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Protecting urban wildlife fauna, fighting zoonoses, and preventing biophobia in Brazil

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Biophobia has increased worldwide, particularly in high-income countries, leading to the loss of natural interactions and fewer health and wellbeing benefits for humans and animals. Wildlife avoidance in Brazilian urban settings has been mostly directed to synanthropic species (so-called “harmful fauna”) due to the risk of zoonosis and mostly involves bats, capybaras, opossums, and monkeys. Additionally, feral cats and stray dogs prey on vulnerable wildlife fauna, decreasing biodiversity. Wildlife protection groups have contributed to this biophobia by demanding the capture and relocation of local wildlife to distant states and federal parks. Nonetheless, some Brazilian state capitals peacefully coexist with steady or growing urban wildlife. Accordingly, this study aimed to present initiatives for wildlife protection, zoonosis surveillance, and biophobia prevention in Curitiba, the eighth-largest Brazilian city in the world and considered among the most sustainable cities in Latin America. Instead of sole sustainability, the One Health approach has been applied to address animal, human, and environmental health as part of city priorities, including free-of-charge veterinary services, basic school education, and a newly established public veterinary hospital. Animal Protection Services, City Secretary of Environment, has promoted substantial improvements in pet guardianship and urban wildlife fauna protection, with an updated city wildlife inventory, attendance, and release of native fauna into city parks. Meanwhile, the Zoonoses Surveillance Unit (ZSU), City Secretary of Public Health, has worked daily to prevent zoonoses and other public health issues, particularly bat rabies, with minimal impact on city wildlife. Children’s outreach and educational handbooks, inserted into teaching content in basic schools, are used to prevent biophobia in future generations. In summary, Curitiba may serve as a model for the One Health approach (in addition to sustainability) for the concomitant improvement of animal health and wildlife protection in major cities in Brazil and worldwide.

KEYWORDS

sustainability, One Health, biophilia, rabies, bats, rats

1 Introduction

Biophobia (*Bio*, life + *phobus*, fear), defined as fear, disgust, aversion, or other negative feelings in response to certain natural stimuli, prevents natural interactions, including with unharmed wildlife organisms, reducing emotional connection toward nature, decreasing pro-environmental behavior and actions, and leading to an increasing cycle of detachment and alienation from nature (Soga and Gaston, 2016; Soga et al., 2023). This phenomenon has been increasingly observed in the highly populated urban areas of contemporary societies in high-income countries, where excessive biophobia has been suggested to be a common phenomenon (Soga et al., 2023). The loss of contact with nature has also been associated with the extinction of experience (Miller, 2005; Soga and Gaston, 2016), which in turn has been linked to the decrease of environmental concern by urban residents, currently accounting for nearly half of the worldwide population (Miller, 2005). In addition, teaching fear and aversion during childhood, particularly in avoidance of animal-to-human diseases, may induce future biophobia (Zhang et al., 2014; Soga and Evans, 2024). Moreover, elevated biophobia may negatively affect biodiversity conservation, including a reduced willingness to coexist with wildlife and protection policies, along with undervaluation of their benefits (Soga et al., 2023). Interestingly, biophobia in urban settings may be justified as animal conservation translocation, with the capture and relocation of native animal species to wildlife reservations, which has questionably increased populations and genetic variability, particularly in endangered species (Conservation translocations: a review of common difficulties and promising directions, 2020). It may also have a dangerous impact on lower and more fragile urban biodiversity, reaching an abiotic point of no return. Increasing biophobia may create feedback cycles, which may magnify individual or collective fear or disgust perceptions towards nature, with reported examples of such vicious loops (Soga and Evans, 2024). Assessment of Chinese school children in urban settings has suggested that nature contact may increase their indirect motivation to support animal conservation by developing positive attitudes toward wildlife (Zhang et al., 2014). Similarly, Japanese children presenting negative attitudes (biophobia) towards invertebrates have shown a decrease in direct nature experiences, which may have triggered increased biophobia (Soga et al., 2020). In such a scenario, efforts to reestablish human connections with the natural environment through meaningful interaction should be strongly considered and applied (Bennett and Reyers, 2024).

In contrast, biophilia (*Bio*, life + *philia*, affection) has been defined as “the urge to affiliate with other forms of life,” as an innate desire to enjoy contact with living nature (Barbiero and Berto, 2021), historically counterpoising biophobia and proposing a more balanced approach, particularly in urban settings, with incorporation into architecture instead of nature avoidance. Although the human evolutionary past has been closely associated with nature, modern societies, particularly teenagers and children, have increasingly lacked direct and frequent contact with wildlife, which can negatively affect physical and mental health (Oswald et al., 2020). A statistically

significant and positive relationship was found between nature interaction and mental health, particularly focused on attention deficit and hyperactivity disorders, according to a systematic review (Tillmann et al., 2018). In China, young adults living in urban areas with direct or indirect natural contact have improved strategies of feeling regulation by cognitive reassessment and control (Gu et al., 2023). Thus, a positive response to nature, including predilection and recognized repair, may be learned and dependent on positive emotional associations (Barbiero and Berto, 2021). In addition, the presence of neighborhood natural areas may improve the general health of adults through physical activity, social contact, and subjective well-being, based on an analytic study in 18 countries (Elliott et al., 2023). Finally, the health and wellbeing benefits of biodiversity in urban areas may surpass the negative effects such as viruses and pollen and may be considered nature-based solutions to address public health concerns, according to a review study (Marselle et al., 2021). The replacement of natural grass, plants, bushes, and trees with sand, gravel, asphalt, artificial grass, and concrete, both outside and inside households, has been justified by cleaner (no mud or leaves) pathways, easier washable areas (such as backyards for pets and vegetables), and fewer synanthropic insects such as ants and termites. Although modern, practical, and useful, a lack of outdoor (and indoor) greenness may deteriorate mental health, as natural exposure has been associated with improvements in physical health such as reduced blood pressure, heart rate, inflammation, stress, anxiety, and depression (Paniccià et al., 2024). In São Paulo, the largest Brazilian city, the fear of branches and trees falling onto people and vehicles after heavy rainfall and of storms damaging walls and houses has condemned large tree canopies and their centuries-old trunks, replacing avenues with cemented sidewalks disturbed only by posts, traffic signs, and garbage cans. The fear of flooding has led to the canalization of entire rivers, suffocating riverside fauna and flora, and manmade underground “pools” made underneath parking lots of São Paulo being built to accumulate the fast-moving rainfall water that floods streets and sidewalks, which can no longer absorb water (FAPESP and AGÊNCIA FAPESP, 2021; Millington, 2021; BBC, 2024). Such fear and avoidance of nature, associated with the apparent lower cost of cleaning and maintenance, have replaced entire lawns of sidewalks, squares, parks, and even backyards with cement and concrete; such areas are commonly isolated by fences, iron grilles, and brick walls. Surrounded by cement and asphalt, trees have been suffocated with little space and water, falling by the dozen during heavy rainfall and thunderstorms in 2024, causing several long-lasting blackouts affecting over half a million people (Jornal da USP, 2024). Curitiba, the eighth largest Brazilian city and considered the most sustainable nationwide, has dealt with flooding by doing the exact opposite—avoiding concrete and asphalt, increasing the soil drainage capacity throughout the city, and using low-level parks as natural pools for rapidly moving flooding (IBGE, n.d.; Curitiba, 2024a).

Pesticides, insecticides, and rodenticides have been ostensibly used in urban areas to control weeds, ants, mosquitoes, termites, and rats, and are often applied by the city hall itself, without any study on their long-term environmental impact. Large urban centers may turn into “concrete jungles” dominated by concrete and asphalt, with glass walls

buildings and concrete cell phone towers mimicking trees which cause fatal collisions with birds every year. Not surprisingly, the number of birds killed every year in the USA by glass collision has been estimated at 365–988 million, surpassed in anthropogenic impact to avian life only by birds killed by free-ranging domestic cats, estimated between 1.3–4.0 billion deaths per year (Schneider et al., 2018). In such a scenario, frogs, dragonflies, fireflies, endangered butterflies, and other native wildlife species gradually became memories, part of grandparents' stories, and urban legends of major cities, reducing natural biomes and ecosystems and impairing the capacity of resilience and self-renovation of such environments.

In addition, the growth of Brazilian road infrastructure towards the countryside to transport agricultural goods and travelers is another important factor in biodiversity losses, mostly due to roadkill and biome fragmentation, with roads splitting into natural areas with no wildlife protection or safe crossing (Navas-Suárez et al., 2022). With no practical answer to date in Brazil, wildlife safety on roads has become crucial for conservation, requiring passages by bridges and tunnels, a nationwide notification system for fauna roadkill, and mapping of critical (fatal) road points for signage and other preventive measures (Navas-Suárez et al., 2022). Accordingly, the present study aimed to provide an overview of biophilia/biophobia in Brazil and public practices to prevent zoonoses while protecting Brazilian wildlife and, concretely, to describe the biophilic actions performed in the city of Curitiba.

2 Methods

The present study provides an overview of biophilia/biophobia in Brazil and the current initiatives of Curitiba, considered one of the most sustainable cities in Latin America.

3 Human-wildlife interactions in ancient Brazil

Although historically threatening human survival and evolution through predation and diseases (direct and vector-borne), wildlife fauna have also provided essential animal-based proteins for human survival (Pettan-Brewer et al., 2021). Perceptions of human and animal health and their interconnectedness have long appeared in the traditional understanding of indigenous peoples in Latin America. Preceding humans by millions of years, animals have profoundly impacted what became Latin America, while the appearance of humans has similarly affected the health and life of native fauna, with a long history of predation starting with the potential extinction of several Latin American megafauna species by the Paleo-Indians (Zhang et al., 2014). Although the domestication of livestock by wildlife has increased protein demand worldwide, not a single Brazilian native animal species has been domesticated by Brazilian indigenous peoples (Camphora, 2017). At the time, domesticated animals in the New

World included only two large birds, turkeys in North America and Muscovy ducks in Central America; four Andean species, two camelids, llama, and alpaca; and two medium-sized rodents, guinea pigs and chinchilla species (Stahl, 2008). Although one report suggested that the few pre-Columbian domesticated species were the result of geographical peculiarities associated with limited domestication candidates after the massive extinctions of the Pleistocene (Diamond, 2005), several native Brazilian species were docile and later domesticated and are currently used for commercial purposes, including several caimans, peccaries, water turtles, tortoises, and bird species (Trajano and Carneiro, 2019). As several Brazilian indigenous peoples may have lived 20–30,000 years in the pre-Columbian era, the lack of animal domestication may have been a result of human decisions, in an unprecedented One Health approach to their own lives, over thousands of years (Supplementary Figure 1) (Pettan-Brewer et al., 2024).

Indigenous populations were dynamic and hostile, with their survival relying on warfare, diverse weapons, soldier skills, and food tactics. Even so, health and wellbeing are intrinsically connected to sophisticated natural knowledge acquired over centuries concerning the balanced use of local ecosystems. Despite reservoirs and sources of soil, water, food, and vector-borne diseases, wildlife (and plants with environmental health impacts) were also used as treatments, amulets, and part of religious rituals at the time (Pettan-Brewer et al., 2021). Thus, the non-submissive balance of human, animal, and environmental health in ancient Brazil may be considered one of the most enduring examples of One Health in history, long before the term was coined (Sibim et al., 2024).

Following the European invasion of the late 15th and early 16th centuries, the Columbian exchange brought exotic livestock species from the Old World, including cattle, sheep, dogs, and horses, leading to another extinction wave of native American species, mostly by turning nature into pastures, bringing livestock diseases to wildlife, and using firearms, horses, and dogs for large-scale wildlife hunting, partially for synergetic purposes (Stahl, 2008). Brazilian indigenous peoples, once sovereign of their vast and unlimited lands, are currently considered highly vulnerable populations, restrained to federal reservations, mostly located within environmentally protected areas, and suffering from post-Columbian zoonotic diseases aggravated by the overlap of humans, companions, livestock, and wildlife (Camphora, 2017). In such a scenario, for better or worse, animals have influenced and are being influenced by indigenous history in an adaptive and interdependent human-animal relationship in Brazil and Latin America, which should be analyzed, understood, and applied by current and future generations (Pettan-Brewer et al., 2024).

As flagged in 2019 by Ailton Krenak, renowned indigenous leader, environmental advocate, philosopher, poet, and the first-ever indigenous person elected to the Brazilian Academy of Letters, “no humanity exists apart from Nature”, meaning that wildlife should be respected as one's own family and heritage instead of an available source of resources (Krenak, 2024).

4 Development of biophobia in major Brazilian cities

In the most highly populated Brazilian cities, beneath the impermeable cover of concrete and asphalt, the original course of rivers crossing urban areas is reborn during each rainfall storm, causing increasingly larger and more frequent floods. Until a few decades ago, washerwomen could be seen in the Anhangabaú River Valley, downtown São Paulo, the biggest Brazilian city that currently constantly suffers from flooding and falling trees, damaging electric posts and cables, leading to days of power outages (Millington, 2021). A similar fate occurred to the native fauna of the city, as native birds and bats in São Paulo have been gradually replaced by invasive and exotic birds, much less targeted and more adapted to food leftovers and trash produced daily by metropolitan life (Fontoura et al., 2013). Likewise, neighborhoods of the second largest city in Brazil, Rio de Janeiro, have suffered from the proliferation of synanthropic fauna, including rats, pigeons, and cockroaches, favored by outdoor trash and a warming climate (Fontoura et al., 2013). In this scenario, One Health has been compromised in three ways—environmental health with trash and degraded nature, animal health through pest control and zoonoses, and human health with exposed people living in such areas.

The term synanthropic (*sin*, with + *anthropo*, human being) fauna has been used in Brazil to designate “urban pests” as animal species capable of potentially harming human health through a biocidal approach to public, animal, and environmental health, mostly conducted by zoonosis surveillance units distributed nationwide (Ministério da Saúde, 2024). However, the term synanthropic fauna was originally used to designate animal groups living close to human beings, particularly in cities, mostly because of the peridomestic supply for their survival needs, including water, food, shelter, and mating. Synanthropic fauna currently comprises both exotic invasive animal species (rats, pigeons, cockroaches, and flies) and native fauna, such as snakes, bats, opossums, spiders, scorpions, mosquitoes, ants, fleas, bees, and wasps, which have been poisoned, trapped, controlled, and relocated by city animal services in major Brazilian cities, sometimes as part of city laws.

Although synanthropic fauna has been called “harmful fauna,” such native species have reportedly assisted in pollination, plant health (bats and bees), and predation of cockroaches, mosquitoes, and flies (bats, spiders, and scorpions). Nonetheless, complaints have been made by residents of the neighborhood of Penha, Rio de Janeiro, due to bats invading at night searching for almond trees, desperately demanding removal since “bats have invaded apartments, defecated on trees, sidewalks, and households, terrorized people and represented a real risk of fatal diseases (rabies)” (de Lima et al., 2023). This clearly shows avoidance and unawareness of the benefits of bats in a city that has suffered from Dengue fever mosquitoes over decades. In addition, an increase in cat rabies has been reported due to cat-bat interactions and predation in urban areas, with cats being ten-fold more likely than dogs to be infected with rabies (de Lima et al., 2023). Although Curitiba created a handbook to better explain bat rabies risk and ecosystem importance, such educational programs

should be provided nationwide (Supplementary Figure 2) (Rede de Proteção Animal, n.d.).

Due to the lack of natural predators, imbalances in the natural food chain have made capybara a problem, as overpopulation has been observed in lakes, parks, and condominiums in large Brazilian cities, such as São Paulo and Belo Horizonte. Because capybaras may host ticks responsible for Brazilian spotted fever, fear has driven residents to request euthanasia and relocation instead of tick management and proper sanitation. In addition, exotic fauna, such as feral cats, stray dogs, and invasive opossums and marmosets, may prey on the high and vulnerable fauna biodiversity living in urban settings, endangering hundreds of native species, including birds, rodents, and other small vertebrates and insects. On the other hand, regular citizens, animal protectors, and non-governmental animal protection organizations have pushed back against legislators regarding animal cruelty, mostly protecting domestic pets (mostly dogs and cats) and livestock (chariot-horses) species. Although justified for animal health and welfare, such urban restrictions have also removed animals from daily contact with residents, contributing to the “abiotic” process in large Brazilian cities. Another fear, expressed as wildlife protection, has made city animal services capture and relocate parrots, parakeets, opossums, snakes, monkeys, and other animals, which are released into state and federal reserves, forests, and parks, often in areas far away from the city squares and parks where they were found. In such a process, wildlife protection groups have mimicked biophobia, as native species have been forced to emigrate based on “take it from here and release it somewhere else better for it.”

During the yellow fever outbreak in Brazil in 2018–2019, the impact on biodiversity loss was due not only to direct viral action in native non-human primates but also in some threatened species such as howler monkeys (Hance and Mongabay Environmental News, 2009; Romero, 2017). Native non-human primates were systematically hunted and killed by the general population due to avoidance and fear of yellow fever transmission (de Oliveira Figueiredo et al., 2020).

5 Lack of animal health and wildlife protection in the worldwide agenda

Although the 17 Sustainable Development Goals (SDGs) established by the United Nations (UN) are a global challenge that includes, education, environmental protection, peace, prosperity, and ending poverty for world citizens by 2030, no SDG has been specifically proposed for animal health and welfare, with animals mentioned only once in the full document (United Nations, n.d.; Negrini et al., 2024). In addition, despite being used several times in the SDGs, sustainability has no animal health in its measurement, meaning that any given city, state, or country may be deemed sustainable without any commitment to domestic animals, livestock, or wildlife (de Moura et al., 2022a). In such a scenario, Curitiba has won several awards as the most sustainable city in Brazil and Latin America and a few times worldwide, without presenting any commitment to animal health and welfare (Stavri and Greenzine, 2021; Gortázar and El País English, 2023). Biophilia,

therefore, remains a challenge at the city, state, country, and global levels on the long journey to sustainability.

Besides Brazil being a UN signatory country for SDG challenges, the country also incorporated One Health into its agenda, establishing the first federal instance of animal rights in its history in 2023, the National Department of Animal Protection and Rights (DAPR), in the Ministry of Environment and Climate Change ([Ministério do Meio, n.d.](#)). Despite focusing on pet population management, mass neutering/spaying programs, and stopping animal cruelty, the DAPR aims to establish a Federal Animal Code and other nationwide regulations, including welfare meat production, meat substitutes, and the reinforcement of wildlife fauna protection in urban areas ([Ministério do Meio, n.d.](#); [Negrini et al., 2024](#)). One important step was recently accomplished with the National Pet Animal Registry, using identification cards based on Federal Law 15,046 of December 18th, 2024 ([Supplementary Figure 3](#)) ([Jornal Nacional, 2024](#)).

Although fighting biophobia may be contemplated through wildlife protection and reinforcement, no specific countrywide program has been implemented to date. The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), responsible for wildlife fauna, municipalized the rescue, apprehension, registration, and microchipping, with immediate (if possible) or after-treatment (when necessary) release within city green areas and parks, in an unbureaucratic and unprecedented manner. The majority of the 26 Brazilian state capitals and the Federal District (Brasília) peacefully coexist with steady or growing urban wildlife in each of the six Brazilian biomes, including toucans, parrots, agoutis, monkeys, sloths, capybaras, armadillos, and anteaters, without excessive fear or avoidance. Foster and definitive adoption programs for stray dogs and cats have become increasingly common in major Brazilian cities, gaining persistent community support as part of the multispecies family. Accordingly, this study aimed to present official data and initiatives for wildlife protection, zoonosis surveillance, and awareness of biophobia in Curitiba.

6 Curitiba as a model of a sustainable city

Curitiba (25°25'40" S and 49°16'23" W), the capital of Paraná State, was ranked as the 8th biggest city with approximately 1.87 million inhabitants, 10th in human development index (HDI) with 0.823 (very high), and 6th in gross domestic product (GDP), out of 5,570 municipalities in Brazil at the time of the survey. Curitiba is situated in a subtropical highland climate region, classified as an urban area only, and is considered one of the most planned and sustainable cities in Latin America, with an average of 64.5 m² of green area per inhabitant ([Gadda et al., 2021](#)). According to recent studies, despite the challenges of human population growth, Curitiba ranks fifth nationwide in afforestation of public ways among major cities, with approximately 20% of its territory covered by forested areas distributed in 49 city parks and other green areas ([Gadda et al., 2021](#)).

An approach to a study on Curitiba from an international perspective may be based on the number of studies conducted with a focus on zoonoses, One Health, and biophilia (AND biophobia), assessed by a systematic literature review in the Web of Science (WoS) database, using the following driver—(zoono* OR “one health” OR biophilia) AND (city OR municip* OR town OR urb*) AND (Curitiba). In this driver, zoono* captured the term “zoonosis” and its derivatives, while municip* and urb* target the terms “municipality” and “urban,” respectively, including their derivatives. The terms city, municipal *, town, and urban * are essential to distinguish studies specifically conducted in the city of Curitiba from those merely associated with the city, such as studies conducted by researchers affiliated with the Federal University of Paraná headquartered in Curitiba. The results were exported in text format and bibliometrically analyzed using the free software VOS viewer version 1.6.20. The main zoonosis studies in the municipality and their interrelations with the animal population were identified using a bibliometric network based on primary keywords from the manuscripts in the surveyed database. For this analysis, only keywords provided by the authors that appeared in at least three different documents were considered and included. A total of 146 publications addressing zoonoses, One Health, and one on biophilia, conducted in the municipality of Curitiba, were assessed. The first two studies were published in 2007, and 23 publications were published by 2024. The Boolean operator AND was included in the syntax, meaning that the sampling included only documents containing all the specified keywords, thereby restricting the scope of the search, i.e., including studies that mentioned “Curitiba” and excluding those that did not contain this term. Thus, the results addressed this issue. In December 2024, when the term “Curitiba” was included in the search string, a total of 146 documents were obtained in WoS, whereas, for example, when the term was replaced with “Warsaw,” the number of manuscripts was reduced to 58. When performing the search in WoS, on 16 March 2025, using the driver (zoono* OR “one health” OR biophilia OR biophobia) AND (city OR municip* OR town OR urb*), a total of 12,523 results were obtained. This indicated that the term “Curitiba” significantly restricted the results, directing them toward the specific object of the study herein. Curitiba demonstrated a high volume of publications compared with other cities worldwide with similar population sizes ([Table 1](#)).

The proposal of the present study was a comparison between cities, and thus a comparative approach rather than an absolute survey. As the sampling was robust, the absolute value (while respecting the sampling restrictions) may not be relevant; rather, the relative values among the number of publications across cities should be considered of comparative importance. For this reason, WoS, the dominant database ([Zhu and Liu, 2020](#)), may be the appropriate approach for the purpose herein. In addition, the driver has been applied to the Scopus database for each city covered in the present study ([Table 2](#)), following a comparative analysis of WoS and Scopus ([Mongeon and Paul-Hus, 2016](#)). Regardless, most of the results obtained herein from the Scopus database were also present in the WoS database.

TABLE 1 The number of publications on zoonoses, One Health, and biophilia in various cities worldwide with similar populations, highlighting Curitiba, PR, Brazil.

City	Country	Population (mi)	Manuscripts
Barranquilla	Colombia	2.0	30
Budapest	Hungary	1.7	74
Cordoba	Argentina	1.5	91
Curitiba	Brazil	1.8	146
Guadalajara	Mexico	1.6	13
Hamburg	Germany	1.8	87
Philadelphia	USA	1.6	109
Sapporo	Japan	2.0	199
Vienna	Austria	1.7	118
Warsaw	Poland	1.7	58

Despite a previous practical guide has been provided to question formation, systematic searching and study screening for literature reviews in ecology and evolution (Foo et al., 2021), the results herein may be considered robust as 1) the data explored were from the most relevant database for the purpose of the present study and 2) the results discussed were comparative rather than absolute among the cities.

The primary zoonoses studied were toxoplasmosis and leptospirosis (each with 13 occurrences of related terms), followed by leishmaniasis (nine occurrences) and Brazilian spotted fever (six occurrences) (Figure 1). Other diseases highlighted among the main keywords included hepatic fascioliasis, rabies, toxocariasis, and Q fever (each with four related terms). In Curitiba, the most frequently studied animals were dogs (18 cases), cats (seven cases), and cattle (three cases). Leptospirosis, toxoplasmosis, and rabies were linked to dogs, rabies and toxoplasmosis to cats, and hepatic fascioliasis to cattle.

7 Curitiba Animal Protection Services

Curitiba has been historically known for advanced animal protection laws, including the banning of animal circuses, rodeos, or other animal shows since 2007 (City law 12,467 of October 25th, 2007) (Curitiba PR, 2007), typifying animal cruelty since 2011 (City law 13,908 of December 19th, 2011) (Curitiba, 2011), banning chariot horses since 2015 (City law 14,741 of October 27th, 2015) (Curitiba, 2015), animal protection as city policy since 2021 (City law 15,852 of July 1st, 2021) (Curitiba, 2021), and updated fines and penalties against animal cruelty established in 2022 (City law 16,038/2022) (Curitiba, 2022c). In 2023, a pet population survey conducted by a consulting company resulted in a statistical estimate of 584,661 dogs and 185,379 cats in the city (Curitiba, 2024b).

The Department of Animal Protection, a part of the City Secretary of the Environment, offers daily pet microchipping, online registration,

TABLE 2 The number of publications on zoonoses, One Health, and biophilia in various cities worldwide with similar populations, obtained from WoS and Scopus, with a focus on Curitiba, PR, Brazil.

City	Country	WoS (Dec 2024)	Scopus (Mar 2025)
Barranquilla	Colombia	30	7
Budapest	Hungary	74	6
Cordoba	Argentina	91	13
Curitiba	Brazil	146	24
Guadalajara	Mexico	13	0
Hamburg	Germany	87	4
Philadelphia	USA	109	1
Sapporo	Japan	199	7
Vienna	Austria	118	11
Warsaw	Poland	58	12

deworming, vaccination, and neutering/spaying programs. Instead of sustainability, the One Health approach has been applied to address animal health as part of city priorities, including free-of-charge low complexity (pet vaccinations, microchipping, deworming, and antifea treatment), medium complexity (neutering/spaying, pet ambulance, and emergency room attendance), and high complexity animal healthcare with a newly established public veterinary hospital. During the last four years (from 1 January 2021 to 31 December 2024), the city has promoted 266 free-of-charge neutering events, with a total of 48,290 dogs (18,923 males and 29,369 females) and 41,710 cats (17,954 males and 23,757 females) neutered and spayed. In addition, the Pet Food Bank City Program was created in 2019 (City Laws 15,449/2019 and 1,226/2019) and has provided 238,000 kg of pet food (over 836,000 meals) to 16 non-governmental organizations (NGOs) and 30 independent protectors. Since 2010, the city has promoted city adoption events in its biggest city park, providing a structure for NGOs and independent protectors, and has officially had 1,950 pets adopted (Secretaria Municipal do Meio, n.d.).

As part of the One Health strategy, a veterinary pet-mobile unit was created in 2018 in partnership with the Federal University of Paraná (UFPR) for residency training in shelter medicine, with around 23,000 dogs and cats brought by vulnerable low-income populations, which included clinical evaluation and procedures, deworming, antifea treatment, rabies, and multiple vaccinations. In 2019, a veterinary ambulance was launched for city pets, particularly stray dogs and cats, with 3,400 rescues to date. In addition, a community dog program was established in 2014 in city bus stations, with healthcare and monitoring of diseases in around 30–50 dogs, including leishmaniasis, Chagas, and vector-borne diseases, as urban One Health sentinels (Constantino et al., 2017). The Curitiba Animal Protection Squad, started in 2014 and officially established in 2021, with four policemen and ten inspectors, receives and performs

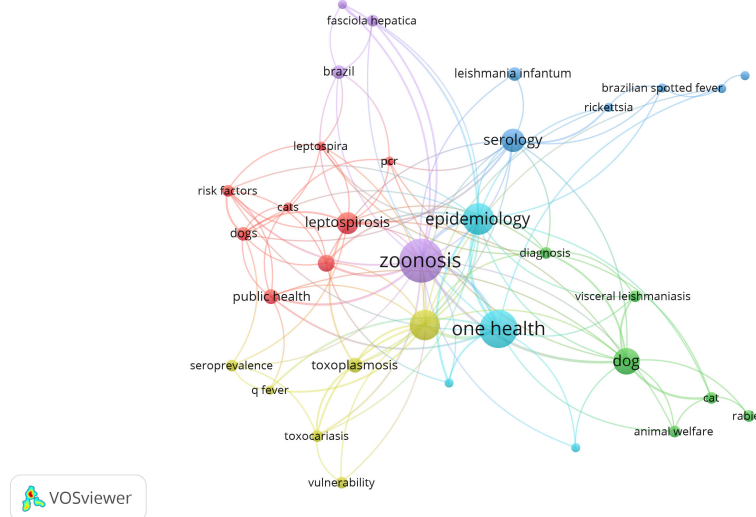


FIGURE 1
Bibliometric network illustrating the relationships between the main keywords in studies on zoonoses, One Health, and biophilia conducted in Curitiba, PR, Brazil.

approximately 5,500 animal cruelty inspections every year (Secretaria Municipal do Meio, n.d.).

The first city Public Veterinary Hospital was established in December 2024, distributed over an area of 68,467.05 m² and primarily attended by low-income individuals and animal protectors. One city hall council was elected for the 2025–2028 term and solely voted on the animal protection platform. Likewise, one federal congressman (currently working on his 2023–2026 term) was elected by the Paraná state exclusively on animal protection as a former state police chief of environmental crimes and animal cruelty.

As a result of its animal protection excellence, Curitiba was recently the 2019 winner of the top 10 best cities with animal protection policies in Latin America and the 2020 winner of the best pet-friendly city, both awarded by World Animal Protection (World Animal Protection, 2020).

8 Protecting urban wildlife fauna

The Curitiba Natural History Museum, established in 1963 as part of the Department of Animal Protection, Curitiba City Secretary of Environment, has a taxidermied collection of 7,000 mammals, 5,933 birds, 50,000 fish, 18,000 reptiles (mostly snakes), 12,000 amphibians (mostly Anura), 10,000 ectoparasites (including ticks/fleas/flies and lice), 70,000 insects, and 12,552 invertebrates (Curitiba P de, 2024c). The museum issued the city fauna inventory in late 2023, which, by city decree (1,082/2022), must be updated every 4 years (Curitiba, 2022a; Curitiba, 2020) (Supplementary Figure 4).

In 2019, the Reference Center of Native Fauna (RCNF) of Curitiba was established adjacent to the museum, with around 8,600 attendees of native species in its first 4 years of existence, mostly released into city parks after registration and appropriate care (Curitiba, 2024d). According to the official records of Curitiba,

10,000 wildlife specimens were examined at the RCNF in the first 5 years (from 2019 to 2023), with approximately 7,900 birds (79%), 1,700 mammals (17%), 400 reptiles (4%), and 16 amphibians. Mammals and birds were more likely to be received during late winter and spring, from August to November, with peaks in October and November, respectively.

The City Zoo, established in 1982, receives an average of 650,000 free visits every year and has guided day and night tours for elementary schools (Curitiba, 2024e). The zoo has become a sanctuary for native and exotic wildlife, receiving animals rescued and apprehended from illegal trade, road accidents, and climate events, such as major floods and forest fires nationwide (Curitiba, 2024e). In 2022, Curitiba Zoo was certified by the Brazilian Zoo Association and Wild Welfare for its institutional work in wildlife conservation and care, particularly for native fauna (Curitiba, 2022b).

Among hundreds of wildlife cared for and released monthly, a toucan rescued by a pet shop owner was received, treated, and released in Passauna City Park, one of the 49 major parks and green areas in Curitiba (Secretaria Municipal do Meio, n.d.) (Supplementary Figures 5–7).

9 Fighting zoonoses through biophilia

While the City Animal Protection Services, City Secretary of Environment, has focused on responsible guardianship and wildlife protection, the Zoonoses Surveillance Unit (ZSU), City Secretary of Health, worked on identifying, monitoring, and preventing diseases, particularly zoonoses. A combined decree of both secretaries (Environment and Health) was issued on 26 September 2014 to ensure coordination on overlapping activities such as outreach education, animal handling and training, zoonosis detection during rescuing, and wildlife preservation (Supplementary Figure 8).

In such a scenario, the ZSU has been controlling and preventing different zoonotic diseases, particularly rabies, mostly in bats and pets. Among the most fatal diseases worldwide, rabies is a growing public health concern in Brazil, as non-hematophagous bats may still potentially infect dogs and cats through spillover events, thereby increasing the risk of infection. Anthropization may have provided a predisposing environment for rabies transmission and overlapping contacts among humans, domestic animals, and wildlife. Although there have been no reported human or pet cases for almost three decades in Curitiba and São Paulo, several cases of bat rabies have been reported annually, showing viral circulation within city limits (de Lima et al., 2023). Recently, single cat rabies cases caused by bat-rabies variants were reported in both cities, probably due to cat hunting habits, preying on infected bats, and being found on the ground in daylight (de Lima et al., 2023).

As an alternative to systematically eliminating bats from Curitiba's urban areas, surveillance for bat rabies and associated risk factors for rabies spillover (even without human and pet cases) have been continuously monitored in Curitiba as part of the daily duties of the city's Zoonoses Control Unit. In a retrospective survey of 1,003 city requests for bat removal between 2010 and 2015, 806 live bats were collected and identified as belonging to 13 genera in three families, showing high urban bat biodiversity, as Curitiba has been classified as an 100% urban area (Ribeiro et al., 2018). Among them, 419/806 (52.0%) were considered healthy and were properly fed, provided water, and left overnight on a high-level shelf to fly away. Only 387/806 (48.0%) individuals considered unhealthy (including those not flying away) were sent for euthanasia and rabies testing, of which only 9/387 (2.32%) tested positive. The nine positive bats included two specimens of the genera *Molossus*, two of *Promops*, three of *Nyctinomops*, one of *Myotis*, and one of the genus *Sturnira* (Ribeiro et al., 2018) (Supplementary Figure 9).

Thus, although non-hematophagous bats may be involved in urban aerial and wildlife cycles, rabies disease in Curitiba has been monitored, controlled, and prevented with minimal wildlife disturbance and without bat biophobia. Non-hematophagous bats may have been one of the reasons why Curitiba has repeatedly won awards as the most sustainable city in Brazil and Latin America, as it biologically controls insects and small rodents without requiring insecticides, pesticides, baits, and traps. The Paraná State Reference Laboratory (LACEN-PR), located in Curitiba and responsible for rabies diagnosis, was given an award in 2019 as it was the first nationwide reference laboratory to replace the standard mouse inoculation test (MIT) with a novel duplex RT-qPCR protocol, ending the use of mice for rabies diagnosis (Minozzo et al., 2022).

Leptospirosis, the most lethal zoonotic disease in Curitiba with 4%–7% human mortality, has also been monitored and prevented by the ZSU by investigating probable infection sites for both notifiable human and dog cases, mapping and monitoring areas with a massive presence of synanthropic rats, monitoring flooding areas, and implementing educational strategies addressing healthcare professionals and occupational risk groups (Sohn-Hausner et al., 2023). In addition, rodents such as capybaras and nutrias live in major Curitiba city parks as their natural wetland habitats. Although there is no evidence of *Leptospira* spp. reservoirs in Curitiba to date

(Ullmann et al., 2017), capybaras have seroconverted and presented up to 41.1% anti-*Leptospira* spp. antibodies in the microscopic agglutination test (MAT) in other Brazilian areas (da Silva et al., 2023). Thus, since some city parks have been used as natural pools to quickly control flooding, capybaras have been monitored and populations have been informed about leptospirosis and other zoonotic transmission risks.

BSF, the most lethal tick-borne disease in Brazil and worldwide, is another important zoonotic disease in Curitiba, as capybaras are reportedly considered the main tick-harboring species and disease reservoirs (G1, 2023). Curitiba has dealt with hundreds of capybaras and their ticks in city parks through wildlife population stability (decreasing transmission) and constant lawnmowing of their living areas and surroundings (decreasing tick spread), particularly when overlapping human pathways and trails. Thus, despite constant surveillance, no reports have been published to date on human or animal BSF cases within city limits.

Finally, other important nationwide endemic vector-borne zoonoses, such as leishmaniasis and Chagas disease, have not yet been reported in Curitiba, due to the lack of competent vectors and constant disease prevention. In such a free-of-disease scenario, human and canine visceral leishmaniasis has been prevented by active surveillance of seropositive dogs (main reservoir); investigation of dog and human autochthonous cases; vector surveillance, which includes trapping, confirmation of sandfly species, and molecular testing for *Leishmania* spp.; and educational door-to-door visits in high-risk areas to raise neighborhood awareness and knowledge that wildlife has no important role in the visceral leishmaniasis cycle (Ministério da Saúde, 2014). Likewise, Chagas disease prevention in Curitiba has been based on ZSU surveillance of kissing bug (triatomine) complaints by city residents, with vector identification and molecular testing for *Trypanosoma cruzi* (Ministério da Saúde, n.d.; Secretaria da Saúde, n.d.). In terms of sandflies, neighborhood visits have been planned to explain kissing bug habits and their prevention, particularly in nearby forest areas (Secretaria da Saúde, n.d.). In addition, environmental disturbances such as major fires, deforestation, and construction may stress wildlife fauna, such as opossums (*Didelphis* spp.), leading to the return of parasitemia, kissing bug infection, and disease spread (Roque et al., 2013).

Thus, zoonosis control, monitoring, and prevention in Curitiba can be safely achieved without biophobia and is based on active surveillance, field evidence, exposed population awareness, and prevention of animal cruelty in wildlife, synanthropic, and domestic species. Unsurprisingly, the city mascot is the capybara (Supplementary Figure 4).

10 One Health Index besides sustainability

A recent study assessed and compared human and companion animal health indicators in 29 cities in the Curitiba metropolitan area, directly obtained from the city secretaries of health and environment. Overall, higher animal protection perceptions were associated with higher city human development index (HDI), population, and income,

whereas lower animal protection was related to cities with low income, higher social vulnerability index (SVI), and higher illiteracy (de Moura et al., 2022a). Thus, advanced community cities with better human health indicators also demanded better animal health actions, such as free city neutering/spaying programs, microchipping, animal cruelty inspections, and guardianship inserted into school content, as in the two handbooks available in Curitiba (Supplementary Materials 2, 7).

A One Health Index (OHI) was built by adding environmental indicators to the calculation and is defined as a comprehensive assessment of human, animal, and environmental health that could provide a specific city-, state-, or country-level assessment (de Moura et al., 2022a). In the analysis of the Curitiba metropolitan area, a higher OHI was associated with a higher city population and income, a shorter distance from the capital, and a tendency of low-income cities to present a lower OHI than higher-income cities, showing that the OHI may portray a comprehensive representation of a city's overall health. Despite the lack of animal and environmental indicators, the OHI has been used to compare South American countries (Sibim et al., 2024). Although within-country scales such as states and metropolitan areas (such as Curitiba) may better present contrasting differences, the OHI applied to South American countries has shown health and warming risks for forests and other natural areas, particularly the Amazon, which should provide proper incentives to promote sustainable economic growth aside from wildlife animal protection and environmental health (Sibim et al., 2024). Thus, animal (companion, livestock, and wildlife) health and welfare indicators may be considered part of local-to-global sustainability, using the OHI to calculate sustainability indices.

Considered a holistic approach, One Health has positively aligned human, animal, and environmental health, overlapping conservation and public health (Supplementary Figure 10) (WHO, n.d.). Biophobic responses to zoonotic pathogens have historically endangered wildlife host species and should be considered indicative of animal health and strategic sentinels of pathogen circulation and public health. Animal health, despite being a key component of the One Health framework, remains overlooked at multiple spatial scales, from local to international levels. Efforts to establish a global animal health index such as the Animal Protection Index (World Animal Protection, n.d.) have been hindered by insufficient official data, limiting the inclusion of many countries. Existing indicators, such as those for sustainability (World Animal Protection, n.d.) that focus on biodiversity, vegetation cover, and human health impacts from climate change, have not directly addressed animal health. As a result, countries often rely on indirect measures, such as zoonosis data and livestock health indicators (WOAH, n.d.), which have primarily focused on animal sanitation, neglecting companion and wildlife health and animal welfare (Sibim et al., 2024).

At local levels, such as municipalities, the absence of standardized data on the health of companion animals and wildlife further restricts the accurate assessment of animal health (de Moura et al., 2022a). Since human health systems and environmental health monitoring are generally more developed than animal health systems (Sibim et al., 2024), implementing a One-Health strategy at a local scale can significantly improve animal health. The relevance of zoonoses, such as COVID-19, highlights the importance of integrated approaches

(Lefrançois et al., 2023). Municipal health systems, in collaboration with zoonosis surveillance units, can effectively enhance animal health outcomes, as already shown in southern Brazil (Leandro A de et al., 2021), and locally integrated strategies that address social challenges, such as animal hoarding and companion animal management, can further strengthen such efforts (de Moura et al., 2022b).

The OHI may overcome sustainability as an applied index for assessing the impact of daily systems, such as in automobile manufacturing. Despite the current global consensus that electric cars are friendly and advantageous for human and environmental health, no assessment has been made of animal health to date, as electric cars may silently hit more wildlife fauna crossing roads than regular cars. Nonetheless, current technology has provided ultrasonic devices emitting high-frequency sounds that disperse wildlife fauna but are inaudible to humans (Conservation Evidence, n.d.), which could be a standard OHI device for automobile manufacturing, saving the lives of millions of animals every year. In addition, fully transparent glass is used in the windows of cars, houses, and buildings, and walls are considered more environmentally beneficial for increasing visibility and saving internal lights (Supplementary Figure 11) (Window Stickers to Prevent Bird Strikes Only Work One Way). However, according to the American Bird Conservancy, such glass is responsible for billions of bird deaths due to collisions every year in the USA alone, according to the American Bird Conservancy (Schneider et al., 2018). However, stickers that are invisible to the human eye but are seen by birds can be developed and layered into regular glass manufacturing, helping prevent bird collisions (American Bird Conservancy, 2015; Window Stickers to Prevent Bird Strikes Only Work One Way).

11 Final considerations

Curitiba may be a successful example and model for the implementation of One Health, in addition to sustainability, highlighting the importance of animal health (domestic, synanthropic, and wildlife) in advanced cities. Despite the current fragmentation and degradation of biomes and ecosystems worldwide, intimate human-animal contact by multispecies families sharing indoor areas has become a new One Health challenge, with more Brazilian households having pets than children in the past decade. In addition, wildlife hunting, poaching, trading, and meat consumption, associated with zoonotic pandemics, have made zoonosis a major public health concern capable of lowering human life expectancy in modern times, as observed during the COVID-19 pandemic.

Such fear and avoidance of wildlife, passed on and reinforced through human generations, may justify the survival of biophobia over time, particularly in the urban settings of major cities. However, current global knowledge, technology, and connections must overcome zoonotic risks and replace fear and avoidance with wildlife protection associated with animal health and welfare, and under One Health, peaceful coexistence.

Zoonoses control, monitoring, and prevention should not be considered a synonym for biophobia, as wildlife affinity and conservation may be concurrently accomplished by zoonoses

surveillance, considering wildlife fauna as vulnerable and as exposed to diseases as human beings. In such a scenario, wildlife species deserve equal veterinary care, assistance, wellbeing, and a long-lasting life in urban areas as in their original environment. In several cities worldwide, permeable asphalt has been designed, channeled rivers have been gradually opened, riverbanks have been revitalized, riverside flora have been reconstituted, and wildlife fauna have been preserved. Concrete backyards, squares, and sidewalks have provided space for native trees, green areas, and lawns. Slowly, fauna biodiversity may return to growth before it is too late. Such harmony should be pursued between human beings and domestic wildlife animal species (exotic and native) within a healthy urban environment, as a persistent One Health balance over thousands of years, as already achieved by ancient Brazilian indigenous peoples.

Author contributions

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcosc.2025.1554076/full#supplementary-material>

References

- American Bird Conservancy. (2015). *Bird-friendly building guide*. Available online at: https://abcbirds.org/wp-content/uploads/2015/05/Bird-friendly-Building-Guide_20151.pdf (Accessed December 20, 2024).
- Barbiero, G., and Berto, R. (2021). Biophilia as evolutionary adaptation: an onto- and phylogenetic framework for biophilic design. *Front. Psychol.* 12. doi: 10.3389/fpsyg.2021.700709/full
- BBC. (2024). Brazil: Eight dead as storms bring strong winds and downpours. Available online at: <https://www.bbc.com/news/articles/czj98v31jjdo> (Accessed December 20, 2024).
- Bennett, E. M., and Reyers, B. (2024). Disentangling the complexity of human–nature interactions. *People Nature*. 6, 402–409. doi: 10.1002/pan3.10611

- Berger-Tal, O., Blumstein, D. T., and Swaisgood, R. R. (2020). Conservation translocations: a review of common difficulties and promising directions. *Anim. Conserv.* 23 (2), 121–131. doi: 10.1111/acv.12534
- Camphora, A. L. (2017). *Animals and society in Brazil, from the sixteenth to nineteenth centuries*. Brazil: White Horse Press.
- Conservation Evidence. (n.d.). *Use ultrasonic noises to deter crop damage by mammals to reduce human-wildlife conflict*. Available online at: <https://www.conservationevidence.com/actions/2479> (Accessed December 20, 2024).
- Constantino, C., de Paula, E. F. E., Brandão, A. P. D., Ferreira, F., Vieira RF da, C., and Biondo, A. W. (2017). Survey of spatial distribution of vector-borne disease in neighborhood dogs in southern Brazil. *Open Vet J.* 7, 50–56. doi: 10.4314/ovj.v7i1.7
- Curitiba. (2020). *Prefeitura lança livro e exposição sobre a diversidade da fauna de Curitiba - Prefeitura de Curitiba*. Available online at: <https://www.curitiba.pr.gov.br/noticias/prefeitura-lanca-livro-e-exposicao-sobre-a-diversidade-da-fauna-de-curitiba/68882> (Accessed December 20, 2024).
- Curitiba. (2022a). *Decreto 1082 2022 de Curitiba PR*. Available online at: <https://leismunicipais.com.br/a/pr/c/curitiba/decreto/2022/109/1082/decreto-n-1082-2022-oficializa-o-inventario-da-fauna-de-curitiba> (Accessed December 20, 2024).
- Curitiba. (2022b). *Zoo de Curitiba recebe certificação em bem-estar animal durante evento nacional - Prefeitura de Curitiba*. Available online at: <https://www.curitiba.pr.gov.br/noticias/zoo-de-curitiba-recebe-certificacao-em-bem-estar-animal-durante-evento-nacional/66368> (Accessed December 20, 2024).
- Curitiba. (2022c). *Lei Ordinária 16038 2022 de Curitiba PR*. Available online at: <https://leismunicipais.com.br/a/pr/c/curitiba/lei-ordinaria/2022/1604/16038/lei-ordinaria-n-16038-2022-estabelece-no-ambito-do-municipio-de-curitiba-sancoes-e-penalidades-administrativas-para-aqueles-que-praticarem-maus-tratos-aos-animais-revoga-as-lei-n-s-13908-de-19-de-dezembro-de-2011-15122-de-22-de-novembro-de-2017-15421-de-7-de-maio-de-2019-e-15450-de-28-de-maio-de-2019-15646-de-16-de-junho-de-2020-15733-de-16-de-outubro-de-2020-e-da-outras-providencias> (Accessed December 20, 2024).
- Curitiba. (2007). *Lei Ordinária 12467 2007 de Curitiba PR*. Available online at: <https://leismunicipais.com.br/a/pr/c/curitiba/lei-ordinaria/2007/1247/12467/lei-ordinaria-n-12467-2007-proibe-a-manutencao-utilizacao-e-apresentacao-de-animais-em-circos-ou-espectaculos-assemelhados-no-municipio-de-curitiba-e-da-outras-providencias> (Accessed December 20, 2024).
- Curitiba. (2011). *Lei Ordinária 13908 2011 de Curitiba PR*. Available online at: <https://leismunicipais.com.br/a/pr/c/curitiba/lei-ordinaria/2011/1391/13908/lei-ordinaria-n-13908-2011-estabelece-no-ambito-do-municipio-de-curitiba-sancoes-e-penalidades-administrativas-para-aqueles-que-praticarem-maus-tratos-aos-animais-e-da-outras-providencias> (Accessed December 20, 2024).
- Curitiba. (2015). *Lei Ordinária 14741 2015 de Curitiba PR*. Available online at: <https://leismunicipais.com.br/a/pr/c/curitiba/lei-ordinaria/2015/1475/14741/lei-ordinaria-n-14741-2015-dispoe-sobre-a-proibicao-de-uso-de-veiculos-da-tracao-animal-e-exploracao-animal-para-tal-fim-no-municipio-de-curitiba> (Accessed December 20, 2024).
- Curitiba. (2021). *Lei Ordinária 15852 2021 de Curitiba PR*. Available online at: <https://leismunicipais.com.br/a/pr/c/curitiba/lei-ordinaria/2021/1586/15852/lei-ordinaria-n-15852-2021-dispoe-sobre-a-politica-municipal-de-protecao-conservacao-e-recuperacao-do-meio-ambiente-e-da-outras-providencias> (Accessed December 20, 2024).
- Curitiba, P. (2024a). *Curitiba aposta em soluções baseadas na natureza para prevenir enchentes*. Available online at: https://www.curitiba.pr.gov.br/noticias/curitiba-aposta-em-solucoes-baseadas-na-natureza-para-prevenir-enchentes/67161?utm_content=mldn (Accessed December 20, 2024).
- Curitiba, P. (2024b). *Censo Animal começa e vai apontar o número de cães e gatos em Curitiba*. Available online at: https://www.curitiba.pr.gov.br/noticias/censo-animal-comeca-e-vai-apontar-o-numero-de-caes-e-gatos-em-curitiba/67563?utm_content=mldn (Accessed December 20, 2024).
- Curitiba, P. (2024c). *Museu de História Natural Capão da Imbuia*. Available online at: <https://www.curitiba.pr.gov.br/loais/museu-de-historia-natural-capao-da-imbuia/82> (Accessed December 20, 2024).
- Curitiba, P. (2024d). *Centro de Apoio à Fauna Silvestre de Curitiba*. Available online at: <https://www.curitiba.pr.gov.br/loais/centro-de-apoio-a-fauna-silvestre-de-curitiba/2974> (Accessed December 20, 2024).
- Curitiba, P. (2024e). *Zoológico Municipal de Curitiba*. Available online at: <https://www.curitiba.pr.gov.br/loais/zoologico-municipal-de-curitiba/1572> (Accessed December 20, 2024).
- da Silva, T. F., de Quadros, A. P. N., do Rêgo, G. M. S., de Oliveira, J., de Medeiros, J. T., Dos Reis, L. F. M., et al. (2023). *Leptospira* spp. in Free-Ranging Capybaras (*Hydrochoerus hydrochaeris*) from Midwestern Brazil. *Vector Borne Zoonotic Dis.* 23, 106–112. doi: 10.1089/vbz.2022.0034
- de Lima, J. S., Mori, E., Kmetiuk, L. B., Biondo, L. M., Brandão, P. E., Biondo, A. W., et al. (2023). Cat rabies in Brazil: a growing One Health concern. *Front. Public Health* 11, 1210203. doi: 10.3389/fpubh.2023.1210203
- de Moura, R. R., Chiba de Castro, W. A., Farinhas, J. H., Pettan-Brewer, C., Kmetiuk, L. B., Dos Santos, A. P., et al. (2022a). One Health Index (OHI) applied to Curitiba, the ninth-largest metropolitan area of Brazil, with concomitant assessment of animal, environmental, and human health indicators. *One Health* 14, 100373. doi: 10.1016/j.onehlt.2022.100373
- de Moura, R. R., de Castro, W. A. C., Farinhas, J. H., da Cunha, G. R., Pegoraro MM de, O., Kmetiuk, L. B., et al. (2022b). Association of hoarding case identification and animal protection programs to socioeconomic indicators in a major metropolitan area of Brazil. *Front. Vet. Sci.* 9, 872777. doi: 10.3389/fvets.2022.872777
- de Oliveira Figueiredo, P., Stoffella-Dutra, A. G., Barbosa Costa, G., Silva de Oliveira, J., Dourado Amaral, C., Duarte Santos, J., et al. (2020). Re-emergence of yellow fever in Brazil during 2016–2019: challenges, lessons learned, and perspectives. *Viruses* 12, 1233. doi: 10.3390/v12111233
- Diamond, J. M. (2005). *Guns, germs, and steel: the fates of human societies* (New York: Norton). Available at: <https://search.library.wisc.edu/catalog/9910007689602121> (Accessed December 20, 2024).
- Einhorn, C. *Window Stickers to Prevent Bird Strikes Only Work One Way* (The New York Times). Available at: <https://www.nytimes.com/2023/02/02/climate/bird-window-strikes-stickers.html> (Accessed December 20, 2024).
- Elliott, L. R., Pasanen, T., White, M. P., Wheeler, B. W., Grellier, J., Cirach, M., et al. (2023). Nature contact and general health: Testing multiple serial mediation pathways with data from adults in 18 countries. *Environ. Int.* 178, 108077. doi: 10.1016/j.envint.2023.108077
- FAPESP and AGÊNCIA FAPESP (2021). *Tree falls during dry season in São Paulo City are due to poor management, study suggests*. Available online at: <https://agencia.fapesp.br/tree-falls-during-dry-season-in-sao-paulo-city-are-due-to-poor-management-study-suggests/36547> (Accessed December 20, 2024).
- Fontoura, P. M., Dyer, E., Blackburn, T. M., and Orsi, M. L. (2013). Non-native bird species in Brazil. *Neotropical Biol. Conserv.* 8, 165–175. doi: 10.4013/nbc.2013.83.07
- Foo, Y. Z., O'Dea, R. E., Koricheva, J., Nakagawa, S., and Lagisz, M. (2021). A practical guide to question formation, systematic searching and study screening for literature reviews in ecology and evolution. *Methods Ecol. Evolution* 12, 1705–1720. doi: 10.1111/2041-210X.13654
- G1 (2023). *Monitoramento indica que capivaras de Curitiba não possuem carrapatos transmissores de febre maculosa, diz especialista*. Available online at: <https://g1.globo.com/pr/parana/noticia/2023/06/16/monitoramento-indica-que-capivaras-de-curitiba-nao-possuem-carrapatos-transmissores-de-febre-maculosa-diz-especialista.ghtml> (Accessed December 20, 2024).
- Gadda, T. M. C., de Souza, J. M. T., de Paula, G. A. R., van Kaick, T. S., and Gervásio, J. H. D. B. (2021). The international biodiversity agenda at the local level: the case of capybaras in Curitiba, Brazil. *Ambient Soc* 24, e02832. doi: 10.1590/1809-4422asoc201802832vu202111ao
- Gortázar, N. G., and El País English. (2023). *Curitiba: Brazil's sustainable green gem*. Available online at: <https://english.elpais.com/eps/2023-07-02/curitiba-Brazils-sustainable-green-gem.html> (Accessed December 20, 2024).
- Gu, X., Zheng, H., and Tse, C. S. (2023). Contact with nature for emotion regulation: the roles of nature connectedness and beauty engagement in urban young adults. *Sci. Rep.* 13, 21377. doi: 10.1038/s41598-023-48756-4
- Hance, J., and Mongabay Environmental News (2009). *Howler monkeys poisoned because of misinformed link to yellow fever*. Available online at: <https://news.mongabay.com/2009/04/howler-monkeys-poisoned-because-of-misinformed-link-to-yellow-fever/> (Accessed December 20, 2024).
- IBGE. (n.d). *Curitiba. Código: 4106902*. Available at: <https://www.ibge.gov.br/cidades-e-estados/pr/curitiba.html> (Accessed December 20, 2024).
- Jornal da USP (2024). *Pouca arborização no meio urbano agrava a intensificação das ondas de calor*. Available online at: <https://jornal.usp.br/radio-usp/pouca-arborizacao-no-meio-urbano-agrava-a-intensificacao-das-ondas-de-calor/> (Accessed December 20, 2024).
- Jornal Nacional. (2024). *Governo cria Cadastro Nacional de Animais Domésticos, com número de identidade para cães e gatos*. *Jornal Nacional* | G1. Available at: <https://g1.globo.com/jornal-nacional/noticia/2024/12/25/governo-cria-cadastro-nacional-de-animais-domesticos-com-numero-de-identidade-para-caes-e-gatos.ghtml> (Accessed December 25, 2024).
- Krenak, A. (2024). *Ideias para adiar o fim do mundo*. Available from: <chrome-extension://efaidnbmnnnibpajpcglclefindmkaj/https://cpdel.ifcs.ufrj.br/wp-content/uploads/2020/10/Ailton-Krenak-Ideias-para-adiar-o-fim-do-mundo.pdf> (Accessed December 20, 2024).
- Leandro A de, S., Lopes, R. D., Martins, C. A., Rivas, A. V., da Silva, I., Galvão, S. R., et al. (2021). The adoption of the One Health approach to improve surveillance of venomous animal injury, vector-borne and zoonotic diseases in Foz do Iguaçu, Brazil. *PLoS Neglected Trop. Diseases* 15, e0009109. doi: 10.1371/journal.pntd.0009109
- Lefrançois, T., Malvy, D., Atlani-Duault, L., Benamouzig, D., Druais, P. L., Yazdanpanah, Y., et al. (2023). After 2 years of the COVID-19 pandemic, translating One Health into action is urgent. *Lancet* 401, 789–794. doi: 10.1016/S0140-6736(22)01840-2
- Marselle, M. R., Lindley, S. J., Cook, P. A., and Bonn, A. (2021). Biodiversity and health in the urban environment. *Curr. Environ. Health Rep.* 8, 146–156. doi: 10.1007/s40572-021-00313-9
- Miller, J. R. (2005). Biodiversity conservation and the extinction of experience. *Trends Ecol. Evolution* 20, 430–434. doi: 10.1016/j.tree.2005.05.013
- Millington, N. (2021). *Stormwater politics: flooding, infrastructure, and urban political ecology in São Paulo, Brazil*. Manchester, UK: Water Alternatives, Vol. 14.
- Ministério da Saúde. (2014). *Manual de vigilância e controle da leishmaniose visceral, 1a Edição*. Available online at: https://bvsms.saude.gov.br/bvs/publicacoes/manual_vigilancia_controle_leishmaniose_visceral_1edicao.pdf.

- Ministério da Saúde. (n.d). *Doença de Chagas*. Available online at: <https://www.gov.br/saude/pt-br/assuntos/saude-de-a-a-z/d/doenca-de-chagas/doenca-de-chagas> (Accessed December 20, 2024).
- Ministério da Saúde. (2024). *Zoonose*. Available online at: <https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/zoonose> (Accessed December 20, 2024).
- Ministério do Meio (n.d). *Ambiente e Mudança do Clima Departamento de Proteção, Defesa e Direitos Animais*. Available online at: <https://www.gov.br/mma/pt-br/composicao/sbio/dpda/departamento-de-protecao-defesa-e-direitos-animais> (Accessed December 20, 2024).
- Minozzo, G. A., Corona, T. F., da Cruz, E. C. R., de Castro, W. A. C., Kmetiuk, L. B., Dos Santos, A. P., et al. (2022). Novel duplex RT-qPCR for animal rabies surveillance. *Transbound Emerg Dis.* 69, e2261–e2267. doi: 10.1111/tbed.14565
- Mongeon, P., and Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*. 106, 213–228. doi: 10.1007/s11192-015-1765-5
- Navas-Suárez, P. E., Diaz-Delgado, J., Caiaffa, M. G., da Silva, M. C., Yogui, D. R., Alves, M. H., et al. (2022). Characterization of traumatic injuries due to motor vehicle collisions in neotropical wild mammals. *J. Comp. Pathology.*, 197:1–19718. doi: 10.1016/j.jcpa.2022.06.003
- Negrini, V., Maiorka, P. C., Kmetiuk, L. B., and Biondo, A. W. (2024). Brazil's landmark change on One Health, animal rights and protection. *One Health* 19, 100847. doi: 10.1016/j.onehlt.2024.100847
- Oswald, T. K., Rumbold, A. R., Kedzior, S. G. E., and Moore, V. M. (2020). Psychological impacts of “screen time” and “green time” for children and adolescents: A systematic scoping review. *PloS One* 15, e0237725. doi: 10.1371/journal.pone.0237725
- Paniccià, M., Acito, M., and Grappasonni, I. (2024). How outdoor and indoor green spaces affect human health: a literature review. *Ann. Ig.* 37 (3), 333–349. doi: 10.7416/ai.2024.2654
- Pettan-Brewer, C., Martins, A. F., de Abreu, D. P. B., Brandão, A. P. D., Barbosa, D. S., Figueroa, D. P., et al. (2021). From the approach to the concept: one health in latin America-experiences and perspectives in Brazil, Chile, and Colombia. *Front. Public Health* 9. doi: 10.3389/fpubh.2021.687110/full
- Pettan-Brewer, C., Penn, G., Biondo, A. W., Jaenisch, T., Grützmacher, K., and Kahn, L. H. (2024). Who coined the term “One Health”? Cooperation amid the siloization. *One Health* 18, 100678. doi: 10.1016/j.onehlt.2024.100678
- Rede de Proteção Animal. (n.d). *Materiais educativos*. Available online at: <https://protecaoanimal.curitiba.pr.gov.br/materialeducativo> (Accessed December 20, 2024).
- Ribeiro, J., Staudacher, C., Martins, C. M., Ullmann, L. S., Ferreira, F., Araujo, J. P., et al. (2018). Bat rabies surveillance and risk factors for rabies spillover in an urban area of Southern Brazil. *BMC Vet Res.* 14, 173. doi: 10.1186/s12917-018-1485-1
- Romero, S. (2017). *Brazil Yellow Fever Outbreak Spawns Alert: Stop Killing the Monkeys* (The New York Times). Available at: <https://www.nytimes.com/2017/05/02/world/americas/Brazil-yellow-fever-monkeys.html> (Accessed December 20, 2024).
- Roque, A. L. R., Xavier, S. C. C., Gerhardt, M., Silva, M. F. O., Lima, V. S., D'Andrea, P. S., et al. (2013). *Trypanosoma cruzi* among wild and domestic mammals in different areas of the Abaetetuba municipality (Pará State, Brazil), an endemic Chagas disease transmission area. *Veterinary Parasitology*. 193, 71–77. doi: 10.1016/j.vetpar.2012.11.028
- Schneider, R. M., Barton, C. M., Zirkle, K. W., Greene, C. F., and Newman, K. B. (2018). Year-round monitoring reveals prevalence of fatal bird-window collisions at the Virginia Tech Corporate Research Center. *PeerJ.* 6, e4562. doi: 10.7717/peerj.4562
- Secretaria da Saúde. (n.d). *Doença de Chagas*. Available online at: <https://www.saude.pr.gov.br/Pagina/Doenca-de-Chagas> (Accessed December 20, 2024).
- Secretaria Municipal do Meio. (n.d). *Ambiente Prefeitura de Curitiba*. Available online at: <https://www.curitiba.pr.gov.br/loais/secretaria-municipal-do-meio-ambiente/862> (Accessed December 20, 2024).
- Sibim, A. C., Chiba de Castro, W. A., Kmetiuk, L. B., and Biondo, A. W. (2024). One Health Index applied to countries in South America. *Front. Public Health* 12. doi: 10.3389/fpubh.2024.1394118/full
- Soga, M., and Evans, M. J. (2024). Biophobia: What it is, how it works and why it matters. *People Nature.* 6, 922–931. doi: 10.1002/pan3.10647
- Soga, M., Evans, M. J., Yamanoi, T., Fukano, Y., Tsuchiya, K., Koyanagi, T. F., et al. (2020). How can we mitigate against increasing biophobia among children during the extinction of experience? *Biol. Conserv.* 242, 108420. doi: 10.1016/j.biocon.2020.108420
- Soga, M., and Gaston, K. J. (2016). Extinction of experience: the loss of human-nature interactions. *Front. Ecol. Environment.* 14, 94–101. doi: 10.1002/fee.1225
- Soga, M., Gaston, K. J., Fukano, Y., and Evans, M. J. (2023). The vicious cycle of biophobia. *Trends Ecol. Evol.* 38, 512–520. doi: 10.1016/j.tree.2022.12.012
- Sohn-Hausner, N., Kmetiuk, L. B., da Silva, E. C., Langoni, H., and Biondo, A. W. (2023). One health approach to leptospirosis: dogs as environmental sentinels for identification and monitoring of human risk areas in southern Brazil. *Trop. Med. Infect. Dis.* 8, 435. doi: 10.3390/tropicalmed8090435
- Stahl, P. W. (2008). “Animal domestication in south America,” in *The Handbook of South American Archaeology*. Eds. H. Silverman and W. H. Isbell (Springer, New York, NY), 121–130. doi: 10.1007/978-0-387-74907-5_8
- Stavri, O., and Greenzine (2021). *The Most Sustainable City in Latin America* (Curitiba, Brazil). Available at: <https://www.greenzine.org/post/the-most-sustainable-city-in-latin-america-curitiba-brazil> (Accessed December 20, 2024).
- Tillmann, S., Tobin, D., Avison, W., and Gilliland, J. (2018). Mental health benefits of interactions with nature in children and teenagers: a systematic review. *J. Epidemiol. Community Health* 72, 958–966. doi: 10.1136/jech-2018-210436
- Trajan, M. d. C., and Carneiro, L. P. (2019). *Diagnóstico da criação comercial de animais silvestres no Brasil*. Available online at: <https://www.ibama.gov.br/phocadownload/fauna/faunasilvestre/2019-ibama-diagnostico-criacao-animais-silvestres-brasil.pdf> (Accessed December 20, 2024).
- Ullmann, L. S., Gravinatti, M. L., Yamatogi, R. S., Santos, L. C. D., de Moraes, W., Cubas, Z. S., et al. (2017). Serosurvey of anti- *Leptospira* sp. and anti- *Toxoplasma gondii* antibodies in capybaras and collared and white-lipped peccaries. *Rev. Soc. Bras Med. Trop.* 50, 248–250. doi: 10.1590/0037-8682-0315-2016
- United Nations. (n.d). *The 17 goals*. Available online at: <https://sdgs.un.org/goals> (Accessed December 20, 2024).
- WHO. (n.d). *One health*. Available online at: https://www.who.int/health-topics/one-healthtab=tab_1 (Accessed December 20, 2024).
- WOAH. (n.d). *World Animal Health Information System WAHIS*. Available online at: <https://www.woah.org/en/what-we-do/animal-health-and-welfare/disease-data-collection/world-animal-health-information-system/> (Accessed December 20, 2024).
- World Animal Protection. (n.d). *Animal Protection Index*. Available online at: <https://api.worldanimalprotection.org/> (Accessed December 20, 2024).
- World Animal Protection. (2020). *Conheça os vencedores do 2º Prêmio “Cidade Amiga dos Animais”*. Available online at: <https://www.worldanimalprotection.org.br/mais-recente/noticias/conheca-os-vencedores-do-2-premio-cidade-amiga-dos-animais/> (Accessed December 20, 2024).
- Zhang, W., Goodale, E., and Chen, J. (2014). How contact with nature affects children's biophilia, biophobia and conservation attitude in China. *Biol. Conserv.* 177, 109–116. doi: 10.1016/j.biocon.2014.06.011
- Zhu, J., and Liu, W. (2020). A tale of two databases: the use of Web of Science and Scopus in academic papers. *Scientometrics*. 123, 321–335. doi: 10.1007/s11192-020-03387-8