to exploit dolphins as prey resources by initially scavenging carcasses, underscoring the potentially underestimated role of dolphins in jaguar foraging ecology and as critical bioindicators of aquatic ecosystem health (Das et al. 2022). The occurrence of jaguar predation on these dolphins may reflect important shifts in local ecological balance, such as changes in feeding strategies or forced displacement of dolphins into more vulnerable habitats due to reduced fish availability (da Silva et al. 2018; Moraes et al. 2025). Therefore, understanding jaguar-dolphin predation interactions not only elucidates aspects of jaguar trophic ecology but also provides valuable insights into the environmental conditions and stability of Amazonian aquatic habitats.

The middle-northern section of the Araguaia River, approximately 2,000 km long, presents structural characteristics that create unique opportunities for jaguar-dolphin interactions. Key factors include shallow waters, the dolphins' "beach-fishing" behavior, and the jaguars' riverside patrolling habits. Jaguars in this ecoregion have likely learned to associate river splashes with dolphin hunting behavior, which attracts them to the scene. This behavior described by locals is supported by ecological evidence. The relatively high number of videos available on the internet (e.g., YouTube) showing jaguars feeding on dolphin carcasses—or at least evidence of scavenging—supports the assumption that interactions between these top predators occur more frequently than previously expected. The reduction in flooded areas and water flow in the Araguaia basin indicated by dos Santos et al. (2024) contribute to the increase in shallow areas and greater exposure of the dolphin during foraging. During the dry season, when the Araguaia River becomes shallower, the dolphins' "beach hunting" behavior likely increases the chances of encounters between these two predators. These scenarios may play a significant role in the diet of jaguars whose home ranges include the river. Future studies should focus particularly on the dry season to monitor jaguar-dolphin interactions more intensively, considering the dolphins' role as critical indicators of ecosystem health, thereby guiding integrated conservation actions within the Araguaia River region.

REFERENCES

Aquino S, Stevaux JC, Latrubesse EM (2005) Regime hidrológico e aspectos do comportamento morfohidráulico do rio Araguaia. Rev. Bras. Geomorfol. 6(2). https://doi.org/10.20502/rbg.v6i2.49

Campbell E, Alfaro-Shigueto J, Aliaga-Rossel E, Beasley I, Briceño Y, Caballero S, et al (2022) Challenges and priorities for river cetacean conservation. Endanger. Species Res. 49: 13-42. https://doi.org/10.3354/esr01201

da Silva VMF, Trujillo F, Martin AR, Zerbini AN, Crespo EA, Aliaga Rossel E, Reeves R (2018) *Inia geoffrensis*. The IUCN Red List of Threatened Species. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T10831A50358152.en

da Silva VMF, Brum SM, Magalhães Drummond de Mello D, et al. (2023) The Amazon River Dolphin, *Inia geoffrensis*: What Have We Learned in the Last Two Decades of Research? Lat. Am. J. Aquat. Mamm. 18(1): 139 – 157. https://doi.org/10.5597/lajam00298.

Da Silveira R., Ramalho, EE, Thorbjarnarson JB, Magnusson WE (2010) Depredation by jaguars on caimans and Importance of reptiles in the diet of jaguar. J. Herpetol. 44(3): 418-424. https://doi.org/10.1670/08-340.1

Dalpaz, L, Simões-Lopes PC (2025) Report on foraging behavior and conflicts of the Araguaia River dolphin in Goiás and Mato Grosso, Brazil. Lat. Am. J. Aquat. Mamm. 20(1): 54-59. https://doi.org/10.5597/lajam00353

Das GC, Sharma SP, Ali SZ et al. (2022) Prioritising River Stretches Using Multi - Modelling Habitat Suitability of Gangetic Dolphin (*Platanista gangetica*) as a Flagship Species for Aquatic Biodiversity Conservation in the Ganga River Basin, India. Ecol. Indic. 145: 109680. https://doi.org/10.1016/j.ecolind.2022.109680

de Moraes, CG, Marmontel M, De Marco Júnior P (2024) Group Dynamics and Social Structure of the Inia araguaiaensis in the Tocantins River, Brazilian Cerrado. Aquat. Mamm. 50(5). https://doi.org/10.1578/AM.50.5.2024.430

de Moraes CG, Marmontel M, Frias MP, Costa MO, De Marco-Junior P (2025) Landscape change and threats to conservation of River Dolphin *Inia* araguaiaensis (Cetacea: Iniidae) in the Brazilian Savanna. Int. Rev. Hydrobiol. 1–9. https://doi.org/10.1002/iroh.70011

Dewhurst-Richman NI, Jones JPG, Northridge S, Ahmed B, Brook S, Freeman R, et al (2020). Fishing for the facts: river dolphin bycatch in a small-scale freshwater fishery in Bangladesh. Anim. Conserv. 23(2): 160-170. https://doi.org/10.1111/acv.12523

Dias G, Gambarini A, Oliveira-da-Costa M, Marmontel M (2025) An Unusual Record of a Marine Dolphin (Likely *Sotalia guianensis*) Being Scavenged by Jaguar (*Panthera onca*) at the Northern Brazilian Amazon. Aquat Mamm *51*(2). https://doi.org/10.1578/AM.51.2.2025.178

dos Santos Teixeira A, Vieira LCG, de Souza CA, Bernardi JVE, Monteiro LC (2024) Evidence of water surface and flow reduction in the main hydrographic basin of the Brazilian savannah (Cerrado biome): the Araguaia river. Hydrobiologia 851(10): 2503-2518. https://doi.org/10.1007/s10750-024-05471-z

Emmons LH (1989) Jaguar predation on chelonians. J Herpetol 23(3): 311-314

Ferreira M E, Nogueira SHDM, Latrubesse EM, Macedo MN, Callisto M, Bezerra Neto JF, Fernandes GW (2022) Dams Pose a Critical Threat to Rivers in Brazil's Cerrado Hotspot. *Water* 14(22): 3762. https://doi.org/10.3390/w14223762

Fonseca L, Arroyo-Arce S, Thomson I, Villachica WN, Rangel E, Valverde RA, Plotkin PT, Quirós-Pereira W (2020) Impacts of jaguar predation on nesting sea turtles at Nancite Beach, Santa Rosa National Park, Costa Rica. Herpetol Conserv Biol 15: 547–55

Gomez-Salazar C, Trujillo F, Portocarrero-Aya M, Whitehead H (2012) Population, Density Estimates, and Conservation of River Dolphins (*Inia* and *Sotalia*) in the Amazon and Orinoco River Basins. Mar. Mamm. Sci. 28(1): 124 – 153. https://doi.org/10.1111/j.1748-7692.2011.00468.x

Hamilton H, Caballero S, Collins AG, Brownell Jr R (2001) Evolution of River Dolphins. Proc. R. Soc. Series B: Biological Sciences 268(1466): 549 – 556. https://doi.org/10.1098/rspb.2000.1385

Hartstone-Rose A, Perry JMG, Morrow CJ (2012) Bite force estimation and the fiber architecture of felid masticatory muscles. Anat Rec 295(8): 1336–1351. https://doi.org/10.1002/ar.22518

Hayward MW, Kamler JF, Montgomery R A, Newlove A, Rostro-García S, Sales L P, Van Valkenburgh B (2016) Prey preferences of the jaguar *Panthera onca* reflect the post-Pleistocene demise of large prey. Front. Ecol. Evol. *3*: 148. https://doi.org/10.3389/fevo.2015.00148

Hrbek T, da Silva VMF, Dutra N, Gravena W, Martin AR, Farias I P (2014) A new species of river dolphin from Brazil or: how little do we know our biodiversity. PLoS One 9(1): e83623. https://doi.org/10.1371/journal.pone.0083623

ICMBio (2022) Atualização da Lista Oficial das espécies ameaçadas de extinção (Portaria 148 de 07 junho de 2022). MMA, Brazil. https://pesquisa.in.gov.br/imprensa/jsp/visualiza/index.jsp?data=08/06/2022&jornal=515&pagina=74 Acessed 10 may 2025

Junk WJ (2013) Current state of knowledge regarding South America wetlands and their future under global climate change. Aquat. Sci. 75 (1):113-131. DOI: https://doi.org/10.1007/s00027-012-0253-8

Latrubesse EM, Arima E, Ferreira ME, Nogueira SH, Wittmann F, Dias MS, Bayer M (2019) Fostering water resource governance and conservation in the Brazilian Cerrado biome. Conserv Sci Pract. 1(9): e77. https://doi.org/10.1111/csp2.778of8

Lininger KB, Latrubesse EM (2016) Flooding hydrology and peak discharge attenuation along the middle Araguaia River in central Brazil. Catena 143: 90–101. https://doi.org/10.1016/j.catena.2016.03.043

Miranda EB, Menezes JFD, Rheingantz ML (2016) Reptiles as principal prey? Adaptations for durophagy and prey selection by jaguar (*Panthera onca*). J. Nat. Hist. Mus *50*(31-32): 2021-2035. https://doi.org/10.1080/00222933.2016.1193644

Negroes N, Revilla E, Fonseca C, Soares AM, Jácomo A T, Silveira L (2011) Private forest reserves can aid in preserving the community of medium and large-sized vertebrates in the Amazon arc of deforestation. Biodivers Conserv *20*:505-518. https://doi.org/10.1007/s10531-010-9961-3

Paschoalini M, Almeida R M, Trujillo F, Melo-Santos G, Marmontel M, Pavanato HJ, Mosquera-Guerra F (2020) On the brink of isolation: Population estimates of the Araguaian river dolphin in a human-impacted region in Brazil. PLoS One 15: e0231224. https://doi.org/10.1371/journal.pone.0231224

Pérez-Flores J (2018) Predation of an adult female Morelet's crocodile (*Crocodylus moreletii*) by a jaguar (*Panthera onca*) in the Calakmul region, Mexico. Herpetol. Notes 11: 613–616

Reeves R R, Martin A R (2009) River dolphins: A global perspective on their conservation status. In: Encyclopedia of Marine Mammals, 2nd ed. Academic Press

Rice DW (1998) Marine Mammals of the World: Systematics and Distribution. Society for Marine Mammalogy

Santos MCO, Rosso S, Santos RA, Lopes XM, Dias DTC, Zampirolli E, Monteiro-Filho EL (2010) Guiana dolphins (*Sotalia guianensis*) displaying beach hunting behavior in the Cananéia Estuary, Brazil: social context and conservation issues. Braz. J. Oceanogr. 58(2):143-152

Schaller GB, Vasconcelos JMC (1978) Jaguar predation on capybara. Z. Saugetierkunde 43: 296–301.

Silveira L, Jacomo ATA., Suero D.R. (2004) Predação de Onça-Pintada sobre boto. XXII Congresso Brasileiro de Zoologia. Written presentation. Brasília, Brazil, 2004.