



NEW DATA ON THE REPRODUCTIVE LIFESPAN OF GIANT ARMADILLOS (*Priodontes maximus*) IN THE WILD

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Abstract: The reproductive lifespan of a species is a key parameter used in a multitude of ecological analyses and conservation status assessments. A long-term study on giant armadillos (*Priodontes maximus*) in the Brazilian Pantanal using camera traps demonstrated that a female had a pup when she was at least 20 years old. It has been confirmed that this female has had at least five offspring and possibly a sixth. In future evaluations of the International Union for Conservation of Nature red list, we recommend that the generation length be set at 11 years, instead of seven years, for this species.

Keywords: age of reproduction, camera traps, Cingulata, generation length, reproductive senescence.

Desbiez *et al.* (2021) reported the potential lifespan of wild giant armadillos *Priodontes maximus* (Cingulata, Clamyphoridae) using long-term camera trap studies in Bolivia and Brazil. While the authors were able to demonstrate that the females documented were at least 18 and 17.5 years old, they were unable to document if the females were still breeding or not, reaching reproductive senescence. Knowing if these females are still breeding could help to better estimate the species' reproductive lifespan, which is calculated as the difference between the age at last reproduction and the age at first reproduction (Pacifi *et al.* 2013). While age at first reproduction may be easier to discover and has been reported as 6.5–8 years for giant armadillos (Luba *et al.* 2020), age at last reproduction requires long term studies that are rare in long-lived

mammals, especially in the wild (Pe'er *et al.* 2013, Morrison *et al.* 2016). The reproductive lifespan of a species is a key statistical parameter used in many ecological analyses (Fung & Waples 2017, IUCN 2019). For example, this parameter is key to calculating the generation length of a species, which is used as a reference timeframe to assess a species' extinction risk due to population reduction (Criteria A, C1 and E from the International Union for Conservation of Nature; IUCN 2019). For this reason, Desbiez *et al.* (2021) reported intending to continue long-term camera trapping efforts in the hope of documenting the reproduction of identified individuals, especially females. Here, we report evidence that a female giant armadillo (TC-04) tracked in the Brazilian Pantanal since 2011 still bred when she was at least 20 years old.

This work is part of a long-term study on giant armadillos that has been carried out since July 2010 at the Baia das Pedras ranch and surrounding cattle ranches (19°16'S, 55°42'W) in the Brazilian Pantanal (Nhecolândia subregion) of the state of Mato Grosso do Sul (see Desbiez *et al.* 2020a for details on study area). The adult female giant armadillo TC-04 was first captured in October 2011, when she was implanted with an intra-abdominal VHF-Transmitter (IMP 310, Telonics, Inc., Mesa, Arizona; Desbiez *et al.* 2020a) that allowed it to be monitored through radiotracking until 2016. In 2020, following the methods described in Desbiez *et al.* (2020b), an array of 10 cameras was placed

in the known home range of TC-04 to allow closer continued monitoring of this individual. This study was performed in line with the guidelines of the American Society of Mammalogists (ASM) concerning the use of wildlife in research (Sikes & Animal Care and Use Committee of the American Society of Mammalogists 2016) and was conducted under license # 27587 granted by Chico Mendes Institute for Biodiversity Conservation (ICMBio).

Here, we compiled all the reproductive events known for TC-04 (Table 1). According to our data, TC-04 has had at least five confirmed offspring since 2010. Four of the offspring have been documented by direct observations of parental care through

Table 1. Reproductive events recorded or presumed for a female giant armadillo (*Prionodontes maximus*; Cingulata, Clamyphoridae) between 2010 and 2024, in the Nhecolândia sub-region of the Brazilian Pantanal, state of Mato Grosso do Sul (19° 16' 60" S, 55° 42' 60" W). The type of record and observations describe how evidence of each reproductive event was gathered (Desbiez *et al.* 2020c). Legend: Sex of offspring: F = Female; M = Male; U = Unknown; Status of each offspring: A = Alive; D = Dead; U = Unknown; * = Suspected offspring of TC-04.

Event	Estimated Parturition date	Sex of offspring	Status of each offspring	Type of record	Observation
1	2010	M	A	Genetic analysis	Genetic analysis of juvenile TC-10 captured in 2013 with 28kg, and who occupied the edge of TC-04's home range
2	November/2012	M	D	Camera trap	Juvenile recorded under TC-04's care since birth
3	July/2013	M	D	Camera trap	Juvenile recorded under TC-04's care since birth
4	August/2016	M	U	Camera trap	Juvenile TC-17 recorded under TC-04's care since birth
5*	June–September/2019	F	A	Camera trap	Juvenile recorded in TC-04's home range in July 2021
6	May–July/2023	U	A	Camera trap	Juvenile recorded under TC-04's care at 5-6 months of age

camera traps that were placed in front of burrows in use (Desbiez *et al.* 2020c; this study). In addition, a genetic study demonstrated that a juvenile (TC-10 body mass = 28 kg; age > 18 months, according

to Desbiez *et al.* 2021), captured in June 2013 at the edge of TC-04's home range, was also her offspring (N. T. Rodrigues, unpublished data), totaling five confirmed offspring.



Figure 1. Body size comparison between an adult female (A) and the juvenile female (B) giant armadillo (*Priodontes maximus*; Cingulata, Clamyphoridae) registered in TC04's home range on July 25, 2021, at Baia das Pedras ranch, state of Mato Grosso do Sul, Brazil. The white rectangle marks the absence of a visible teat (B), which means this animal has not bred. Furthermore, the relatively small size of the armadillo (animal in image B is closer than in image A, but still smaller) indicates that the individual is a juvenile (see Massocato & Desbiez 2019) (B).



Figure 2. Identification of an individual of giant armadillo (*Priodontes maximus*; Cingulata, Clamyphoridae; TC-04) in 2014, showing both the left (A) and right (B) flanks, at Baia das Pedras ranch, state of Mato Grosso do Sul, Brazil. The left flank was used to identify TC-04 in Desbiez *et al.* (2021), whereas the right flank was used in this study.

We suspect that TC-04 may have produced a sixth offspring. This occurred because on July 25, 2021, a female juvenile armadillo was recorded by one of the cameras placed in TC-04's home range (Figure 1). Given the animals' smaller size and

comparing with images of juveniles of known age, we estimated that the female juvenile was 20-30 months old (Massocato & Desbiez 2019). Giant armadillos, especially females, maintain almost exclusive home ranges, and the occupation of a female's home

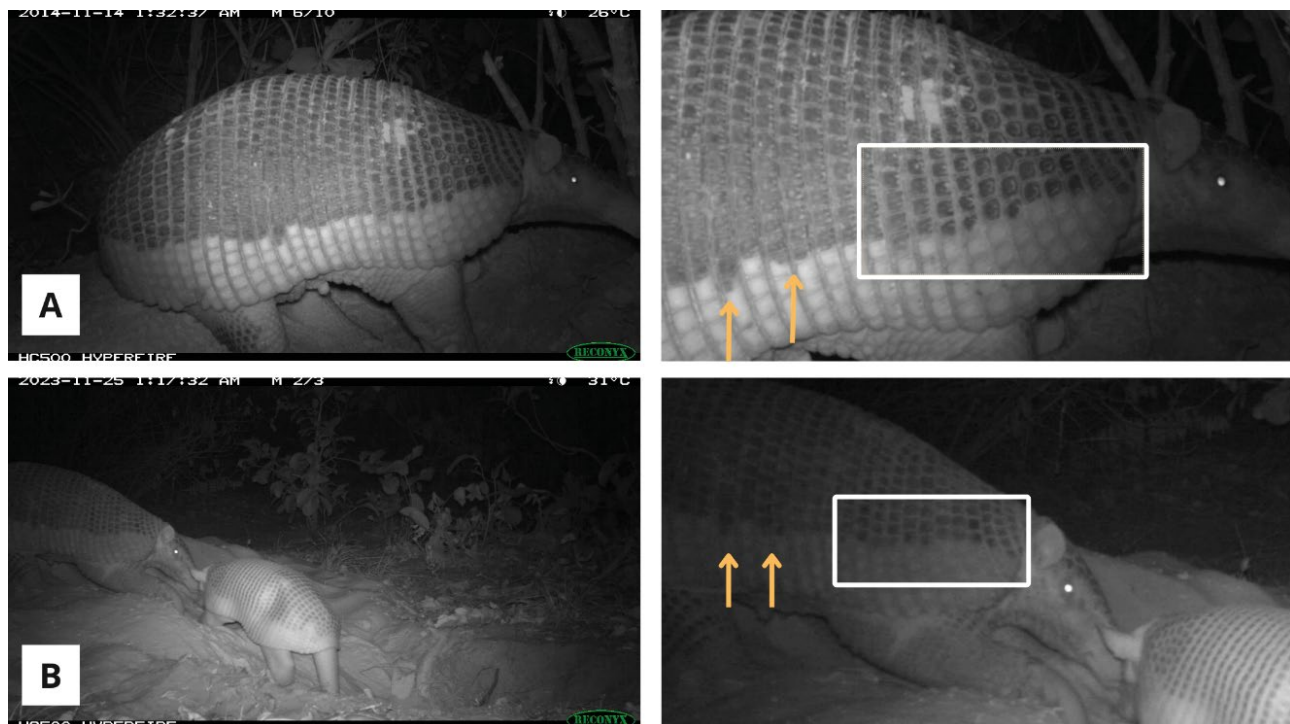


Figure 3. Identification of an individual of giant armadillo (*Priodontes maximus*; Cingulata, Clamyphoridae; TC-04) from the right flank in 2014 (A) and from the right flank in 2023 (B), with her pup at Baia das Pedras ranch, state of Mato Grosso do Sul, Brazil. An augmented image of the scale pattern that can be used to identify the individual is presented on the right side of the figure for (A) and (B).

range by another individual has been recorded only during the juvenile phase of their offspring (e.g., between TC-04 and her offspring TC-17; Desbiez *et al.* 2020a). Furthermore, this species presents a long developmental process between weaning and sexual maturity, when the juvenile may be recorded within its mother's home range but unaccompanied by her (Desbiez *et al.* 2020a,c, Luba *et al.* 2020). Our team has been able to document only one juvenile dispersal event, which was from a female that dispersed at four years of age from her mother's territory (Giant Armadillo Conservation Program, personal communication). Given the estimated age of the juvenile female recorded in TC-04's home range, it would be reasonable to assume that it was a potential offspring of TC-04.

We cannot rule out the possibility that this juvenile was the offspring of a neighboring female, but her age aligns with previous estimates of interbirth rates. Desbiez *et al.* (2020c) proposed that giant armadillos have interbirth rates of three years or more. The short interbirth rate between events 2 and 3 is due to the infanticide of offspring 2 described by Desbiez *et al.* (2020c) (Table 1). Assuming a three-year interbirth rate and that the

above mentioned juvenile female is an offspring of TC-04, we propose that this suspected offspring was approximately 24 months old when recorded on July 25, 2021, and was born sometime in the second semester of 2019.

The last record of TC-04 accompanied by offspring was made on November 25, 2023. On this occasion, TC-04 was registered with a young pup estimated to be 4-5 months old (Figures 2 and 3). The age of the pup was estimated according to records in Desbiez *et al.* (2020c), who analyzed the behavior of TC-04 and her successive offspring throughout the years. In addition to the pup's behavior and size, the behavior of the mother closing the burrow entrance and the frequency of her visits to the pup can help to indicate the age of the pup (Desbiez *et al.* 2020c). Based on her size and reproductive status, TC-04 was estimated to be at least 17.5 years old in January 2021 (Desbiez *et al.* 2021). Therefore, she would be 20.5 years old when she was last seen with a pup (November 2023). This is the minimum estimate and TC-04 could be older. This record showed that TC-04 had a pup when she was at least 20 years old, which makes TC-04 the oldest female known to present reproductive behavior in the wild.



Figure 4. Records of the successive offspring of the giant armadillo (*Priodontes maximus*; Cingulata, Clamphoridae) TC-04 in chronological order (A-F) registered at Baia das Pedras ranch, state of Mato Grosso do Sul, Brazil, during the past 10 years (2013–2023). Juvenile E is suspected to be TC-04's offspring, whereas all the other offspring are confirmed.

TC-04 is also the individual with the most recorded successive offspring (Figure 4).

It should be noted that in camera trap records obtained between 2014 and 2023, TC-04 did not show any external morphological or behavioral evidence of aging (Figures 2 and 3). Hence, we are not able to age adult giant armadillos according to these

external morphological characteristics. Currently, we rely on sporadic recapture events and individual markings to identify individuals and potentially estimate the minimum age of adult giant armadillos by recaptures and records of reproductive activity (Desbiez *et al.* 2019, Desbiez *et al.* 2021).

Luba *et al.* (2020) speculated that giant armadillos could breed until they are at least 20 years old. The authors used this estimate to calculate the reproductive lifespan of the species and, according to the formula by Pacifici *et al.* (2013), calculated a conservative generation length of 11 years. The record from TC-04 reported here supports that 20 years is a conservative, but valid, minimal guess for age at last reproduction in giant armadillos. This record corroborates the change in generation length suggested by Luba *et al.* (2020). In future evaluations of the IUCN red list for giant armadillos (Anacleto *et al.* 2014), we recommend that the generation length be set at 11 years instead of seven years for this species.

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REFERENCES

- Anacleto, T. C. S., Miranda, F., Medri, I., Cuellar, E., Abba, A. M., & Superina, M. 2014. *Priodontes maximus*. The IUCN Red List of Threatened Species 2014. e.T18144A47442343. Retrieved on February 15, 2024, from <https://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T18144A47442343.en>
- Desbiez, A. L. J., Massocato, G. F., Kluyber, D., Luba, C. N., & Attias, N. 2019. How giant are giant armadillos? The morphometry of giant armadillos (*Priodontes maximus* Kerr, 1792) in the Pantanal of Brazil. *Mammalian Biology*, 95(1), 9–14. DOI: 10.1016/j.mambio.2018.12.007
- Desbiez, A. L. J., Massocato, G. F., Kluyber, D., Oliveira-Santos, L. G. R., & Attias, N. 2020a. Spatial ecology of the giant armadillo (*Priodontes maximus*) in Midwestern Brazil. *Journal of Mammalogy*, 101(1), 151–163. DOI: 10.1093/jmammal/gyz172
- Desbiez, A. L. J., Massocato, G. F., Attias, N., & Cove, M. 2020b. Comparing density estimates from a short-term camera trap survey with a long-term telemetry study of giant armadillos (*Priodontes maximus*). *Mastozoología Neotropical*, 27(2), 1–18.
- Desbiez, A. L. J., Massocato, G. F., & Kluyber, D. 2020c. Insights into giant armadillo (*Priodontes maximus* Kerr, 1792) reproduction. *Mammalia*, 84(3), 283–293. DOI: 10.1515/mammalia-2019-0018
- Desbiez, A. L. J., Larsen, D., Massocato, G. F., Attias, N., Kluyber, D., & Rumiz, D. I. 2021. First estimates of potential lifespan of giant armadillo (*Priodontes maximus*) in the wild. *Edentata*, 22(1), 9–15. DOI: 10.2305/IUCN.CH.2021.Edentata-22-1.3.en
- Fung, H. C., & Waples, R. S. 2017. Performance of IUCN proxies for generation length. *Conservation Biology*, 31(4), 883–893. DOI: 10.1111/cobi.12901
- IUCN - International Union for Conservation of Nature. 2019. Guidelines for using the IUCN Red List categories and criteria. Version 14. Standards and Petitions Committee. Retrieved on March 30, 2021, from www.iucnredlist.org/documents/RedListGuidelines.pdf
- Luba, C. N., Kluyber, D., Massocato, G. F., Attias, N., Fromme, L., Rodrigues, A. L. R., Ferreira, A. M. R., & Desbiez, A. L. J. 2020. Size matters: Penis size, sexual maturity and their consequences for giant armadillo conservation planning. *Mammalian Biology*, 100(1), 621–630. DOI: 10.1007/s42991-020-00065-3
- Massocato, G. F., & Desbiez, A. L. J. 2019. Guidelines to identify individual giant armadillos, *Priodontes maximus* (Kerr, 1792), through camera traps. *Edentata* 20: 1–16.
- Morrison, C., Wardle, C., & Castley, J. G. 2016. Repeatability and reproducibility of population viability analysis (PVA) and the implications for threatened species management. *Frontiers in Ecology and Evolution*, 4(1), e98. DOI: 10.3389/fevo.2016.00098
- Pacifici, M., Santini, L., Di Marco, M., Baisero, D., Francucci, L., Marasini, G. G., Visconti, P., & Rondinini, C. 2013. Generation length for mammals. *Nature Conservation*, 5(1), 87–94. DOI: 10.3897/natureconservation.5.5734
- Pe'er, G., Matsinos, Y. G., Johst, K., Franz, K. W., Turlure, C., Radchuk, V., Malinowska, A. H., Curtis, J. M. R., Naujokaitis-Lewis, I., Wintle, B. A., & Henle, K. 2013. A protocol for better design, application and communication of population viability analyses. *Conservation Biology*, 27(4), 644–656. DOI: 10.1111/cobi.12076

Sikes, R. S., & Animal Care and Use Committee of the American Society of Mammalogists. 2016. Guidelines of the American Society of Mammalogists for the use of wild mammals in research and education. *Journal of Mammalogy*, 97(3), 663–688. DOI: 10.1093/jmammal/gyw078

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