

Presence and monitoring of albino giant anteaters (*Myrmecophaga tridactyla*) in the *Cerrado* savanna

Presença e monitoramento de tamanduás-bandeira (*Myrmecophaga tridactyla*) albinos no Cerrado

Nina Attias^I  | Débora Regina Yogui^{I, II, III}  | Mario Alves^{I, II}  | Danilo Kluyber^{I, IV}  | Miriã Ribeiro Costa^I  |
Polyana Mayume Pereira da Silva^V  | Ednilson Paulino Queiroz^{VI}  | Arnaud L. J. Desbiez^{I, VII, VIII} 

^IInstituto de Conservação de Animais Silvestres. Campo Grande, Mato Grosso do Sul, Brasil

^{II}Universidade Federal do Mato Grosso do Sul. Programa de Pós-Graduação em Ecologia e Conservação. Campo Grande, Mato Grosso do Sul, Brasil | ^{III}Nashville Zoo. Nashville, Tennessee, USA | ^{IV}Naples Zoo at Caribbean Gardens. Naples, Florida, USA

^VUniversidade Federal do Mato Grosso do Sul. Programa de Pós-Graduação em Ciências Veterinárias. Campo Grande, Mato Grosso do Sul, Brasil | ^{VI}Batalhão de Polícia Militar Ambiental. Campo Grande, Mato Grosso do Sul, Brasil | ^{VII}Instituto de Pesquisas Ecológicas. Nazaré Paulista, São Paulo, Brasil | ^{VIII}Royal Zoological Society of Scotland. Murrayfield, Edinburgh, United Kingdom

Abstract: Here we present two cases of albinism in giant anteaters from the same area in Central Brazil. The two juvenile individuals presented light-colored fur, unpigmented eyes, and pinkish skin around the eyes, ears, and snout tip. One of the individuals died before achieving adulthood. Given that albinism might affect individual behavior, survival, and fitness, we have started the GPS monitoring of one of the albino individuals. We present the results of our initial health assessment of the individual, showing that its parameters are generally within normality. We also present opportunistic observations showing that its atypical coloration did not affect intraspecific interactions, i.e., the parental care provided by its mother. Finally, we discuss the potential relationship between the individuals, how this could be related to landscape degradation and its associations with population declines in the region. Hence, these records provide additional evidence on the urgency of implementation of conservation measures to cease further population declines of giant anteaters in the *Cerrado* biome, here, focusing on the Mato Grosso do Sul state, Brazil.

Keywords: Atypical coloration. Conservation. Mato Grosso do Sul state. Pilosa. Population decline. Xenarthra.

Resumo: Apresentamos dois casos de albinismo em tamanduás-bandeira da mesma área no Centro-Oeste do Brasil. Os dois indivíduos juvenis apresentavam pelagem clara, olhos não pigmentados e pele rosada ao redor dos olhos, orelhas e ponta do focinho. Um dos indivíduos morreu antes de atingir a idade adulta. Dado que o albinismo pode afetar o comportamento individual, a sobrevivência e a aptidão darwiniana, iniciamos o monitoramento via GPS de um dos indivíduos albinos. Apresentamos os resultados de nossa avaliação inicial de saúde do indivíduo, mostrando que seus parâmetros estão, em geral, dentro da normalidade. Também apresentamos observações oportunísticas mostrando que sua coloração atípica não afetou as interações intraespecíficas, ou seja, o cuidado parental prestado por sua mãe. Por fim, discutimos a possível relação entre os indivíduos, como isso pode estar relacionado à degradação da paisagem e suas associações com o declínio populacional na região. Portanto, esses registros fornecem evidências adicionais sobre a urgência da implementação de medidas de conservação para impedir novos declínios populacionais de tamanduás-bandeira no bioma Cerrado, focando aqui no estado de Mato Grosso do Sul, Brasil.

Palavras-chave: Coloração atípica. Conservação. Mato Grosso do Sul. Pilosa. Declínio populacional. Xenarthra.

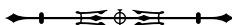
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Autora para correspondência: Nina Attias. R. Georges Sleiman Abdalla, 38. Campo Grande, Mato Grosso do Sul, BR. CEP 79004-230 (nina.attias@gmail.com).

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INTRODUCTION

Atypical coloration in animals is caused by genetic conditions that cause abnormal production of pigmentation and can have fitness consequences for individuals. The three most observed patterns are albinism, leucism, and melanism. Albinism is the total absence of skin and retina pigmentation (Hiller, 1983). Partial albinism occurs when there is a reduction in pigmentation in the skin, fur, or eyes. Leucism is a form of partial albinism where the animal presents typical coloration in their eyes, but their skin or hair contains no color pigment (Forrest & Naveen, 2000). In contrast, melanism is characterized by an excessive deposition of pigmentation. These are rare genetic conditions generally related to recessive alleles (McCardle, 2012; Summers, 2009) and can become more frequent in small populations with higher inbreeding rates (Cuxim-Koyoc et al., 2020; Kuras et al., 2001).

Animal coloration can have an important role in intraspecific behavior and is one of the main factors responsible for crypsis, i.e., an animal's ability to blend with their surroundings and be unnoticed by their predators and prey. Hence, atypical coloration tends to have negative effects on animal survival and fitness (Cuxim-Koyoc et al., 2020; Uieda, 2000). However, when presented in the species with cryptic or nocturnal habits, or those with efficient defense mechanisms, individuals have higher chances of survival (Sazima & Di-Bernardo, 1991). Coat color also plays a key role in filtering solar radiation. Hence, coat color abnormalities could increase skin cancer propensity (Marçon & Maia, 2019) and also affect heat gain, which, in turn, could affect behavioral and metabolic thermoregulation mechanisms (Stuart-Fox et al., 2017; Walsberg, 1983). Furthermore, because pigment cells are essential for the proper functioning of sensory organs such as eyes and ears, color mutations can also negatively affect sensory organs and nerves (Reissmann & Ludwig, 2013). Unfortunately, most records of color abnormalities are presented as opportunistic photographic or video records (e.g., LaPergola, 2019; Uieda, 2000), and few studies

have been able to monitor these individuals in the wild to understand how this condition affects their behavior and survival rates (e.g., Tavares et al., 2020).

The giant anteater (*Myrmecophaga tridactyla* Linnaeus, 1758) is a large sized insectivorous mammal (22-45 kg) that can reach up to 2 m in length (Bertassoni & Desbiez, 2021). The species is broadly distributed throughout the Neotropics and inhabits a variety of habitats, from grasslands to forests (Bertassoni & Desbiez, 2021). They are mostly nocturnal but increase diurnal activity when experiencing lower temperatures (Camilo-Alves & Mourão, 2005; Giroux et al., 2021). Due to their size and defense mechanisms, the only animals known to predate on adult giant anteaters are jaguars (*Panthera onca* Linnaeus, 1758) and pumas (*Puma concolor* Linnaeus, 1771). Although there is high phenotypic variation in fur coloration along the distribution of lesser anteaters of the genus *Tamandua* Rafinesque, 1815 (Hayssen, 2011), coat color of giant anteaters presents a consistent pattern with small intraspecific variation along its distribution (Möcklinghoff et al., 2018).

In this study, we present two cases of albinism in giant anteaters from the same area in Midwestern Brazil and discuss the potential relationship between the cases. Given that albinism might affect individual behavior, survival, and fitness, we present the initial conditions and preliminary results of a monitoring program for one of these albino individuals.

METHODS

STUDY AREA

This study is being conducted at Barra Bonita Ranch, Arapuá district, Três Lagoas municipality, Mato Grosso do Sul state, Brazil (Figure 1). The ranch is dedicated to cattle ranching activity, being covered mainly by pasturelands, and is inserted in a region of Cerrado savanna that has undergone severe degradation, through the conversion of native vegetation into pastureland and *Eucalyptus* plantations, with only a few remnant native savanna fragments (Reynolds et al., 2016).



Figure 1. Study region and location of the records of the two albino individuals at Barra Bonita Ranch, Arapua district, Trés Lagoas municipality, Mato Grosso do Sul state, Brazil. Map: GoogleEarth (2023).

The *Cerrado* is one of the world's largest Biodiversity Hotspots (Myers et al., 2000), but it has one of the lowest levels of protection (1.6% strictly protected). In Mato Grosso do Sul state, only 16% (58,459 km²) of native *Cerrado* remains pulverized in small fragments (average ~9 ha) within an agricultural matrix (Reynolds et al., 2016).

FIRST RECORD

In August 2021, an individual giant anteater with atypical coloration was recorded walking alone in a pasture area (photographed and filmed; Figures 2A and 2C¹) by two ranch workers (Valdemar da Silva and Elias Menossi). Based on video and photo records, it is possible to state that the individual of unknown sex presented hypopigmentation in its fur, skin, and eyes, which are characteristic of albinism. The record was publicly shared by a local news website (Arapua News, 2021). The presence of the atypical individual was recorded by the reporter from the environmental military police (Tenente Coronel Ednilson Queiroz from the 15^o *Batalhão da Polícia Militar Ambiental*, Campo Grande; August 2nd, 2021),

who then contacted our team (Danilo Kluyber) to check on the individual in the field (August 31st, 2021). After receiving the alert about the albino individual, our team was able to visit the study site on September 8th, 2021. After three days of active search, we encountered the carcass of an albino juvenile individual near the location of the first sighting by ranch workers (approx. 200 m; 20° 51' 5.5" S, 52° 02' 6.7" W; Figure 3), which makes us assume this is the same albino individual that had last been seen alive on August 2nd, 2021.

SECOND RECORD

One year later (August 22nd, 2022), a second juvenile albino individual was seen by the same ranch workers in the same area and reported directly to our team. This individual seemed younger than the first one, as it was still on its mother's back (Figure 2B), a behavior observed in individuals under 6 months of age (Jerez & Halloy, 2003). Our team visited Barra Bonita Ranch (September 5th 2022) and captured both mother and cub using long-handled dip nets. Individuals were anesthetized through intramuscular injection and had samples of tissue, blood, hair, feces, and swabs (nasal, oral, ear, and rectal) collected. Capture and handling procedures followed (Kluyber et al., 2021). Finally, to enable periodic health assessments and behavioral monitoring, during anesthesia the albino juvenile was equipped with a GPS harness (TGW4570-4 Iridium GPS; Bertassoni et al., 2022). This will allow us to understand the potential consequences of albinism for individual behavior, physical conditions, and survival. To ensure that the harness does not harm the individual and is fit to the body, periodic recaptures of the individual are being performed for adjustment of the harness' size and health assessments.

To assess the potential relatedness between the albino individuals recorded in the same area, tissue and

¹ Links for the video records of the albino giant anteater (*Myrmecophaga tridactyla*) encountered in August 2021, at Barra Bonita Ranch, Trés Lagoas municipality, Mato Grosso do Sul state, Brazil: ICAS (2022a, 2022b).



Figure 2. Giant anteater (*Myrmecophaga tridactyla*) individuals with atypical coloration pattern recorded at Barra Bonita Ranch, Três Lagoas municipality, Mato Grosso do Sul state, Brazil. (A) Subadult individual (individual #1) with atypical coloration pattern recorded in August 2021. (B) Young giant anteater (individual #2) with atypical coloration pattern (albino) on the back of its mother with typical coloration recorded in August 2022. (C) Close-up showing the faded spots with slightly darker coloration along the head of individual #1 and the characteristic red coloration of the eyes associated with albino individuals on individual #1 (C) and #2 (D). Photos (A) and (C) are still frames from video provided by Valdemar da Silva; photos (B) and (D) were taken by D. Yogui.

hair samples from both albino individuals and from the female that was nursing the second one, were sent to the Molecular Biodiversity and Conservation Lab at the University of São Carlos for genetic kinship analysis. Blood samples were subjected to hematology and biochemistry analysis to assess the health conditions of the albino individual and its mother.

ETHICAL GUIDELINES

This study was performed under License No. 53798-16 from the Chico Mendes Institute for Biodiversity

Conservation, granting permission for individual capture and handling, and biological sample collection and storing. All procedures followed the Guidelines of the American Society of Mammalogists for the use of wild mammals in research (Sikes & ACUC, 2016).

RESULTS AND DISCUSSION

In this study, we actively recorded two juvenile individuals with light-colored fur and unpigmented (red) eyes, characteristic of albinism, in the field. The skin around the eyes, ears, and tip of the snout were light and pinkish

SECOND RECORD

The second individual was recorded in the same area as the first one, one year later (20° 51' 40" S, 52° 01' 49" W). Based on its size and behavior (riding on its mother's back; Figure 2B), the albino individual #2

seemed younger than #1 and was estimated to be 4-5 months old (ZIMS, 2023).

The albino individual and its mother, which presented typical fur and skin coloration (Figure 2B), were captured on September 5th 2022, for the collection of



Figure 4. Morphological details of the albino individual show the lack of pigmentation on its fur (top), snout and tongue (left), forefeet and nails (middle), and hindfeet (right). The bottom photos are shown to provide a reference of the typical coloration of these body parts in giant anteaters (*Myrmecophaga tridactyla*). Images on the top were taken from the second albino individual captured at Barra Bonita Ranch, Arapua district, Trés Lagoas municipality, Mato Grosso do Sul state, Brazil, in 2022. Photos by M. Alves.

biological material (blood and skin), a health assessment, and the fitting of the juvenile with a GPS harness. Upon close inspection, it was possible to record that individual #2 presented a complete absence of pigmentation, with red eyes, a pinkish tongue (the usual coloration is blackish or brown), and unpigmented claws (Figures 2D and 4). Skin tissue was stored at the aforementioned biological collection under the ids #MAM_1043 (albino juvenile) and #MAM_1044 (the albino's mother). Both the mother (body mass = 28 kg) and the albino cub (body mass = 5.6 kg) showed good body condition and blood parameters generally within normality (Table 1; Alves et al., 2023). The alkaline phosphatase of the juvenile was over the normal range, but that is a common pattern among juvenile individuals (Alves et al., 2023). Serum alkaline phosphatase (ALP) activity is used primarily as an indicator of hepatic disease. However, there are numerous non-hepatic factors that can increase serum ALP activity (Fernandez & Kidney, 2007), such as bone mineralization (Vimalraj, 2020), which can explain higher ALP values in growing animals. Both individuals showed blood platelet numbers that indicate thrombocytosis. Thrombocytosis is a multifactorial condition, and some of its causes can be associated with an inflammatory response (Neel et al., 2012). In the present study, the animals did not show signs of inflammatory disease, however, we will repeat these exams to confirm a potential diagnosis, as the other leucogram results do not show any indication of inflammation.

Although records of atypical coloration in wildlife seem to be rare in the scientific literature in comparison to their observation in the wild (McCardle, 2012), other species of xenarthrans have been reported with atypical coloration. Albinism has been recorded in quadruplets of nine-banded armadillo (*Dasypus novemcinctus* Linnaeus, 1758) in Mexico (LaPergola, 2019). There have been records of albinism (Xavier et al., 2010) and leucism (Lopes et al., 2020) for brown-throated sloths (*Bradypus variegatus* Schinz, 1825) in northeastern Brazil and of melanism in

southeastern Brazil (Novaes, 2020). For anteaters, there have been records of leucism (in Peru; More et al., 2021) melanism (in Ecuador; Ríos-Alvear and Cadena-Ortiz, 2019) for tamanduas (*Tamandua tetradactyla* Linnaeus, 1758 and *T. mexicana* (Saussure, 1860)).

Atypical coloration can affect fitness and survival in mammals (Cuxim-Koyoc et al., 2020; Uieda, 2000), and albinos of most species tend to be rapidly removed from populations through predation (Espinal et al., 2016). Albino individuals lack pigmentation in their eyes which can result in poor eyesight (Summers, 2009) and could hinder the detection of resources and predators by visually oriented species, reducing their fitness (Espinal et al., 2016). However, due to the opportunistic nature of most records of albinism, there is little evidence of its ecological consequences in the wild, and most discussions regarding its fitness consequences are speculative (Espinal et al., 2016). Giant anteaters are primarily smell-oriented species that feed on colonial insects (Bertassoni & Desbiez, 2021). Hence, albinism is unlikely to affect the individual's ability to feed, but it could potentially make it more prone to predation. Much like other mammals, the natural coloration of giant anteaters is key to their camouflage in forests and savannas (Nedyalkov et al., 2014). The lighter coloration of albino and leucistic animals can make individuals more conspicuous in the landscape and more prone to predation (Sandoval-Castillo, 2006). In general, the survival of albino individuals until adulthood is low (McCardle, 2012). Nevertheless, this disadvantage can be offset in high-quality habitat (Kehas et al., 2005), with more vegetation cover and high-quality food resources (Peles et al., 1995). Unfortunately, this is not the case in our study region, and one of the juvenile albino individuals here reported was encountered dead in a degraded savanna landscape, which could be the result of a predation event. Hence, albinism in giant anteaters could be considered a maladaptive trait leading to premature death, however, further observations would be needed to confirm this.

Table 1. Hematological and biochemical values for the albino juvenile captured and its mother. Reference values are represented by the mean (^afor normally distributed variables) or median (^b for nonnormally distributed variables) and their standard deviation. Blood samples were collected from the individuals on September 6th 2022 and February 15th 2023.

Variable	Unit	Juvenile (albino)		Adult (mother)	Reference values (Alves et al., 2023)
		Sep/2022	Feb/2023	Sep/2022	
Hematology					
Red blood cells	x1012/L	3.42	3.95	2.22	2.36 ^b ± 0.42
Hemoglobin	g/L	114	115	106	124 ^b ± 13.2
Hematocrit	l/l	0.36	0.36	0.3	0.35 ^b ± 0.06
MCV	fL	104.7		135.1	146.1 ^a ± 16.8
MCHC	g/L	318	329	353	361 ^a ± 47.1
White blood cells	x109/L	9	10.2	7.2	8.7 ^b ± 4.5
Eosinophils	%	20	19	20	17 ^b ± 12
Neutrophils	%	58	46	64	61.5 ^b ± 15.7
Lymphocytes	%	19	27	11	21.7 ^a ± 9.9
Monocytes	%	2	7	3	3 ^b ± 3.67
Platelets	x1012/L	0.34	0.32	0.36	0.18 ^b ± 0.1
Biochemistry					
Total protein	g/L	61	67	67	65 ^b ± 12.6
Albumin	g/L	15	16	14	15 ^b ± 7.6
Globulin	g/L	46	51	53	48 ^a ± 8.2
A/G	ratio	0.33	0.31	0.26	0.31 ^b ± 0.23
Urea Nitrogen (BUN)	mmol/L	11.33	7.07	17.33	12.76 ^a ± 3.61
Creatinine	μmol/L	61.89	17.68	79.58	64.05 ^a ± 20.9
AST	U/L	27.1	35		29 ^b ± 25.7
ALT	U/L	34	45	54.1	77.9 ^a ± 32
Alkaline phosphatase	U/L	150.9	91	17.1	30.3 ^b ± 59.4
GGT	U/L	11			17 ^b ± 13.2
Total bilirubin	μmol/L	3.42			3.4 ^b ± 1.8
Amylase	U/L	687.9			579 ^b ± 216.5
CK	U/L	371.2			193 ^b ± 625
Triglycerides	mmol/L	0.27			0.27 ^b ± 0.49
Cholesterol	mmol/L	2.76	2.23		1.86 ^b ± 0.73
Total Calcium (Ca)	mmol/L	2.07	1.89	2.02	2.2 ^b ± 0.27
Phosphorus (P)	mmol/L	2.02	2.94	1.84	1.97 ^b ± 0.6

Color abnormalities can also affect intraspecific relationships, e.g., parental care and mate choice (McCardle, 2012). However, we did not observe any abnormalities in the parental care behavior of the adult female with normal coloration patterns towards her albino young. During the first two and a half months of GPS monitoring of the albino individual captured in 2022, the female cared for her young as expected according to his life stage, carrying him on her back, nursing him and sleeping together (Bertassoni & Desbiez, 2021). Afterwards, the albino juvenile started foraging by himself, as expected according to his estimated age. The last time it was seen on its mother's back was on November 21st 2022.

In the future, the movement tracking of the albino giant anteater will also allow us to understand the consequences of this color abnormality in the species thermoregulatory mechanisms. Like other xenarthrans, giant anteaters have low basal metabolic rates when compared to other placental mammals of similar size, limiting their physiological capacity for thermoregulation (McNab, 1985). Hence, giant anteaters often rely on behavioral mechanisms for thermoregulation (Camilo-Alves & Mourão, 2005; Giroux et al., 2021). Because hair coat pigmentation plays a key role in filtering solar radiation, we expect albino giant anteaters to have different dynamics of heat gain, which could affect their thermoregulation mechanisms (Stuart-Fox et al., 2017; Walsberg, 1983) and could be reflected in their activity and habitat selection patterns (Camilo-Alves & Mourão, 2005; Giroux et al., 2021). Hence, the GPS-monitoring of this albino individual could provide key insights on the role of coat color in the thermoregulation strategies of this iconic tick-furred mammal in tropical savannas.

In this study, we recorded two albino individuals in the same area (1.2 km apart) over the course of a year. Giant anteaters occur at low densities (< 1 individual/km²; Bertassoni et al., 2021) and, in general, the female is responsible for bearing one pup per year (Bertassoni & Desbiez, 2021). Hence, it is possible that both albino individuals share the same mother or some other close

relationship. Kinship analysis based on the collected tissue samples will be performed by the Laboratory of Molecular Biodiversity and Conservation (UFSCar), which will allow us to test this hypothesis. Furthermore, the occurrence of two albino individuals in the same area raises concerns regarding the population's genetic diversity. That is because the frequency of albinism in a population can be associated with population size, with smaller populations leading to higher rates of inbreeding, which increases the chances of the manifestation of recessive alleles (Kuras et al., 2001; Nedyalkov et al., 2014).

Large mammal species with highly specialized feeding behaviors and solitary habits, such as giant anteaters, are expected to suffer genetic consequences from habitat loss and fragmentation (Lino et al., 2019). The *Cerrado* biome is highly degraded due to human activities, and very little native vegetation remains within its landscape, which suffers from increasing urbanization and is dominated by agricultural lands and transected by an extensive road network (Reynolds et al., 2016). Giant anteaters have been experiencing population declines throughout their distribution due to habitat loss, roadkill, fire, human-wildlife conflicts, and sometimes hunting, and are classified as Vulnerable by the Species Survival Committee of the International Union for Conservation of Nature (Miranda et al., 2014). In Mato Grosso do Sul state, road kills have been shown to significantly reduce population growth rates, being a real threat to the persistence of giant anteater species in the region (Ascensão & Desbiez, 2022). In addition, recent genetic demographic analysis has shown that the current population of giant anteaters in this region presents a significant inbreeding coefficient value and a moderate level of genetic diversity that are likely related to a recent bottleneck (i.e., decrease) in the population (Barragán-Ruiz et al., 2021). Hence, the cases of albinism reported in this study might be additional evidence of the population decline and loss of genetic diversity in this highly degraded part of the *Cerrado*. This highlights the urgency of the implementation of conservation measures to cease

further population declines of giant anteaters in the Cerrado of Mato Grosso do Sul state.

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AUTHORS' CONTRIBUTION

N. Attias contributed with conceptualization, writing of initial draft, formal analysis, reviewing and editing; D. R. Yogui with conceptualization, data collection, project administration, reviewing and editing; M. Alves with data collection, reviewing and editing; D. Kluyber with data collection, reviewing and editing; M. R. Costa with data collection, reviewing and editing; P. M. P. Silva with data collection, reviewing and editing; E. P. Queiroz with data collection, reviewing and editing; and Arnaud L. J. Desbiez with conceptualization, reviewing and editing, funding acquisition, project administration.