Bat fauna in an ore extraction area in Central Brazil

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Keywords: Chiroptera; inventory; ferronickel; conservation.

ABSTRACT – Opencast mining often causes considerable changes to the landscape, including habitat fragmentation and impact on bat activities. The present study aimed to survey the composition of bats in an open pit-mining region in Barro Alto, Goiás. During 20 days of sampling in the rainy season between October (2021) and February (2022), 174 bats of 15 species were sampled. All animals belonged to the Phyllostomidae family of seven subfamilies and 13 genera. *Carollia perspicillata* was the dominant species corresponding to 70.69% of captures. The captured animals had a variety of eating habits, categorized as nectarivore, hematophagous, frugivore, insectivore, and omnivore. According to the national and international lists, none of the species are endangered. Finally, new research is encouraged to leverage knowledge of the bats diversity in the region and relate it to the impacts of mining.

Fauna de morcegos em área de extração de minério no Brasil Central

Palavras-chave: Chiroptera; inventário; ferroníquel; conservação.

RESUMO – A mineração a céu aberto geralmente provoca mudanças consideráveis na paisagem, incluindo a fragmentação de *habitat* e impacto nas atividades dos morcegos. O presente estudo teve como objetivo levantar a composição de morcegos em uma região de mineração a céu aberto no município de Barro Alto, Goiás. Durante 20 dias de amostragens no período chuvoso entre o final de outubro (2021) e fevereiro (2022) foram amostrados 174 morcegos de 15 espécies. Todos os animais pertenciam à família Phyllostomidae de sete subfamílias e 13 gêneros. *Carollia perspicillata* foi a espécie dominante correspondendo 70,69% das capturas. Os animais capturados possuíam uma

variedade de hábitos alimentares categorizados como nectarívoro, hematófago, frugívoro, insetívoro e onívoro. Nenhuma das espécies encontra-se ameaçada de extinção, conforme as listas nacional e internacional. Finalmente, novas pesquisas na área são encorajadas para alavancar o conhecimento da diversidade de morcegos na região e, sobretudo relacionar com os impactos da mineração.

Fauna de murciélagos en un área de extracción de minerales en el centro de Brasil

Palabras clave: Quirópteros; inventario; ferroníquel; conservación.

RESUMEN – La minería a cielo abierto a menudo provoca grandes cambios en el paisaje, incluida la fragmentación del hábitat y el impacto en las actividades de los murciélagos. El presente estudio tuvo como objetivo relevar la composición de los murciélagos en una región minera a cielo abierto en el municipio de Barro Alto, Goiás. Durante 20 días de muestreo en época de lluvias entre finales de octubre (2021) y febrero (2022) se muestrearon 174 murciélagos de 15 especies. Todos los animales pertenecían a la familia Phyllostomidae de siete subfamilias y 13 géneros. *Carollia perspicillata* fue la especie dominante correspondiendo al 70,69% de las capturas. Los animales capturados tenían una variedad de hábitos alimenticios categorizados como nectarívoros, hematófagos, frugívoros, insectívoros y omnívoros. Ninguna de las especies encontradas amenazadas según la lista nacional e internacional. Finalmente, se impulsan nuevas investigaciones en el área para aprovechar el conocimiento de la diversidad de murciélagos de la región y, sobre todo, relacionarlo con los efectos del proyecto.

Introduction

The order Chiroptera comprises 1474 species of bats [1], 22% of the world's mammals. These animals are the second most diverse group of mammals on the planet, surpassed only by rodents. In Brazil, the country with the world's second-highest diversity of bats, 186 species of 68 genera and nine families are recognized [2][3]. For the Cerrado, 118 species are listed [4]; that is, 65% of the bat richness in the country is found in this biome. Linked to their diversity, the bats have varied eating habits, one of the mechanisms that allow them to survive in different places [5][6]. These animals feed on insects, and others consume fruits and nectar, but there are also carnivorous bats that feed on fish and small crustaceans such as scorpions and the well-known vampire bats that feed on blood [7].

However, bats are under several pressures around the world. Among the main ones are fungi that cause white-nose syndrome [8], wind turbines [9], habitat loss [10], climate change [11], run over on roads [12], and contamination by chemical agents [13][14]. Regarding chemical agents, mining areas are particularly noteworthy for their potential to harm biodiversity and impact human health. Although mining is economically significant, open-pit mining, in particular, causes sudden and extensive changes to the landscape, including habitat fragmentation and disruption of bat activities [15], this effect can then generate complications in their health, having effects on the sustainability of their populations and the survival of the species.

For example, liver metal bioaccumulation and DNA damage in insectivorous bats was observed in coal mining animals in the Santa Catarina Carboniferous Basin, southern Brazil [16]. Another study in the area of coal mining indicated that chronic exposure of bats to environments filled with ore dust particles causes histological and oxidative damage [17]. In a Ferronickel mining area in Goiás, the location of the present study, bats were observed with a high frequency of DNA damage [18][19]. Finally, iron mining pollution in fruit bats in the Atlantic Forest also showed greater hepatic accumulation of aluminum, calcium, iron, and barium; muscular accumulation of Ca and Fe, in addition, they detected oxidative stress in the brain, hepatic and renal oxidative damage associated with liver fibrosis and renal inflammation [20], indicating the susceptibility of these animals to pollutants generated by mining companies that can compromise its survival.

Although these works have highlighted the ecotoxicological impact, primary studies, such as fauna inventories in mining areas, remain scarce

for open-pit mining. In contrast, the bat fauna in underground mining is well-documented in several regions around the world [21][22][23]. In this context, the present study aimed to survey the composition of bats in an open-pit mining region in Barro Alto, Goiás, to know the diversity of local animals. To our knowledge, this is the first study, at least in the state of Goiás, to inventory bats within a ferronickel mining area.

Material and Methods

Sampling

Bats were sampled in Barro Alto, Goiás, between October 2021 and February 2022, ten days in each period, Barro Alto, the city where the study was carried out, has had an industrial ferronickel production plant since 2011 [18]; being one of the main areas of metal extraction in the country. Ten mist nets were used in fragments of cerrado in the ore extraction area with points up to 100 meters from the excavation zones and peripheral regions, totaling ten sampling sites (Figure 1). The mist nets were open for the first four hours of activities [21][24], between 6:00pm and 10:00pm and inspected every 30 minutes, totaling 19,200m2h of nets. Each animal was packed in a cotton bag, sorted, and released in the same capture area. Biological samples were obtained from some species and have been published elsewhere [18]. The species identification criterion was used by Reis et al. [25] in addition to checking the list of bats in Goiás [26] and the list of the Sociedade Brasileira de Estudos de Chiroptera [2]. The project was licensed by the Chico Mendes Institute under number 75819-1 and by the Ethics Committee of the Federal University of Goias (nº 004/21).

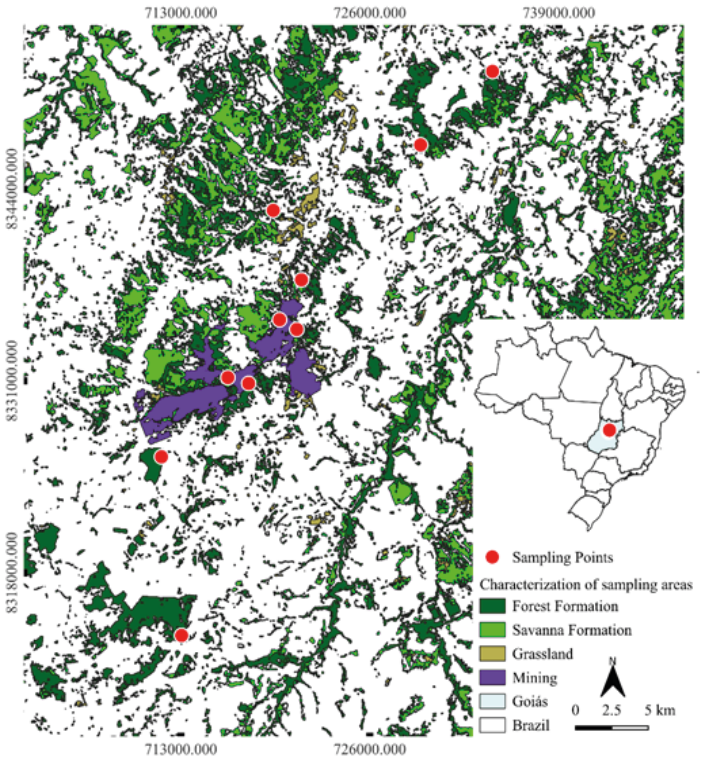

Figure 1 – Bat sampling region in Barro Alto, Goiás.

Data analysis

The diversity index was conducted following Shannon-Wiener, and the Equitability index using the H/Hmax ratio. A richness estimation curve was constructed based on 1,000 randomizations, and the estimator used was the first-order Jackknife. Finally, the conservation status of all species was assessed according to the Brazilian list of endangered fauna from the Ministry of the Environment [27] and the IUCN international list [28].

Results and Discussion

The present study sampled 174 bats of 15 species in Barro Alto, Goiás. The study sampled 13% of bats from the Cerrado and 8% when considering the Brazilian territory. All captured animals belonged to the Phyllostomidae family, comprising seven subfamilies and 13 genera (Table 1). However, it is important to note that the mist net method favors the capture of the Phyllostomidae family [29]. Additionally, given that the sampling was conducted over 20 nights with 4 hours per night, these results are still preliminary for the study area.

Table 1 – Bats sampled in Barro Alto Goiás in Central Brazil.

Táxons	Abundance		Guild	Status	
	Absolute	Relative		MMA	IUCN
Phyllostomidae					
Glossophaginae					
Anoura caudifer	2	1.15%	N		LC
Glossophaga soricina	11	6.32%	N		LC
Desmodontinae					
Desmodus rotundus	6	3.45%	H		LC
Stenodermatinae					
Artibeus lituratus	5	2.87%	F		LC
Artibeus planirostris	1	0.57%	F		LC
Artibeus cinereus	2	1.15%	F		LC
Platyrrhinus lineatus	6	3.45%	F		LC
Platyrrhinus incarum	1	0.57%	F		LC
Sturnira lilium	4	2.30%	F		LC
Carolliinae					
Carollia perspicillata	123	70.69%	F		LC
Lonchophyllinae					
Lionycteris spurrelli	1	0.57%	N		LC
Phyllostominae					
Lophostoma silvicola	6	3.45%	I		LC
Tonatia maresi	1	0.57%	I		*
Phyllostomus discolor	4	2.30%	O		LC
Micronycterinae					
Micronycteris sp.	1	0.57%	I		*
Abundância	**174**				
Riqueza	**15**				
Shannon H	**1.294**				
Equitabilidade J	**0.478**				

Trophic Guild: N) Nectarivore, H) Hematophage, F) Frugivore, I) Insectivore and O) Omnivore. LC) Least concern. No species at risk for MMA. * Not found. MMA) Ministry of the Environment, IUCN) International Union for Conservation of Nature and Natural Resources.

The diversity index in the region was H' = 1.294, and the uniformity of J = 0.478. The rarefaction curve did not tend to an asymptote, indicating four more species in the area (Figure 2). Although it did not occur in a mining area, a previous study on a farm in the municipality of Barro Alto, Zortéa and D'arc [30] sampled 116 bats from 14 species. The diversity (H' = 1.657) and uniformity (J = 0.628) indices were higher in the study by Zortéa and D'arc [30]. In contrast to the present study, it's likely that our high capture abundance, particularly for *Carollia perspicillata,* contributed to this difference, despite the presence of one additional species. In a study conducted in an iron and manganese mining area in Corumbá, Mato Grosso do Sul, 83 bats representing nine species were captured, all of which belonged to the Phyllostomidae family. This finding supports the notion that the mist net method tends to be more biased toward capturing species within this family.

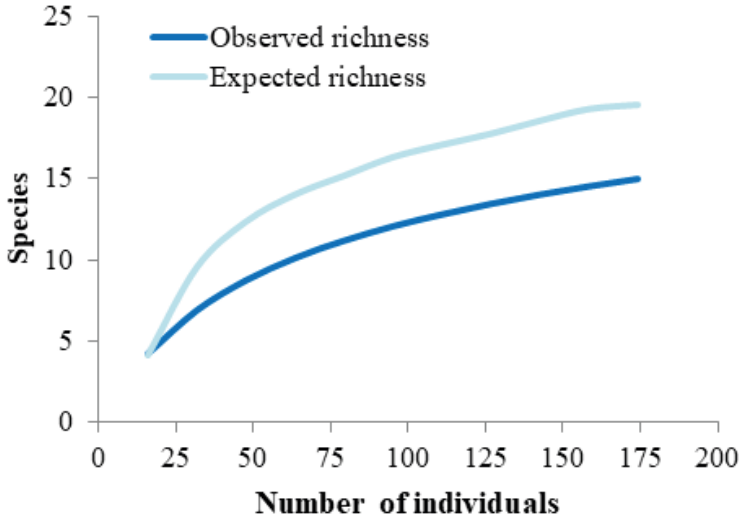

Figure 2 – Species accumulation curve. Dark blue line indicates the observed richness, while the light blue line is the expected richness (Jackknife 1). The test was performed with a 95% confidence interval for the association with the estimate.

Carollia perspicillata was the dominant species corresponding to 70.69% of the total number of captured animals, corroborating Zortéa and D'arc [30], followed by *Glossophaga soricina* with 6.32%. The significant representation in captures of *G. soricina* has also been evidenced in studies from Goiás [31] [30]. This species is a generalist and opportunistic, and its capture is widespread [32][33][34][35]. In addition to these common species, it is worth highlighting those less captured in the present study, such as *Artibeus planirostris*, *Platyrrhinus incarum*, *Lionycteris spurrelli*, *Tonatia maresi*, and *Micronycteris* sp. Future studies in the same investigated areas may answer whether such species are rare in the respective locations, although seasonality affects the abundance and composition of species [36][37].

Bats were represented by five trophic guilds (Figure 3). Frugivores had the highest species richness (n = 7) and abundance (n = 142; 82%). The prominent representatives were from the subfamily Stenodermatinae and Carolliinae. Stenodermatinae are bats that generally have facial stripes, and some species have stripes on the back [25], which are evident or barely perceptible. In Brazil, there are 35 species [2]. Carolliinae, the species belonging to this subfamily, was *C. perspecillata*. For hematophagous, the typical vampire bat, *Desmodus rotundus*, was captured. However, in the state of Goiás, there is still the occurrence of the other two species of bats that feed on blood, *Diaemus youngi* and *Diphylla ecaudata* [26]. *Desmodus rotundus* is a species of interest for public and rural health in Tropical America because it is an essential transmitter of the rabies virus [38].

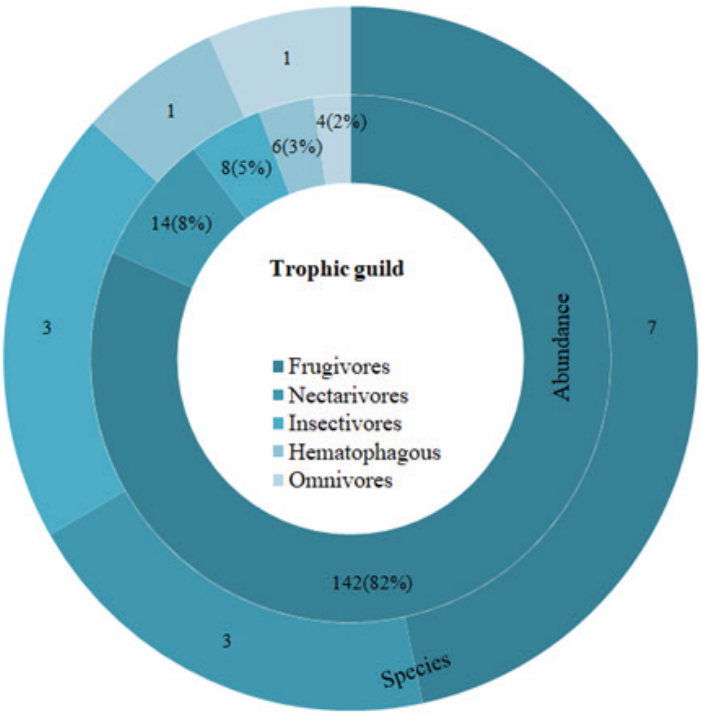

Figure 3 – Bat trophic guild. Inner circle indicates the abundance and the peripheral circle species richness.

The omnivores were represented by the species *Phyllostomus discolor*. This species can be found in forest environments and altered by plantations and urban areas [25]. As for the nectarivorous species, *Anoura caudifer*, *Glossophaga soricina*, and *Lionycteris spurrelli* were captured. The insectivores were *Lophostoma silvicola*, *Tonatia maresi*, and *Micronycteris sp*., which corresponded to 5% of the total abundance. Bats with an insect-based diet suppress populations of pests in agricultural ecosystems [39], which generates income for farmers [40]. Therefore, in a state where the leading economy is based on agriculture, it is essential to consider these animals as partners in crops and natural pest controllers, which is highly beneficial to environmental health. Typical and exclusively insectivorous bat families such as Molossidae and Vespertilionidae were not sampled, although they are rarely sampled in the fog network. However, in the review by Hannibal et al. [26], the authors listed 12 species of Vespertilionidae and 14 of Molossidae for the state of Goiás.

Ultimately, in mining areas, the stressors on bats include noise pollution generated by machinery, which could impact the foraging behavior of certain species. Moreover, the presence of vehicles results in a notable decrease in bat activity near roads, largely attributable to elevated noise levels [41]. Theobald et al. [15] noted that distance from the mine is considered an essential predictor of bat species richness and activity levels, with the effect on richness extending to approximately 900 m from the site and the effect on activity potentially extending beyond the sampling area (1,200 m). In this study, some sampling points were conducted in forest remnants over 100 meters from the ore extraction area. For *Lonchophylla dekeyseri* an endemic species of the Brazilian Cerrado, deforestation and mining are acknowledged as significant threats [42]. Moreover, studies in the field of ecotoxicology have raised alarms regarding bat contamination by metals in mining areas on a global scale [16][43][20].

Conclusion

The richness and diversity of bats were evaluated in a mining company in Barro Alto, Goiás, in the Central Plateau, Brazil. The study surveyed 15 species of bats, which represents 17% of the total recorded in the state of Goiás. Considering that basic biology studies, such as inventories in Brazilian mining areas, are scarce. There is limited understanding of

the bat composition in mining areas. We acknowledge that our study was not exhaustive in identifying all potential species in the area, and further research is warranted. Future studies in mining areas could explore bat composition across various sampling sites and compare them with reference (control) areas. Additionally, evaluating different stations would provide insights into the impact of mining activities on bat composition, thus enhancing our understanding of their ecological dynamics in these environments.

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References

1. MDD. Mammal Diversity Database [https://www.mammaldiversity.org/taxa.html]. Explore Current Mammalian Taxonomy. [accessed on November 5, 2024]. Available at: https://www.mammaldiversity.org/taxa.html

2. Garbino GST, Gregorin R, Lima IP, Loureiro L, Moras LM, Moratelli R, Nogueira MR, Pavan AC, Tavares VC, do Nascimento MC, Peracchi AL. Updatedche cklist of Brazilian bats: versão 2020. Comitê da Lista de Morcegos do Brasil - CLMB. Sociedade Brasileira para o Estudo de Quirópteros (Sbeq). [Internet]. 2024 November [cited November 04]. Available from: https://www.sbeq.net/lista-de-especies

3. Zortéa M, Ribeiro MCS, Mata PSD, Bonvicino CR. Morphological and molecular evidence of the occurrence of *Artibeus amplus* (Chiroptera: Phyllostomidae) in Brazil. Zoologia (Curitiba). 2023; 40: e22058. https://doi.org/10.1590/S1984-4689.v40.e22058

4. Aguiar LM, Bernard E, Ribeiro V, Machado RB, Jones G. Should I stay or should I go? Climate change effects on the future of Neotropical savannah bats. Glob. Ecol. Conserv. 2016; 5: 22-33. doi.org/10.1016/j.gecco.2015.11.011

5. Benvindo-Souza M, Hosokawa AV, Dos Santos CGA, de Assis RA, Pedroso TA, Borges RE, Pacheco SM, Souza Santos LR, Silva DDM. Evaluation of genotoxicity in bat species found on agricultural landscapes of the Cerrado savanna, central Brazil. Environ Pollut. 2022; 118579. doi.org/10.1016/j.envpol.2021.118579

6. Sil-Berra LM, Sánchez-Hernández C, Romero-Almaraz MDL, Reynoso VH. Bat species diversity and abundance of trophic guilds after a major hurricane along an anthropic disturbance gradient. Diversity. 2022; 14: 818. https://doi.org/10.3390/d14100818

7. Gorbunova V, Seluanov A, Kennedy BK. The world goes bats: living longer and tolerating viruses. Cell Metab. 2020; 32: 31-43. doi.org/10.1016/j.cmet.2020.06.013

8. Hoyt JR, Kilpatrick AM, Langwig KE. Ecology and impacts of white-nose syndrome on bats. Nat. Rev. Microbiol. 2021; 19: 196-210. doi.org/10.1038/s41579-020-00493-5

9. Reusch C, Lozar M, Kramer-Schadt S, Voigt CC. Coastal onshore wind turbines lead to habitat loss for bats in Northern Germany. J Environ Manage. 2022; 310: 114715. doi.org/10.1016/j.jenvman.2022.114715

10. Frick WF, Kingston T, Flanders J. A review of the major threats and challenges to global bat conservation. Ann. N. Y. Acad. Sci. 2020; 1469: 5-25. doi.org/10.1111/nyas.14045

11. Kafash A, Ashrafi S, Yousefi M. Modeling habitat suitability of bats to identify high priority areas for field monitoring and conservation. Environ Sci Pollut Res. 2022; 29: 25881-25891. doi.org/10.1007/s11356-021-17412-7

12. Altringham J, Kerth G. Morcegos e estradas. Gerald. Bats and roads. Bats in the Anthropocene: conservation of bats in a changing world. Springer, Cham. 2016; 35-62.

13. Schanzer S, Koch M, Kiefer A, Jentke T, Veith M, Bracher F, Bracher J, Müller C. Análise de resíduos de pesticidas e poluentes orgânicos persistentes em morcegos alemães. Chemosphere. 2022; 305: 135342. doi.org/10.1016/j.chemosphere.2022.135342

14. Sotero DF, Benvindo-Souza M, de Freitas RP, Silva DDM. Bats and pollution: Genetic approaches in ecotoxicology. Chemosphere. 2022; 307:135934. doi.org/10.1016/j.chemosphere.2022.135934

15. Theobald E, Hosken DJ, Foster P, Moyes K. Mines and bats: the impact of open-pit mining on bat activity. Acta Chiropt. 2020; 22: 157-166. doi.org/10.3161/15081109ACC2020.22.1.014

16. Zocche JJ, Leffa DD, Damiani AP, Carvalho F, Mendonça RÁ, dos Santos CEI, Boufleur LA, Dias JF, de Andrade VM. Heavy metals and DNA damage in blood cells of insectivore bats in coal mining areas of Catarinense coal basin, Brazil. Environ. Res. 2010; 110: 684-691. doi.org/10.1016/j.envres.2010.06.003

17. Pedroso-Fidelis GS, Farias HR, Mastella GA, Boufleur-Niekraszewicz LA, Dias JF, Alves MC, Silveira PCL, Nesi RT, Carvalho F, Zocche JJ, Pinho RA. Pulmonary oxidative stress in wild bats exposed to coal dust: A model to evaluate the impact of coal mining on health. Ecotoxicol. Environ. Saf. 2020; 191: 110211. doi.org/10.1016/j.ecoenv.2020.110211

18. Sotero DF, Benvindo-Souza M, de Carvalho Lopes AT, de Freitas RMP, de Melo e Silva D. Damage on DNA and hematological parameters of two bat species due to heavy metal exposure in a nickel-mining area in central Brazil. Environ. Monit. Assess. 2023; 195(8): 1000. doi.org/10.1007/s10661-023-11526-w

19. Benvindo-Souza M, Sotero DF, Dos Santos CGA, de Assis RA, Borges RE, de Souza Santos LR, de Melo e Silva D. Genotoxic, mutagenic, and cytotoxic analysis in bats in mining area. Environ Sci Pollut Res. 2023; 30(40): 92095-92106. doi.org/10.1007/s11356-023-28861-7

20. Destro ALF, Gonçalves DC, da Silva Alves T, Gregório KP, da Silva VM, Santos VR, Castro OW, Baggio Filho H, Garbino GST, Gonçalves RV, Oliveira JM, Freitas MB. Iron and aluminum ore mining pollution induce oxidative and tissue damage on fruit-eating bats from the Atlantic Forest. J Hazard Mater. 2014; 465: 133285. doi.org/10.1016/j.jhazmat.2023.133285

21 Storz JF, Williams CF. Summer population structure of subalpine bats in Colorado. Southwest. Nat. 1996; 41(3): 322-324.

22. Diamond GF, Diamond JM. Bats and mines: evaluating Townsend's big-eared bat (*Corynorhinus townsendii*) maternity colony behavioral response to gating. West. N. Am. Nat. 2014; 74(4): 416-426. doi.org/10.3398/064.074.0407

23. Thakare M, Randive K. Distinctive Bats Species in Abandoned Mines: Adventure Geotourism for Nature Enthusiasts. In: Randive K, Pingle S, Agnihotri A. (eds.) Innovations in Sustainable Mining. Earth and Environmental Sciences Library. Springer, Cham. 2021. doi.org/10.1007/978-3-030-73796-2_14

24. Porfirio G, Bordignon MO. Phyllostomid bats and their diets at Urucum massif, Mato Grosso do Sul, Brazil. Chiropt. Neotrop. 2013; 21(2): 1332-1337.

25. Reis NR, Fregonezi MN, Peracchi AL, Shibatta OA. Morcegos do Brasil: Guia de Campo. Rio de Janeiro: Technical Books. Londrina; 2013.

26. Hannibal W, Zortéa M, Calaça AM, Carmignotto AP, Bezerra AM, Carvalho HG, Bonvicino CR, Martins ACM, Aguia LMS, de Souza MB, Mattos I, Oliveira RF, Brito D, Silva DA, Guimães MA, Carmo EMB, Moreira, JC. Check list of mammals from Goiás, central Brazil. Biota Neotrop. 2021; 21. doi.org/10.1590/1676-0611-BN-2020-1173

27. MMA. Ministério do Meio Ambiente - Lista Oficial das Espécies da Fauna Ameaçadas de Extinção, 2022. [Internet]. 2024 November [cited November 04]. Available from https://drive.google.com/file/d/13H9_s1eWJgwczD0D1-v5ptpeHBVzcbdE/view

28. IUCN. The IUCN Red List of Threatened Species. Version 2022-1. [Internet]. 2024 November [cited November 04]. Available from: https://www.iucnredlist.org

29. Pereira MJR, Fonseca C, Aguiar LM. Loss of multiple dimensions of bat diversity under land-use intensification in the Brazilian Cerrado. HYSTRIX, 2018; 29(1): 25. doi.org/10.4404/hystrix-00020-2017

30. Zortéa M, D'arc FC. Diversity of three bat assemblages of Central Brazil. Mastozool. Neotrop. 2019; 26: 468-474. doi.org/10.31687/saremMN.19.26.2.0.09

31. da Silva JPA, Carvalho AR, de Oliveira Motta JA. Fauna de morcegos (Mammalia, Chiroptera) em cavernas do bioma Cerrado na região de Indiara (Goiás). Rev. Bras. Zoociênc. 2009; 11(3): 209-217.

32. Pina SM, Meyer CF, Zortéa M. A comparison of habitat use by phyllostomid bats (Chiroptera: Phyllostomidae) in natural forest fragments and *Eucalyptus plantations* in the Brazilian Cerrado. Chiropt. Neotrop. 2013; 19: 14-30.

33. Torres JM, dos Anjos EA, Ferreira CM. Frugivory by phyllostomid bats (Chiroptera, Phyllostomidae) in two cerrado urban remnants in Campo Grande, Mato Grosso do Sul. Iheringia. Iheringia, Sér. Zool. 2018; 108. doi.org/10.1590/1678-4766e2018002

34. Carvalho WD, Meyer CF, Xavier BDS, Mustin K, Castro IJD, Silvestre SM, Pathek DB, Capaverde Jr. UD, Hilário R, Toledo JJD. Consequences of replacing native savannahs with acacia plantations for the taxonomic, functional, and phylogenetic α-and β-diversity of bats in the Northern Brazilian Amazon. Front. Ecol. Evol. 2020; 8:609214.

35. Benvindo-Souza M, de Souza Santos LR, Elias Borges R, Alves de Assis R, de Melo e Silva D, Zortea M, Missel Pacheco S. Thousands of bats: A portrait of the chiropteran fauna of Palmas city, Central Brazil. Austral Ecol. 2021; 46(5): 876-879. doi.org/10.1111/aec.13032

36. Sperr EB, Caballero-Martínez LA, Medellin RA, Tschapka M. Seasonal changes in species composition, resource use and reproductive patterns within a guild of nectar-feeding bats in a west Mexican dry forest. J. Trop. Ecol. 2011; 27(2): 133-145. doi.org/10.1017/S0266467410000714

37. Ferreira DF, Rocha R, López-Baucells A, Farneda FZ, Carreiras JM, Palmeirim JM, Meyer CF. Season-modulated responses of Neotropical bats to forest fragmentation. Ecol. Evol. 2017; 7(11): 4059-4071. doi.org/10.1002/ece3.3005

38. Cárdenas-Canales EM, Stockmaier S, Cronin E, Rocke TE, Osorio JE, Carter GG. Social effects of rabies infection in male vampire bats (*Desmodus rotundus*). Biol. Lett. 2022; 18: 20220298. doi.org/10.1098/rsbl.2022.0298

39. Beilke EA, O'Keefe JM. Bats reduce insect density and defoliation in temperate forests: An exclusion experiment. Ecology. 2022; e3903. doi.org/10.1002/ecy.3903

40. Aguiar LM, Bueno-Rocha ID, Oliveira G, Pires ES, Vasconcelos S, Nunes GL, Frizzas MR, Togni PH. Going out for dinner - The consumption of agriculture pests by bats in urban areas. PloS One 2021; 16:e0258066. doi.org/10.1371/journal.pone.0258066.

41. Zurcher AA, Sparks DW, Bennett VJ. Why the bat did not cross the road?. Acta Chiropt. 2010; 12(2): 337-340. doi.org/10.3161/150811010X537918

42. Oliveira HFM, Fandos G, Zangrandi PL, Bendini HD N, Silva DC, Muylaert RL, Marinho-Filho JS, Fonseca LM, Rufin P, Schwieder M, Domingos FMC. Crops, caves, and bats: deforestation and mining threaten an endemic and endangered bat species (*Lonchophylla: Phyllostomidae*) in the Neotropical savannas. HYSTRIX. 2022; 33(2): 158-166. doi.org/10.4404/hystrix-00541-2022

43. Carrasco-Rueda F, Loiselle BA, Frederick PC. Mercury bioaccumulation in tropical bats from a region of active artisanal and small-scale gold mining. Ecotoxicology. 2020; 29: 1032-1042. doi.org/10.1007/s10646-020-02195-3

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