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Far Beyond Bushmeat: A Review of the Hunting and Uses of Neotropical Columbids

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ABSTRACT

Hunting and the use of wild columbids are widely documented practices across the Neotropical region, associated with multiple forms of utilization, harvesting pressures, and conservation implications. This study presents the first systematic literature review focused on the uses, hunting, and legal or illegal trade of Neotropical Columbiformes. Data were obtained from scientific articles, books, theses, dissertations, and technical reports indexed in major international databases. We recorded 49 species belonging to 10 genera, distributed across 23 countries, with *Patagioenas*, *Geotrygon*, and *Columbina* comprising the highest species richness. The main uses identified were food, followed by commercial, pet, medicinal, magico-religious, and artisanal purposes. Ten hunting and capture techniques firearms and slingshots being the most frequent. All recorded species are listed in the IUCN Red List, including 38 classified as Least Concern, 4 as Near Threatened, 3 as Endangered, 2 as Vulnerable, 1 as Critically Endangered, and 1 as Extinct in the Wild. These findings reveal a mismatch between formal conservation status and actual exploitation pressures, as many frequently used species remain classified as Least Concern. By revealing which species are most frequently exploited, where records are concentrated, and which use categories and capture techniques are most recurrent, the study helps support evidence-based policy design, targeted educational actions, and research priorities across the Neotropics.

Keywords: Ethnozoology; Wildlife uses; Neotropical avifauna; human–wildlife interactions; illegal wildlife trade.

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SIGNIFICANCE STATEMENT

This study provides the first comprehensive, systematic synthesis of the uses and wildlife trade affecting Neotropical columbids across 23 countries of Latin America and North America countries where some Neotropical

columbid species also occur. By integrating dispersed ethnobiological, ecological, and market-based evidence, it reveals that exploitation is far broader than currently reflected in global conservation assessments. By identifying 49 exploited species, documenting six categories of use, recording hunting/capture techniques, and revealing the countries where these interactions are concentrated, this study provides a baseline for future research on uses and conservation of Columbiformes, supports the prioritization of monitoring efforts, and helps guide public policies and community-based conservation strategies in one of the world's most biodiverse regions.

INTRODUCTION

Hunting involves the pursuit, capture, or killing of animals for various purposes and is a widely documented practice worldwide (Alves et al. 2018). Today, this activity is carried out for multiple purposes, including food, keeping animals as pets, medicinal uses, religious rituals, sport, and the control of conflict-associated wildlife (Alves et al. 2018; Nielsen et al. 2018; Pinto-Marroquin et al. 2022; Souto et al. 2018).

Several forms of wildlife exploitation are widespread throughout the tropics (Beltrão-Mendes et al. 2024). Subsistence hunting, for example, is the most common modality across tropical regions, especially in rural and urban areas of South America, Africa, and Asia (Aragão Silva et al. 2023; Arobaya et al. 2025; Fa et al. 2022; Ingram et al. 2021; Santos et al. 2024; van Velden et al. 2018). Preferences for consuming bushmeat are influenced by socioeconomic factors and cultural values, including the perceived taste and quality of the meat (Barboza et al. 2016; Chaves et al. 2019; Morsello et al. 2015). Beyond meat consumption, wildlife trade represents a globally widespread activity, generating billions of dollars annually and causing severe ecological impacts on wild populations (Anagnostou and Doberstein 2022; Aragão Silva et al. 2023; Azeredo and Alves 2024; Borges et al. 2022; Mozer and Prost 2023).

The demand for wild pets and wildlife products, driven by aesthetic and behavioral attributes, also threatens biodiversity, with birds standing out as the most heavily exploited group in the Neotropical region (Azeredo and Alves 2024; Roldán-Clarà et al. 2014; Souto et al. 2017). Columbiformes (pigeons and doves), for example, are notable for their ethnozoological value and broad global distribution, with the exception of Antarctica (Parish 2025), and are commonly used for food, medicinal purposes, trade, and as pets (Azeredo and Alves 2024; Charity and Ferreira 2020; Souto et al. 2018).

The expansion of digital platforms and emerging forms of online commerce has further increased access to wild species, facilitating transactions, obscuring supply chains, and intensifying pre-existing pressures on columbids and other bird orders (Fiennes et al. 2023; Nijman et al. 2022). Across tropical regions, attributes such as rarity, vocalization, and plumage coloration have become key determinants of market value, contributing to the specialization of capture networks and trade dynamics, as demonstrated by recent analyses of social-media activity and informal supply chains (Azeredo and Alves 2024; Charity and Ferreira 2020; Nijman et al. 2022). The capture of wild birds for consumption, live-animals uses, and trade continues to coexist and interact with illegal trade, forming a continuum of vulnerability that affects both abundant and rare species (Santos et al. 2024; Souto et al. 2017). Thus, simultaneously examining domestic use, subsistence consumption, and the live-animal market is essential for assessing the magnitude of the pressures affecting columbids and the sociocultural drivers shaping their exploitation across the tropical region.

Columbids, due to their multiplicity of uses and exposure to other anthropogenic pressures, rank among the most threatened bird groups worldwide (Cambrone et al. 2023; Silva et al. 2021). At least 20% of columbid species are at risk of extinction, particularly in tropical regions and on isolated islands (Cambrone et al. 2023). The main threats to columbids include habitat loss and fragmentation driven by agriculture and resource extraction, followed by unsustainable hunting and the introduction of invasive species such as the domestic cat (Aragão Silva et al. 2023; Cambrone et al. 2023; Silva et al. 2021).

The consolidation of this scenario reveals that knowledge of wildlife uses, trade routes, capture techniques, and sociocultural motivations is essential for informing public policies and designing more effective conservation actions. Such information helps identify which species are most frequently exploited, where pressures are geographically concentrated, and which human practices are most closely associated with hunting and trade. In practical terms, this evidence can support the prioritization of monitoring areas, the development of targeted environmental education programs, the strengthening of wildlife trade regulations, and the formulation of community-based management strategies adapted to local realities. Literature reviews such as this one also help identify broad patterns, geographic and thematic gaps, and particularly vulnerable species, including those still classified as Least Concern but heavily exploited at the local level. Understanding this complexity is essential for anticipating risk scenarios, refining threat assessments, and guiding integrated management and conservation strategies.

Given this context, this study aims to systematically identify the Neotropical columbid species reported in the literature as being hunted, captured, or

traded, to classify their main categories of use, and to analyze the geographic distribution of these records based on the number of species reported per country. Additionally, we document the hunting and capture techniques associated with these uses to provide a comprehensive overview of human-columbid interactions across the Neotropics. By assembling this information, we aim to improve understanding of the anthropogenic pressures affecting this group and to provide support for management and conservation strategies that incorporate the sociocultural dimension of wildlife use.

MATERIAL AND METHODS

Data collection

We adapted the protocol of Alves et al. (2012b), originally applied in a study on the capture and trade of Brazilian wild birds kept as pets, to examine the hunting and uses of Neotropical columbids. We first compiled all species of the family Columbidae occurring in the Neotropical region using the Catalogue of Life 2025 Annual Checklist (Bánki et al. 2025) and *The Neotropical Birds* database of the Cornell Lab of Ornithology (The Cornell Lab of Ornithology 2024). The Neotropical region comprises the tropical areas of South America, Central America, southern and central Mexico, and the Antilles (Morrone et al. 2022). The study focuses on Neotropical columbids, although some species also occur naturally in the Nearctic region, such as *Zenaida asiatica* (Linnaeus, 1758) (The Cornell Lab of Ornithology 2024).

We gathered information on bird species and the countries in which their uses, commercial exploitation, and hunting and/or capture methods were reported, drawing on published articles, books, book chapters, theses, dissertations, and reliable technical reports from governmental and non-governmental organizations available online up to 2018. For this purpose, we conducted searches across five international databases: ScienceDirect (sciencedirect.com), Scirus (scirus.com), Google Scholar (scholar.google.com), Scopus (scopus.com), and Web of Science (isiknowledge.com). Together, these databases provide broad coverage of peer-reviewed publications and gray literature relevant to biodiversity, ethnobiology, and wildlife trade, thereby supporting the comprehensive retrieval of information on Neotropical columbids (see, for instance, Aragão Silva et al. 2023). Review articles presenting overlapping data from previously published field studies were excluded. The temporal scope up to 2018 reflects the period covered during the original data compilation phase of this study. Additionally, the dataset was part of a project reviewing the uses of Neotropical terrestrial vertebrates coordinated by the Federal University of Piauí. Data collection for the project was fully completed in 2018. Although more recent publications may exist, the dataset provides a robust and representative baseline for understanding patterns of use and trade of Neotropical columbids throughout their geographic distribution.

For the database searches, we used the following search terms and keyword combinations: *ethnoornithology + columbid species name*; *etnoornitologia* (Portuguese)/ *etnoornitología* (Spanish) + *columbid species name; hunting + columbid species name; caça + columbid species name; caza + columbid species name; cacería + columbid species name; bushmeat + columbid species name; wild meat (or wild-meat) + columbid species name; carne de caça + columbid species name, carne de monte + columbid species name; pets + columbid species name; mascota + columbid species name; animal de estimação + columbid species name; traditional medicine + columbid species name; zootherapy + columbid species name; zootherapeutic + columbid species name; medicinal + columbid species name; zooterápico + columbid species name; wildlife uses + columbid species name; usos de la fauna + columbid species name; usos da fauna + columbid species name.* We used combinations of terms in English, Spanish, and Portuguese, as these languages represent virtually the entire scientific communication base of Latin America.

Only taxa identified at the species level were included in our database. The conservation status of the species followed the IUCN Red List 2025, version 2025-1 (IUCN 2025).

Data analyses

We used descriptive statistical analyses to compile information on use categories, species richness of exploited taxa, countries of occurrence, and conservation implications. Following Alves et al. (2016), we evaluated sampling effort by estimating species richness species richness from our dataset (studies included in the database) using the non-parametric incidence-based estimator Chao 2 (Gotelli and Colwell 2011). We used EstimateS v. 9.1.0 (Colwell 2013) to calculate the estimator values and generate the rarefaction curve based on 1,000 randomizations of the mean estimator values for each sampling unit.

We converted the compiled information into quantitative and incidence-based variables to allow comparisons among exploited species. For each species, we calculated: (i) the number of countries in which use records were reported; (ii) the number of use categories documented; (iii) the number of hunting or capture techniques associated with each species; and (iv) the number of hunting/use types. We also constructed binary incidence matrices for species × country, species × use category, and species × hunting/capture tech-

nique, which were used to summarize patterns of exploitation and geographic distribution.

To evaluate relationships among exploitation variables, we performed pairwise Spearman rank correlations at the species level, testing associations between the number of countries, use categories, capture techniques, and hunting/use types recorded for each species. These analyses were used to assess whether widely distributed species tended to show broader use profiles and greater diversity of hunting strategies. Correlation matrices were generated to visualize the strength and direction of these relationships. All statistical analyses were performed using SPSS v. 30 (IBM, 2024). Additionally, graphical outputs were refined using Claude AI (Anthropic, 2025), followed by double-checking manual verification to ensure the accuracy and integrity of the final figures.

RESULTS

Richness of harvested Neotropical columbids and geographic distribution

Of the 70 Neotropical columbid species, we recorded the exploitation of uses and/or trade for 49 species (70%), belonging to 10 genera (Additional File 1). Among the genera reported, those with the highest species richness were *Patagioenas* (n = 14 spp.; 28.6%), *Geotrygon* (n = 8; 16.3%), *Columbina* (n = 7; 14.2%), *Leptotila* (n = 7; 14.2%), and *Zenaida* (n = 5; 10.2%). With regard to geographic distribution, the countries with the highest richness of recorded species were Mexico (n = 17 spp.; 34.7%), Brazil (n = 16; 32.6%), Peru (n = 13; 26.5%), Colombia (n = 11; 22.4%), Argentina, and Trinidad and Tobago (n = 10 each; 20.4%). Regarding hunting purposes, 22 species (44.9%) were recorded as used for subsistence (bushmeat consumption) in 11 countries, 17 (34.7%) for sport hunting in 12 countries, and 13 (26.5%) for commercial exploitation in 6 countries (Figure 1, Table 1).

The Chao 2 estimator indicated a richness of 70 ± 12.28 species of exploited Neotropical columbids. These results clearly suggest that virtually all columbid species in the region are exploited by humans, even though we effectively documented the use of 49 species (Figure 2). Hunting and commercial uses of Neotropical columbids were recorded for 23 countries. Among the species with the broadest geographic scope of documented use and trade, we highlight *Zenaida auriculata* (n = 11 countries; 45.8%), *Leptotila verreauxi* (n = 10; 41.7%), *Geotrygon montana*, *Zenaida asiatica*, and *Patagioenas fasciata* (n = 8 each; 33.3%), as well as *Columbina passerina* and *Columbina talpacoti* (n = 7 each; 29.2%). The remaining species were recorded in fewer regions, ranging from 1 to 6 countries. Examples of Neotropical Columbiformes captured and traded for diverse uses are shown in Figure 3.

Hunting/trapping techniques and types of columbids

We recorded a total of 10 hunting/trapping techniques. Firearms were the most frequently documented technique (n = 16 species), followed by slingshots and ambush/wait strategies (n = 13 each), birdlime and arapuca traps (n = 10 each), and decoys (n = 9). Less frequent techniques included baiting (n = 6), active night hunting (n = 4), manual capture (n = 3), and sangra traps (n = 1) (Figure 4A). Among the total number of techniques, four can be classified as traps: arapuca, birdlime, baiting, and sangra. When considering the cumulative number of hunting/capture technique records associated with exploited species per country, Brazil, Colombia, Mexico, Venezuela, and Ecuador showed the highest richness (n = 10 techniques each), followed by Argentina, Bolivia, and Chile (n = 9 each) (Figures 4A and 4B).

We identified six main categories of use for Neotropical columbids: food, medicinal, pets, magico-religious, artisanal, and commercial. Use categories were heterogeneously distributed among species. Food use was the most frequent category, reported for 31 species (63.2%), followed by commercial exploitation and pet keeping (n = 20 each; 40.8%), medicinal use (n = 17; 34.6%), magico-religious use (n = 9; 18.3%), and artisanal use (n = 7; 14.2%) (Table 1). Here, artisanal use refers to the capture of pigeons and doves for the use of parts such as ornaments or hunting trophies. Commercial uses, broadly speaking, mainly referred to the trade of animals for meat consumption or as wild pets, although this distinction was often unclear.

The countries with the greatest diversity of uses were Brazil, Mexico, and Colombia (n = 6 categories each), followed by Argentina (n = 4) and Peru, Ecuador, Venezuela, and the United States (n = 3 each). Among the 70 Neotropical columbid species analyzed, 20 showed records of commercial exploitation across 9 countries. The countries with records of species legally or illegally exploited for commercial purposes were: Brazil (n = 11 spp.; 22.4%); Peru (n = 10; 20.4%); Venezuela (n = 6; 12.2%); Colombia (n = 5; 10.2%); Mexico (n = 3; 6.1%); Argentina (n = 2; 4.1%); and Cuba, the United States, and Bolivia (n = 1 each; 2%). Among the reported points of sale, street fairs, open markets, and market stalls were the most frequently mentioned. For *Zenaida auriculata* (the eared dove), Fernandes-Ferreira et al. (2012) reported the sale of both birds and their eggs even along highways. At the country level, the documented richness of exploited columbid species was strongly and positively

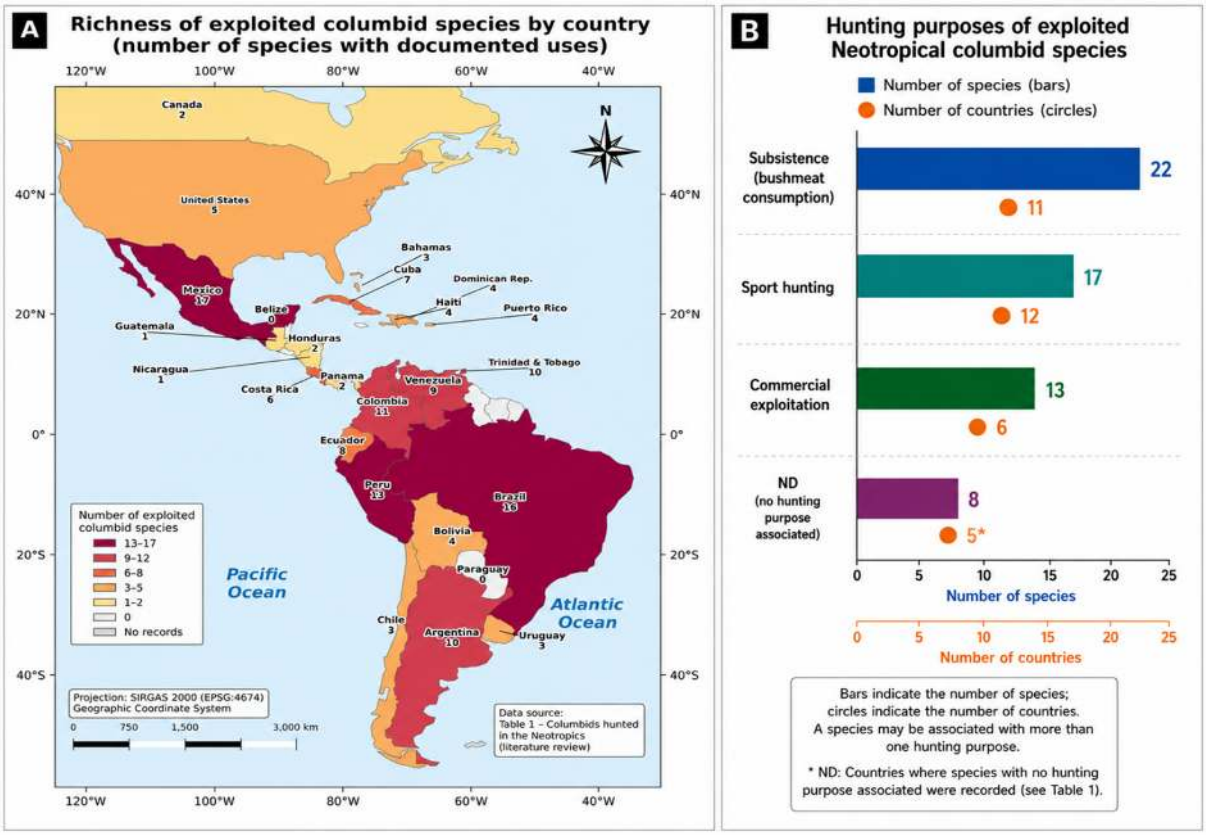


Figure 1. Geographic distribution and hunting purposes of exploited Neotropical columbids recorded in the literature. (A) The map shows the richness of exploited columbid species per country across the American continent, based on records compiled from Table 1 (Supplementary Material). Countries are represented using a color gradient proportional to the number of species with documented uses, while numbers indicate the exact richness values for each country. (B) The horizontal bar graph summarizes the number of species associated with each clearly identified hunting purpose. Because a single species may be associated with more than one category, totals are not mutually exclusive.

associated with the total number of use records documented in the literature (Spearman $\rho = 0.918$, $p < 0.001$; Figure 4C). Countries with a greater number of exploited species also tended to exhibit a broader diversity of reported uses, indicating that patterns of exploitation intensify as the number of species involved increases.

At the species level, strong and significant relationships were observed among exploitation variables (Figures 4D and 4E). The number of use categories was strongly correlated with the number of countries in which each species was recorded ($\rho = 0.838$, $p < 0.001$), indicating that widely distributed species tend to have broader use profiles (Figure 4D). Similarly, the number of capture techniques was strongly associated with hunting/use types and geographic distribution (Figure 4E). The correlation matrix (Figure 4E) further highlights the consistency of these relationships, suggesting that exploitation patterns are structured and interconnected rather than random.

Conservation issues

All 49 columbid species with records of use or trade identified in this review are listed in the IUCN Red List (IUCN 2025). These species are distributed across the following threat categories: Least Concern (LC) (n = 38; 77.5%), Near Threatened (NT) (n = 4; 8.2%), Endangered (EN) (n = 3; 6.1%), Vulnerable (VU) (n = 2; 4.1%), Critically Endangered (CR) and Extinct in the Wild (EW) (n = 1 each; 2%).

DISCUSSION

Our results reveal a strong interaction between human populations and Neotropical columbids. This can be understood in several ways. First, at least 70% of Neotropical columbids are exploited across differ-

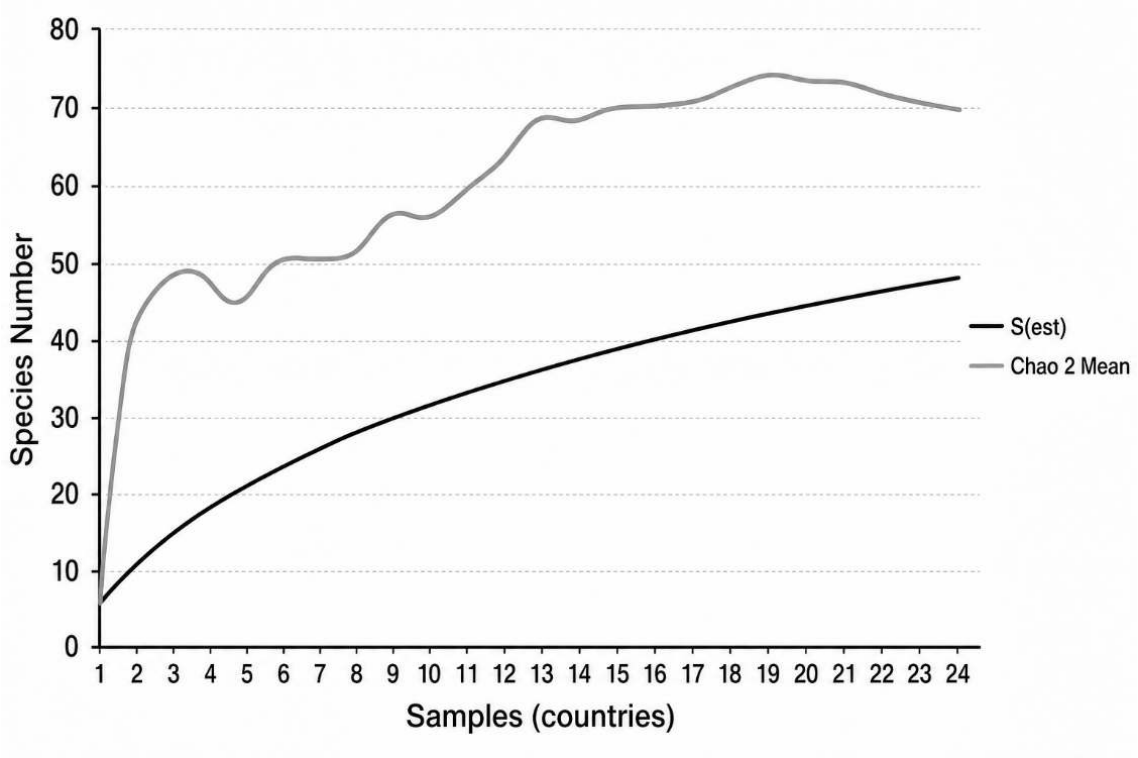


Figure 2. Rarefaction curve of species, comparing the observed number of species S(est) with the estimated richness of Neotropical columbids captured and traded (Chao 2). Source: WMSS (2025).

ent categories of use, including food, pets, medicinal, magico-religious, artisanal, and commercial purposes. The recurrent use of the same species, genera, or broader taxonomic groups across different points of tropical region reinforces their cultural importance (Setiyani and Ahmadi 2020).

This pattern has also been observed in other bird groups, such as Psittaciformes, a taxon in which nearly 80% of populations are in decline, mainly due to use and trade for multiple purposes, with approximately 28% of species targeted by the illegal pet trade (Setiyani and Ahmadi 2020; Sánchez-Mercado et al. 2020). Many widely distributed Neotropical Psittaciformes and Passeriformes species, such as *Amazona aestiva*, *Aratinga jandaya*, and *Sporophila albogularis*, are frequently exploited for identical uses across different areas of occurrence, particularly to meet urban demands, thereby imposing strong pressure on their populations (see Sánchez-Mercado et al. 2020; Souto et al. 2017). Analogously, our results reflect the important role of columbid species as a significant sociocultural resource for diverse urban and rural communities worldwide (Azeredo and Alves 2024; Borges et al. 2021b; Eckert and Clark 2009; Silva et al. 2021).

However, the overexploitation of columbids through excessive hunting significantly contributes to population declines, as well as local extirpations and extinctions (Benítez-López et al. 2017; Cambrone et al. 2023). Our findings reinforce the need for more effective conservation strategies that take into account the complexity of sociocultural relationships and the multifunctionality of columbid use by human populations in the Neotropical region.

The analysis of the geographic distribution of exploited species reveals a relationship between species richness per country and the number of use records. Latin American countries such as Brazil, Mexico, and Peru stood out for having the highest frequency of species-use records and are among the richest in numbers of columbid species (Alvarez-Alvarez et al. 2020; Daut et al. 2015; Pacheco et al. 2021; Vélez et al. 2021). Other countries - such as Colombia, Bolivia, and Argentina—occupied intermediate positions in terms of the number of exploited species, even though they harbor substantial columbis diversity within their territories (Bauni et al. 2022; Echeverry-Galvis et al. 2022; Schulenberg et al. 2007). These findings highlight the need for wildlife conservation in the face of persistent contemporary challenges, such as excessive hunting, increasing urbanization, and the broad-spectrum illegal wildlife trade (Aragão Silva et al. 2023; Souto et al. 2018; Van Vliet et al. 2016). In this context, sustainable management, combined with the strengthening of policies and community engage-

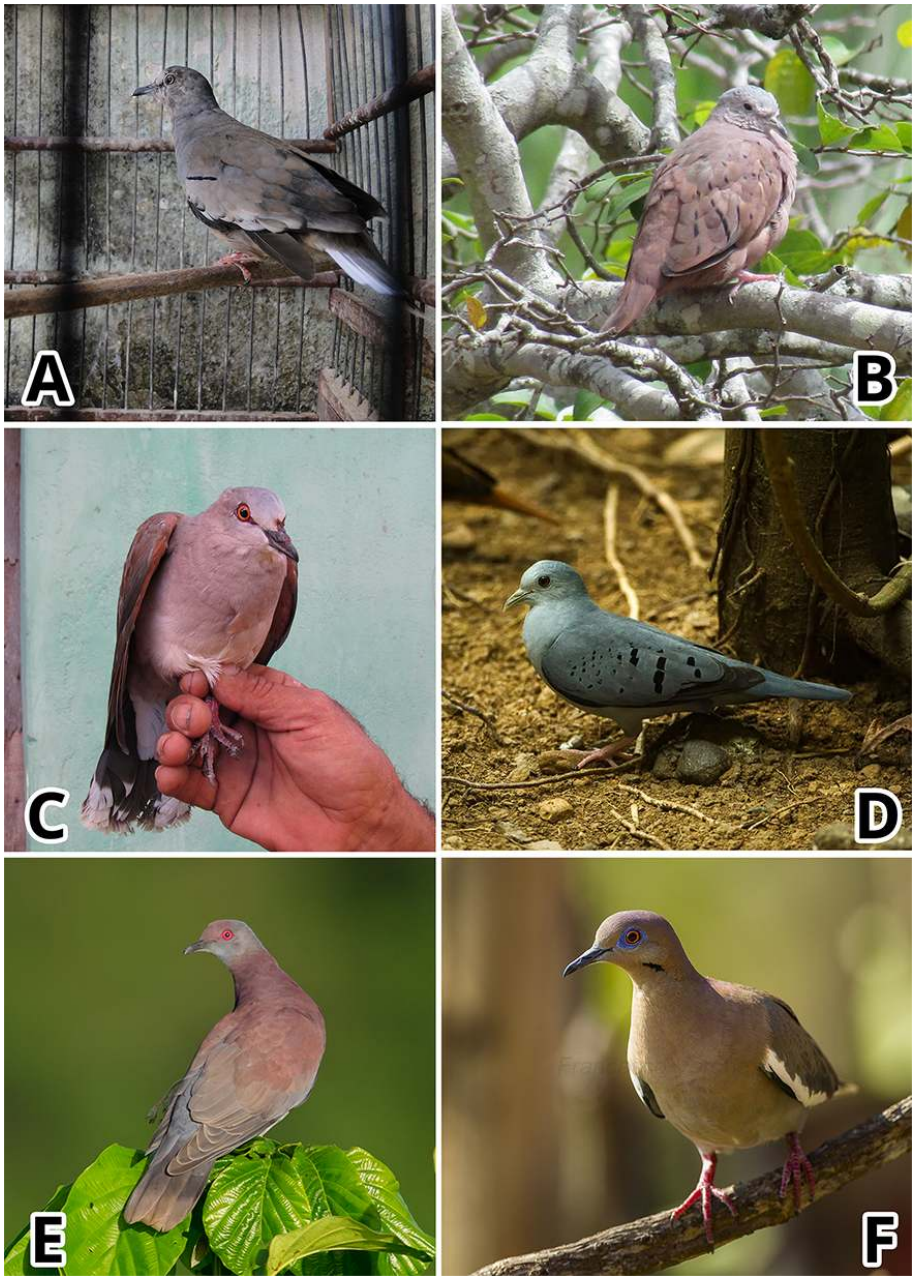


Figure 3. Examples of harvested and traded Neotropical wild columbids. (A) *Columbina picui*, (B) *Columbina talpacoti*, (C) *Leptotila verreauxi*, (D) *Claravis pretiosa*, (E) *Patagioenas cayannensis*, (F) *Zenaida macroura*. A-C: Wedson M. S. Souto, D: Francesco Veronesi, under license CC BY-SA 2.0 on website https://animalia.bio/pt/blue-ground-dove; E: Joao Quental under license CC BY-SA 2.0 on the Flickr website, F: Francesco Veronesi, under license CC BY-SA 2.0 on Flickr. *Columbina* sp. are hunted and trapped for food, medicine and as pets in several countries of South America. *Zenaida asiatica* is a key target of hunters and trappers in North and Central America hunted as a source of wild meat and, apparently more rarely, captured for wild-pet keeping.

ment, is essential to ensure the preservation of biodiversity.

Several non-biological factors may influence the number of species with documented use in a given country. For example, countries with greater research infrastructure, funding, and academic tradition tend to document the use of more species (Aragão Silva et al. 2023; Cambrone et al. 2023). The number of active researchers in the field, the presence of institutions dedicated to ethnozoological research, the

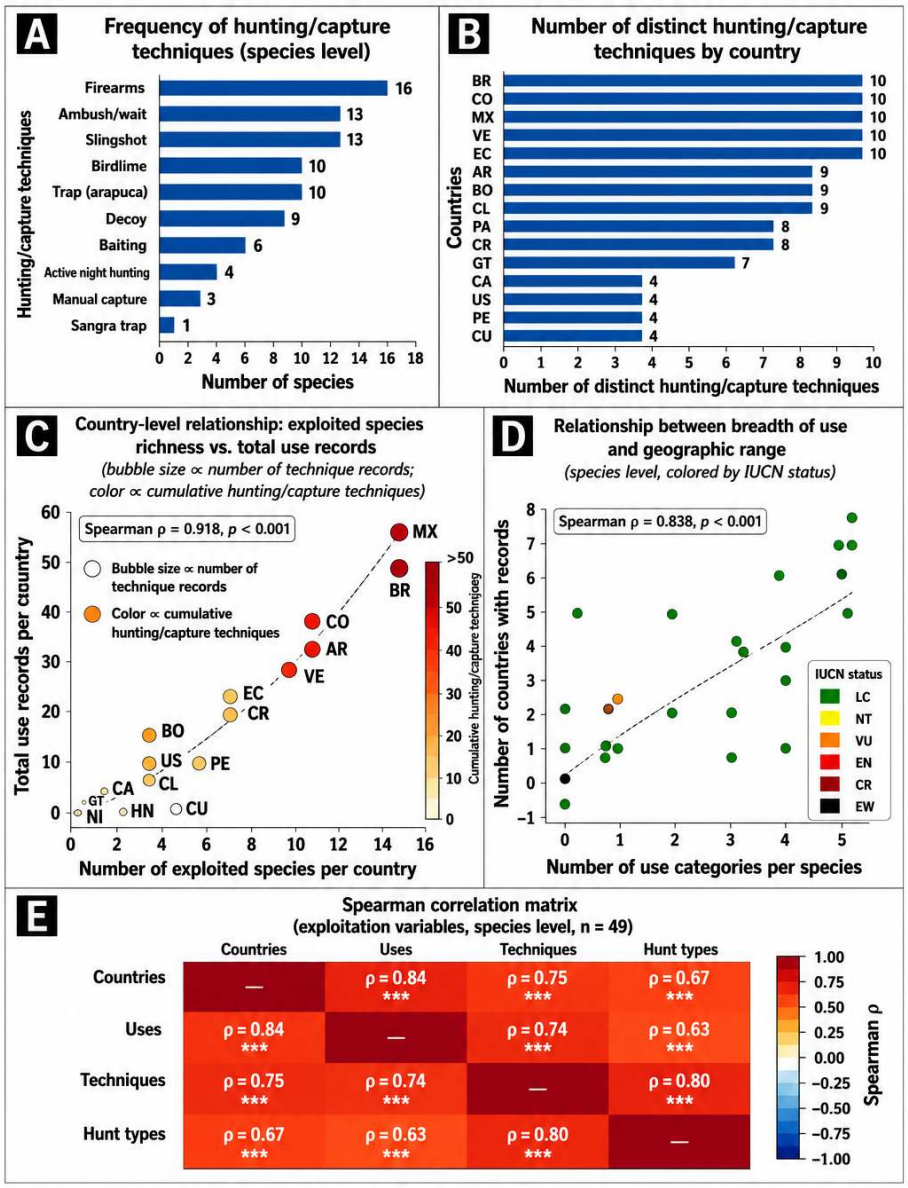


Figure 4. Patterns of exploitation of Columbidae in the Neotropics. (A) Frequency of hunting/capture techniques recorded for exploited species. (B) Number of distinct hunting/capture techniques documented per country. (C) Country-level relationship between exploited species richness and total use records; bubble size is proportional to the number of technique records and color represents the cumulative number of hunting/capture techniques. (D) Relationship between the number of use categories per species and the number of countries with records, colored by IUCN conservation status. (E) Spearman correlation matrix among exploitation variables at the species level (n = 49); *** p < 0.001. **Country abbreviations in B and C:** AR = Argentina; BO = Bolivia; BR = Brazil; CA = Canada; CL = Chile; CO = Colombia; CR = Costa Rica; CU = Cuba; EC = Ecuador; GT = Guatemala; HN = Honduras; MX = Mexico; NI = Nicaragua; PA = Panama; PE = Peru; US = United States; VE = Venezuela.

cultural value attributed to wildlife, and national and international scientific cooperation may play a decisive role in the production and availability of generated knowledge (Alves and Albuquerque 2018; Aragão Silva et al. 2023). In this context, the absence of records in a particular region does not necessarily reflect the absence of uses, but may instead be associated with a lack of systematic ethnobiological studies, resulting in gaps in knowledge about the use value of Columbiformes across different countries.

The different types of uses attributed to Neotropical columbids are, in general, widespread across various regions of Latin America, as shown by previous studies (Aragão Silva et al. 2023; Daut et al. 2015; Roldán-Clarà et al. 2017; Souto et al. 2018). Among these uses, food consumption stands out as the main form of exploitation, encompassing most of the species analyzed and reinforcing the importance of Columbiformes as an alternative protein source, particularly for vulnerable rural populations in tropical and Neotropical regions (Aragão Silva et al. 2023; Silva et al. 2021; Souto et al. 2019; Teixeira et al. 2024). This observed pattern may be related to a combination of factors, including their relative abundance, broad geographic distribution, the taste of the meat, high protein value, and the increasing scarcity of other faunal groups traditionally used as food sources, such as medium- and large-bodied mammals and birds (Alves et al. 2012a; Borges et al. 2021b; Souto et al. 2019). In addition, the ease of access and the low risk associated with hunting activities facilitate the exploitation and capture of columbids by hunters, especially in communities where low-cost techniques are available, and enforcement is limited (Silva et al. 2023; Silva et al. 2024; Souto et al. 2017).

The high frequency of records involving Columbiformes kept as pets reflects reflects a strong sociocultural component associated with maintaining wild birds in captivity, a practice predominantly observed among passerines (Oliveira et al. 2018; Roldán-Clarà et al. 2017; Silva et al. 2022; Souto et al. 2017). Many Columbiformes species are kept as pets, particularly due to attributes such as plumage coloration, characteristic vocalizations, and ease of handling in domestic environments (Alves et al. 2016; Bezerra et al. 2017; Daut et al. 2015; Oliveira et al. 2020; Silva et al. 2022; Souto et al. 2017). In this context, the popularity of these animals as pets underscores the need to incorporate sociocultural practices into conservation strategies and to improve the regulation of the wild-bird trade (Bezerra et al. 2017).

In other parts of the world, birds are among the most heavily traded animals, with numerous species, including Columbiformes, threatened by the illegal pet trade (Aloufi et al. 2025; Leupen et al. 2025; Leupen et al. 2022; Nijman et al. 2022). This is especially prevalent in Southeast Asia, where, for example, Leupen et al. (2025) recorded 90 incidents of illegal trade involving a minimum of 3,086 columbid individuals from at least 18 species from Indonesian region. Considering that the Neotropical region is also a hotspot for domestic and international trade in wild birds (see Azeredo and Alves 2024; Ferrari et al. 2023), it is plausible to assume that the richness of columbid species used to meet rural and urban demands across the Neotropics is likely close to the entire diversity of Neotropical Columbiformes. Likewise, given the species richness and the wide geographic scope of uses recorded, a substantial number of Neotropical columbid individuals may be removed from the wild each year to meet subsistence and non-subsistence demands.

The trade in wild birds is not restricted to street fairs, open markets, and informal shops commonly used for this purpose in various regions of the world (Leupen et al. 2022; Silva et al. 2021; Souto et al. 2017). The expansion of the internet has enabled a significant level of wildlife trade, with online markets and digital platforms (i.e., social media) frequently used because they facilitate the illegal trade of birds and other taxa (Alves et al. 2019; Borges et al. 2021a; Borges et al. 2022; Leupen et al. 2025; Salas-Picazo et al. 2023; Souto et al. 2017). These transformations, driven by the widespread use of smartphones and social networks, impose new challenges for detecting wildlife-trade supply chains, which directly affects biodiversity conservation (El Bizri et al. 2024; Leupen et al. 2022; Salas-Picazo et al. 2023; Souto et al. 2017).

The advancement of digital technologies has played a decisive role in intensifying the use and trade of columbids. Recent studies show that platforms such as Facebook, WhatsApp, TikTok, and marketplace networks facilitate the offering of wild birds - including columbids - and popularize different types of biodiversity use across countries, especially in urban areas, creating parallel markets that are difficult to regulate and significantly expanding the spatial scale of transactions (Fiennes et al. 2023; Salas-Picazo et al. 2023). For Neotropical columbids, *Zenaida auriculata* (the eared dove) already represents a particularly emblematic case in certain regions. Widely distributed across South America, this species is the target of intense commercial exploitation in northeastern Brazil, primarily for its meat and eggs (Aragão Silva et al. 2023; Silva et al. 2021; Silva et al. 2020). Studies in Brazil have documented that *Zenaida* spp. and other columbids (genus *Columbina* spp. and *Leptotila* spp.) are traded through structured exploitation chains that include highways and public markets, highlighting the intensity of anthropogenic pressure on these species (Alves et al. 2012a; Aragão Silva et al. 2023; Silva et al. 2021; Silva et al. 2023). This scenario evokes the case of the North American passenger pigeon (*Ectopistes migratorius*), driven to extinction due to intensive human-driven exploitation (Guiry et al. 2020). Evidence already suggests that hunters in northeastern Brazil widely use social media to intensify the trade of *Zenaida auriculata* and other columbids (Souto 2014). Thus, understanding how these platforms structure the trade in columbids is essential for properly interpreting the patterns of use observed in the Neotropical

region.

Overall, commercial records were concentrated predominantly on the sale of columbids for food consumption and as pets. However, it is likely that more detailed studies will reveal additional commercial purposes, such as medicinal and artisanal uses, considering that animals acquired for consumption may have body parts (i.e., feathers, skin, bones, etc.) or by-products later used for these other purposes (Aragão Silva et al. 2023; Souto et al. 2018).

In addition to direct impacts resulting from the removal of native specimens from the wild, the pet bird trade may act as an important vector for the introduction of exotic species, especially when birds escape or are released by their owners into a new geographic region, resulting in ecological impacts (Souto et al. 2017; Suárez-Rodríguez et al. 2023). In Indonesia, for example, Columbiformes dominate the online trade in exotic birds, representing about 38% of non-native species sold on platforms such as Shopee and Tokopedia (Justryaningsih et al. 2025). Due to their low ecological requirements and granivorous and/or frugivorous diets, species of the order Columbiformes can establish themselves in anthropogenic and urban environments (Silva et al. 2024). The wildlife trade has facilitated the introduction and establishment of several doves and pigeon species in Europe, including *Columbina passerina* (Linnaeus, 1758) (native to tropical America) (DAISIE - Inventory of alien invasive species in Europe 2009). The Neotropical *Columbina minuta* (Linnaeus, 1766) was introduced in the northern coast of Bahia (Brazil) – an area outside the species' native range - by the environmental authorities, where it has been reported breeding (Fontoura et al. 2013). The introduction of a Neotropical columbid into another area of the Neotropics where it does not naturally occur may contribute to intra-guild competition and, consequently, increase the likelihood of ecological imbalance. The introduction of these birds, often affected by parasitic diseases, poses risks both to native fauna and to public health (Cambrone et al. 2023). In this context, stricter monitoring and regulation of the international pet bird trade are necessary to mitigate these risks.

Most columbid species threatened with extinction are found in tropical regions, such as *Ectopistes migratorius* (the passenger pigeon), *Zenaida graysoni* (the Socorro dove), and *Leptotila ochraceiventris* (the ochre-bellied dove) (Cambrone et al. 2023; IUCN 2025). *Zenaida graysoni*, classified as Extinct in the Wild (EW) and endemic to Socorro Island in Mexico, had its natural population eliminated due to subsistence hunting, habitat loss, and the introduction of exotic predators such as the domestic cat (*Felis catus*) (Ortiz-Alcaraz et al. 2017).

Although our review identified a diverse set of hunting and capture strategies associated with Columbiformes across the Neotropics, this repertoire is likely broader than currently documented. Several technical reports, ethnobiological or hunting studies often prioritize species richness and use categories (e.g., Bezerra et al. 2019, Silva et al. 2020), while the specific techniques employed to obtain birds are frequently reported only as secondary information or omitted altogether. This pattern may generate an underrepresentation of the true diversity of local capture practices. Such underdetection is particularly relevant in the Neotropical region, where studies on bird exploitation and wildlife hunting have consistently revealed highly diversified and context-dependent strategies, including active pursuit, decoys, adhesive traps, selective trapping systems, and firearms, varying according to habitat, species behavior, and local traditions (Bastos Silva et al. 2022; Silva et al. 2022; Souto et al. 2017). Thus, the hunting repertoire associated with Columbiformes is probably more complex than the available literature currently suggests.

Final implications for conservation

Our results, showing substantial richness of exploited columbid species across different parts of the Neotropical region, suggest that the the threat posed by hunting and bird trade is systematically underestimated in global risk assessments (see also Cambrone et al. 2023). Although many Neotropical columbid species are classified as "Least Concern" by the IUCN, the breadth of documented uses - including food, trade, traditional medicine, and keeping birds as pets - suggests a higher level of vulnerability than what is reflected in threat listings. This discrepancy between the formal conservation status and the a real pressure of exploitation may compromise the effectiveness of management policies and delay necessary interventions.

In our review, we identified 13 species listed by the IUCN as threatened, including *Claravis geoffroyi*, *Leptotila ochraceiventris*, *Geotrygon purpurata*, and *Patagioenas leucocephala*. The main drivers of decline for these target species include agriculture, logging, habitat loss, excessive hunting, mining, and urban and industrial expansion - factors that directly affect the availability of shelter, food, and breeding sites (Antonelli 2022; Benítez-López et al. 2017; IUCN 2025). *Claravis geoffroyi*, classified as Critically Endangered, is under severe pressure due to deforestation and fragmentation of the Atlantic Forest, caused primarily by agricultural and urban expansion (Galetti et al. 2021; Lees et al. 2022). However, a total of 11 Neotropical columbid species are listed by the IUCN (2025) as having "hunting and trapping" among the threats to their survival: *Claravis geoffroyi*, *Leptotila ochraceiventris*, *Zenaida graysoni*, *Geotrygon purpurata*, *Geotrygon caniceps*, *Geotrygon leucome-*

topia, *Geotrygon saphirina*, *Starnoenas cyanocephala*, *Patagioenas leucocephala*, *Patagioenas inornata*, and *Patagioenas oenops*. Among these, four species are associated with use and trade as pets, while eight are exploited for food, with some species appearing in both categories. According to the IUCN Red List, 29 species reported in the literature are used for food, and another 29 are kept as pets, reflecting the overlap and breadth of uses attributed to this group and identifying use and trade as major threats (IUCN 2025).

Although considered rare in trade, the capture of certain species can have significant impacts given the small size of their remaining populations. The Critically Endangered *Columbina cyanopis* (blue-eyed ground-dove) exemplifies how habitat degradation and fragmentation, along with climate change, land-use change and shifts in wildlife exploitation in the Cerrado biome, drive species toward extinction by reducing population size, genetic diversity, and altering community structure (Borges et al. 2019; Braz et al. 2023). Thus, it is essential to establish conservation priorities that are more explicitly grounded in evidence of use and trade. Recent quantitative studies, such as Cambrone et al. (2023), demonstrate that combinations of socioecological variables can accurately predict which species are most prone to decline. Such interventions are particularly urgent in countries with high diversity of target species and multiple forms of exploitation and trade, such as Brazil, Mexico, Colombia, and Peru.

This issue has important conservation implications because the risk imposed on Columbiformes populations is not determined solely by the number of species used or by the diversity of use categories, but also by the efficiency and selectivity of the hunting methods themselves. Firearms, for example, can substantially increase harvest success and allow the rapid removal of multiple individuals (Bastos Silva et al. 2022; Coronel-Castro et al. 2024), while specialized trapping devices may intensify capture rates in predictable movement corridors or feeding sites (Silva et al. 2022). Moreover, some techniques may affect non-target species, increasing collateral impacts on local bird assemblages. Similar patterns have been documented in Neotropical wildlife harvesting systems, where efficient and diversified hunting technologies are strongly associated with increased extraction pressure and localized wildlife depletion (Silva et al. 2022; Chaves et al. 2019). The widespread use of firearms for capturing columbids across the Neotropical region, particularly for food and medicinal purposes, likely reflects broader socioeconomic transformations, including increasing access to urban goods and hunting technologies in rural areas (El Bizri et al. 2015; Bastos Silva et al. 2022). Therefore, understanding how Columbiformes are captured is as important as documenting why they are used, as both dimensions are essential for assessing exploitation intensity and designing effective conservation strategies.

The conservation of Neotropical columbids requires a set of integrated strategies aimed at minimizing the impacts of exploitation and promoting the sustainable use of species (see Develey 2021). Environmental education initiatives targeting local communities and school-age children - designed to raise awareness about the impacts of hunting and to value wildlife as natural heritage - also represent important measures (Cambrone et al. 2023; Charity and Ferreira 2020). Ecotourism, particularly birdwatching tourism associated with citizen-science platforms such as WikiAves, *eBird*, and *iNaturalist*, demonstrates the potential of avifauna for sustainable tourism activities. These initiatives represent an important strategy for promoting local community participation in monitoring and ethnoconservation (Bonfim et al. 2024).

The increasing pressure on wild populations in the context of climate change and the persistence of high levels of exploitation in many parts of the world raises the possibility of using captive-breeding programs as an alternative to meet part of the demand for food, pets, and cultural uses. International experiences indicate, however, that implementing such a model presents substantial challenges. Studies conducted in Southeast Asia show that legal breeding systems can paradoxically facilitate the laundering of individuals taken from the wild, especially when rigorous mechanisms of traceability, auditing, and continuous monitoring are lacking (Chng and Eaton 2016; Sy et al. 2022; Wyatt et al. 2018). To mitigate these risks, it would be essential to adopt integrated systems of individual identification, genetic certification, systematic enforcement, and transparency throughout supply chains, along with policies that prevent the expansion of breeding facilities that operate as channels for legalizing illegally sourced wildlife (Sy et al. 2022). Only under these conditions could captive breeding contribute to reducing pressures on natural populations, provided it is supported by robust, clear, and fully enforced regulations implemented by environmental authorities.

Biodiversity conservation is a foundational element of quality of life, as outlined in the UN Sustainable Development Goals (SDGs), particularly for vulnerable societies that depend directly on natural resources (United Nations, 2023). In this context, conserving Neotropical columbids directly contributes to multiple SDGs, including SDG 2 (Zero Hunger) by supporting food security for rural communities, SDG 3 (Good Health and Well-being) by recognizing the role of traditional medicinal practices in local well-being, SDG 11 (Sustainable Cities and Communities) by safeguarding cultural heritage and traditional ecological

knowledge, SDG 12 (Responsible Consumption and Production) by promoting sustainable wildlife use, SDG 13 (Climate Action) through the maintenance of ecological resilience, and SDG 15 (Life on Land) by preserving biodiversity, ecosystem functions, and habitat integrity. Thus, protecting these birds extends beyond species conservation alone, representing an essential component of socioecological sustainability, cultural continuity, and human resilience in the Neotropical region.

CONCLUSION

In our review, we identified 49 species of Neotropical columbids, distributed across 23 countries, that are exploited for different purposes, primarily for food, trade, and keeping as pets. This review demonstrates that Neotropical columbids play a central role in the relationship between people and wildlife, through their multiple forms of use, broad distribution, and accessibility to hunters and trappers. The results show that the group is exploited in diverse ways- food, commerce, cultural practices, medicinal uses, and as pets - revealing a complex network of sociocultural interactions that shape patterns of hunting pressure throughout the Neotropics. By compiling information dispersed across the literature, this synthesis contributes to a more integrated understanding of the breadth of use of these animals and their importance to different human communities.

This review highlights the importance of deepening studies on patterns of use, trade routes, sociocultural motivations, and the ecological impacts associated with Neotropical columbids. Such information is essential for guiding more effective management actions and public policies that consider both conservation objectives and the social realities that shape wildlife use. Our study provides a foundation for more informed and integrated decision-making, supporting strategies that reconcile biodiversity conservation, the sustainability of bird populations, and the needs of the human communities that interact with these resources.

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DATA AVAILABILITY

Table 1 (Additional File) was prepared so that all data from this study are available therein. Any questions or additional related information can be obtained from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: EPOS, WMSS.
Carried out the data collection: EPOS.
Carried out the data analysis: WMSS.
Wrote the first draft of the manuscript: WMSS, JAAS, ISM, ABS, EPOS.
Review and final write of the manuscript: JAAS, ABS, RRNA, WMSS.
Supervision: RRNA, WMSS.

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DISCLOSURE OF AI USE

Artificial intelligence (Claude AI) was used exclusively for graphical enhancement and visual refinement of figures generated using SPSS version 30 (Figures 1B, 2 and 4). All final figures were reviewed and validated by the authors to ensure fidelity to the original analyses. AI was not used for data analysis, interpretation, or generation of scientific content.

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Additional Files

Add File 1. List of Neotropical Columbid species with hunting record on literature. Categorized by Country, Use, Hunting Type, and Capture Technique.

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