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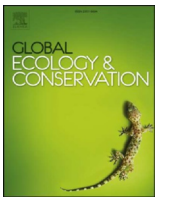

Characterizing trade at the largest wildlife market of Amazonian Peru

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ABSTRACT

Wildlife exploitation has nutritional, medicinal, luxury, sociocultural, and financial significance for human societies. Yet, it also risks undesired outcomes for conservation, animal welfare, and public health. Although it is prohibited in urban markets, the wildlife trade in Peru is poorly monitored, and practiced openly. To identify those species most likely to be affected, we investigated the trade in live wild animals and their derivatives at the Belén Market, and additional smaller open-air markets, which together make Iquitos the largest and most important wildlife trade hubs in the Peruvian Amazon. Specifically, we asked what wild animals or animal products were most profitable, what were they used for, and which wild animals were perceived by vendors to have increased most in rarity. Vendors provided 44 local animal names, from which we inferred an estimated 205 species. Nine per cent (n = 19) of these inferred species are categorised on the IUCN Red List as threatened; 35% (n = 71) are categorised as declining. We found that wild meat/food was the most frequently stated purpose of sale of wildlife, followed by pets, spiritual/belief-based use, traditional medicine, and decorative use. The most commonly cited most profitable wildlife derivatives were 'lowland paca', 'yellow footed tortoise', and 'collared peccary'. A significant positive correlation was found between the most profitable species and those that are becoming increasingly rare. Further research focused on the actual impacts on wildlife, the socio-economic importance of this trade, the societal pressures driving consumer demand, and the risks to public health is warranted.

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1. Introduction

Peru is a mega-diverse nation (Rodríguez and Young, 2000), and an important wildlife trade hotspot in the Latin America region (Reuter et al., 2018). Wildlife trade in Peru involves numerous species across taxonomic groups including amphibians (Quevans et al., 2013), birds (Daut et al., 2015), invertebrates (SERFOR, 2016), reptiles (Pineda-Catalan et al., 2012), and mammals (Bodmer and Lozano, 2001). The exploitation of wild animals for their meat is the most common use of wildlife in Peru (Bodmer et al., 2004), which can be an important source of fats and nutrients, particularly for people living in rural rainforest areas (Asprilla-Perea and Díaz-Puente, 2019). However, wildlife also provides the raw materials for zootherapeutic remedies and for use in magico-religious rituals in the form of amulets and charms (Venero, 1998). In comparison, the exploitation of wild animals as exotic pets is considered to represent a smaller component of the wider wildlife commerce in Peru (Bodmer and Lozano, 2001). Yet, a thriving domestic market persists (Daut et al., 2015). Peru is recognised as one of the most active exporters of live wild animals, traded annually to meet international consumer demand (Can et al., 2019). In addition, another relatively small, yet substantial, fraction of the wildlife commerce in Peru is directed towards tourists who purchase animal derivatives (Bodmer and Lozano, 2001), or pose with wild animals for photographs (D'Cruze et al., 2018), as souvenirs. Beyond its potential nutritional, medicinal, luxury, and socio-cultural significance for human societies, for many Peruvian rainforest residents, the harvest of wild animals can represent an important source of financial security (Espinosa, 2008).

However, despite these potential benefits, the trade of wildlife in Peru is poorly regulated and can have unexpected and undesired outcomes (Dutton et al., 2013). For example, from a conservation perspective, unsustainable hunting threatens both the survival of wild species and the financial income of the region's poorest citizens in the long-term (van Halle, 2002); with the trade of wild meat to supply urban markets considered an on-going major issue of concern (Zapata-Ríos et al., 2009). There are also substantial consequences for animal welfare as the potential for suffering exists at each stage of the trade chain, including capture, captive breeding, transport, slaughter or private ownership (Baker et al., 2013). This, in turn, poses a risk to public health, particularly in scenarios where animals have endured debilitating conditions that compromise their immune systems and that promote disease transmission, such as when they are packed in dirty cages in close proximity to other species (Watsa, 2020). Markets selling wildlife in open-air environments with little to no health safety precautions or sanitation measures are common in Peru (Leberatto, 2017), and have become of particular concern since the emergence of COVID-19 (Aguirre et al., 2020).

A major challenge in addressing wildlife trade is identifying the species that are most at risk and require immediate conservation attention (D'Cruze et al., 2020). To this end, species-focused surveys can be valuable at markets where wildlife and their body parts are sold (Harris et al., 2015). The trade in wildlife in Peru is thought to be significant and widespread (Leberatto, 2017). However, many aspects remain poorly understood with specific data having been reported in the scientific literature for a relatively few select urban wildlife markets. To date, such research has focused on the cities of Chiclayo, Ica, Lima, Piura, Tumbes, and Trujillo in the coastal lowlands; Arequipa, Cusco and Puno in the Andes; and Iquitos, Pucallpa, Puerto Maldonado, and Yurimaguas in the Amazonian lowlands (see e.g., Bodmer and Lozano, 2001; Daut et al., 2015; Gastañaga et al., 2011). These existing studies provide useful insights into the wildlife trade and highlight the need for additional data on the species most used, the nature of their use, and the socio-economic importance of the trade. Together this information can help to identify those species that might be threatened by over-exploitation, subject to inhumane use, or pose a particular threat to public health.

The Belén Market, located in Iquitos, is considered to be the largest and most important open market selling wildlife in the Peruvian Amazon (Mayor et al., 2019). This market is known to trade in a wide variety of wildlife products obtained from the rainforest, primarily wild meat (Bodmer and Lozano, 2001), but also traditional medicine, and exotic pets (Mayor et al., 2019). Wildlife is typically sold to urban market vendors, restaurants, or consumers directly by local hunters or by middlemen (Mayor et al., 2019). However, wild meat typically represents a traditional and/or luxury dish for most urban consumers in Iquitos, rather than a daily staple such as domesticated chicken and fish (Mayor et al., 2019). In addition to Belén, smaller open-air markets also contribute to the wider wildlife trade network in and around Iquitos. Given that wildlife is traded openly in the Belén and other nearby markets in and around Iquitos, in this study we used a dataset collected from wildlife sellers therein to gain insight into the diversity of wild animal species being sold. In particular, we sought to identify: (1) those species perceived to be most commercially profitable by traders (i.e., those that generate the most money on an annual basis, as opposed those that are most expensive per item), both in terms of live animals and their body parts; (2) those species deemed to have increased most in rarity; and (3) information on the circumstances under which traders sell wildlife and their reasons for doing so.

2. Methods

2.1. Data collection

Structured surveys based on a set of predetermined questions [including open-ended, closed, and multiple-choice questions (see Appendix A1)] were carried out with vendors at Belén, Maynas, Modelo, San Carlos, and Venecia markets (3° 42′ 11″- 4° 30′ 21″ S, 73° 14′ 28″ - 73° 34′ 16″ W) between January 30th and March 28th, 2019. The surveys were conducted by two researchers in Spanish and later translated into English. Vendors who were willing to participate in the study were identified through a process of chain referral (Newing, 2011), whereby participants recommended other potential participants or asked others to

take part. In accordance with the British Sociological Association Statement of Ethical Practice (BSA, 2017), informed consent was obtained verbally from every survey participant prior to the interview, participants were made aware of their rights to voluntarily participate or to decline, no identifying participant or household data were collected and the database collated was entirely anonymous. In addition, vendor stands were coded in the database and names not reported to further protect study participants from harm or discrimination (John et al., 2016).

Specifically, vendors were asked to identify and rank the 10 wild animals (using local common names) that they currently considered to be the most profitable (as opposed to most valuable per item or most commonly traded, with wildlife body parts and live animals considered separately), and the 10 wild animals that they considered to have most increased in rarity (and therefore inferred reduced availability) over the past five years (corresponding to the period 2014–2019). Common names relating to taxonomic class (e.g., bird and mammal) or below were included in the analysis of the survey responses, but were excluded when considering conservation status. Vendors were also asked to provide additional information including the wildlife body parts sold, their minimum and maximum price, estimated number of units sold (in the last year, last five years and last 10 years) and their intended purpose [which were categorised as "food" (wild meat and other nutritional use), "pets" (live companions or pest control), "spiritual" (e.g., items to invoke magic, good luck and prosperity), "medicinal" (ingested or topical treatments for illness) and "decorative" use (aesthetic purposes or clothing)]. Where multiple purposes were cited for one species, they were classed as "multiple".

For wildlife, local common names provided by vendors in Spanish were translated into English. A list of inferred species and their respective scientific names were assigned to each common names based on the documented presence of wild species in Peru, according to the International Union for Conservation of Nature Red List of Threatened Species (IUCN, 2020) (hereafter the IUCN Red List). For all species [excluding names relating to taxonomic class or above (which were considered too broad, e.g., "bird" and "mammal") and any common names relating to invertebrates and fish (given a relative lack of Red List data relating to these taxonomic groups)], information regarding their conservation status and population trend was also gathered from global species assessments on the IUCN Red List because comprehensive national level assessments are not yet available for Peru. Threat status was recorded in accordance with the 2001 IUCN Red List Categories and Criteria system (version 3.1) as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC) or Data Deficient (DD). For all species, information regarding their international legal trade status was gathered from the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) website (https://www.cites.org).

2.2. Data analysis

We used descriptive statistics to summarise the demographic data collected for each respondent to provide a socio-economic overview of the traders at Iquitos. Monetary values were reported in Peruvian Nuevo Soles and converted to US dollars (USD) using 1 USD = 3.30 Nuevo Soles (conversion rate as of 28.02.19, the midpoint of the surveys, https://www.xe.com).

Due to inconsistency in the number of responses from participants for the questions "most profitable species - body parts", "most profitable - live wild animal sales", and "species that have become extremely rare and/or unavailable" (e.g. we asked respondents to list 10 most profitable species but some respondents listed fewer than 10), only the top answers were considered for the main analysis, however all responses were used when considering conservation and population status. The top ranked species for the responses to the questions "most profitable species - body parts", "most profitable - live wild animal sales", and "species that have become extremely rare and/or unavailable" were used to examine the distribution of responses across species, body part, and purpose. Chi-square goodness of fit test was used to test if frequencies were evenly split across categories. All 10 possible species listed per question per respondent were then used to construct a matrix of species per question and purpose.

The sum rank of each species was calculated across all responses per question and then each species was ranked based on this value. Species ranking across the three questions were then correlated using a Spearman Rank correlation to look at the relationship between questions. All data analysis was undertaken in R version 4.0.2 (R Core Team, 2020).

3. Results

3.1. Demographic data

Surveys were conducted with 99 respondents (49 males and 50 females), ranging between 18 and 75 years in age [mean (±1 SD) = 42 years old (±14.4)]. The number of people declared by vendors to live in their households ranged from 1 to 15 individuals (mean = 4.8 ± 2.4), with the number of children in a household ranging from none to 9 (mean = 3.0 ± 1.9). Over half (53%, n = 52) of respondents owned at least one pet; 50 respondents reported owning at least one domesticated species, and 3 respondents reported having a wild (i.e., non-domesticated) species. In terms of marital status, most (37%, n = 37) individuals were 'married', 'single' (28%, n = 28) or 'cohabitant' (24%, n = 24), with the remaining respondents being 'widows/widowers' (8%, n = 8), 'married polygamists' (1%, n = 1) or in a 'free union' (1%, n = 1). Most (79%, n = 78) respondents did not provide any information regarding their ethnicity. However, 10% (n = 10) identified themselves as Riverine, 8% (n = 8) stated that they did not identify with any ethnicity, 2% (n = 2) identified as Kukama, and 1% (n = 1) as being of 'Chinese descent'. Respondents were predominantly from the district of Belén (73%, n = 72) and Mainas (11%, n = 11), with the majority (71%, n = 73) reporting that

they were born in villages therein. Religion was predominantly 'Catholic' (59%, n = 58), followed by 'Evangelical Christian' (12%, n = 12), and 'Christian' (4%, n = 4).

Respondent education level was variable; 54% (n = 53) were educated to secondary school level, 27% (n = 27) to higher education level, and 15% (n = 15) to primary school level. One individual reported receiving a technical education (i.e., occupation-specific rather than general education). Almost all (96%, n = 95) respondents reported some form of employment, but most (75%, n = 74) relied solely on trade as their source of income, and the remainder (25%, n = 24) supplemented their income with a secondary source of income. With regards to their primary source of income, 23% (n = 22) of respondents reported operating a 'food stall', 21% (n = 20) reported wild meat sales, 7% (n = 6) reported medicinal product sales, and 18% (n = 17) reported selling a range of products (such as vegetables, domesticated meat, eggs, fish, clothes, souvenirs, and electronic devices). The mean estimated annual income per household was 84,444 USD (± 10,330; median = 6049) and ranged between 907 and 695,702 USD, with 66% (n = 65) of respondents reporting that they considered their business to be lucrative. On average, respondents had been selling animal parts for 16.9 (±11.5) years (range = < 1–41 years).

3.2. Species and product diversity

Overall, during our survey, the 99 respondents used 44 distinct different common names to refer to the wildlife species traded, comprising of 8 common names referring to birds (18% of total number of distinct names); 23 to mammals (52%); and 13 to reptiles (29%) (Fig. 1). Across all species and product types, at the time of asking, live wildlife and their derivatives sold for a maximum of 907 USD for a whole jaguar (*Panthera onca*) specimen and 454 USD for a jaguar skin (Appendix A2). When considering all common names (n = 39) provided by 77 respondents relating to animal derivatives sold (Appendix A2), a significant positive correlation was found between the declared most profitable species and those that were stated as becoming increasingly rare (Spearman's rho = 0.78, $P < 0.001$). However, no significant correlation was found between most profitable and live animals ranks (rho = 0.17, $P = 0.525$) and between those species becoming rare and live animals ranks (rho = −0.25, $P = 0.341$).

A complete breakdown (including species, body part, unit of sale, frequency of response, and reported price) of all species mentioned by vendors during the survey can be found in Appendix A2. Here, we report only on the most frequently mentioned common names in relation to the most profitable animal derivatives, most profitable live animals, and the animals that have increased most in rarity from the vendors' perspective.

3.3. Most profitable animal derivatives

The most frequently mentioned common names for the 'ten most profitable wildlife species sold following slaughter' [when considering only the top ranked responses (18 common names from 77 vendors)] were 'lowland paca' (*Cuniculus paca*) (44%, n = 34), followed by 'yellow footed tortoise' (*Chelonoidis denticulatus*) (10%, n = 8), 'collared peccary' (*Pecari tajacu*) (9%, n = 7), and 'common boa' (*Boa constrictor*) (9%, n = 7) (Fig. 2; Appendix A3). The frequency of species listed as the most profitable animal derivatives was not evenly distributed amongst vendors ($X^2 = 224.8$, df = 16, $P < 0.001$). A total of 12 different body parts related to these particular common names with 'meat' being most frequently cited (Fig. 2). Across all market locations surveyed, the most frequently cited purpose of sale of animal derivatives was as 'food' (82%, n = 63), followed by 'spiritual' (9%, n = 7) 'medicinal' (5%, n = 4), and 'decorative' (3%, n = 2) [the purpose of sale was not evenly distributed amongst vendors ($X^2 = 200.4$, df = 4, $P < 0.001$)] (Fig. 2). Animal derivatives mentioned in relation to 'food' included 'meat', 'spine', 'ribs', 'liver', 'eggs', 'carapace', 'penis', 'tail', 'whole specimen', and 'horns'. A total of 22 respondents did not list a purpose for the sale of animal derivatives. The most expensive individual items were derived from 'river dolphin' (*Inia geoffrensis*) (151 USD per genitalia), 'common boa' (151 USD per skull), and 'black caiman' (*Melanosuchus niger*) (60 USD per skull) (Appendix A3). A breakdown of species sold as animal derivatives, and their purposes, across the different market locations surveyed is shown in Appendix A3.

3.4. Most profitable live animals

The most frequently mentioned common names for the 'ten most profitable wildlife species sold while alive' [when considering only the top ranked responses (10 common names from 17 vendors)] were 'parakeet' (Psittacidae) (18%, n = 3), followed by 'common Boa' (18%, n = 3), 'squirrel monkey' (*Saimiri* spp.) (12%, n = 2), 'parrot' (Psittacidae) (12%, n = 2) and 'sloth' (Folivora) (12%, n = 2) (Fig. 3). The frequency of species listed as the most profitable live animals was evenly distributed amongst vendors ($X^2 = 3.6$, df = 9, $P = 0.936$). Across all market locations surveyed, the most frequently cited purpose of sale of live animals was as 'pets' (68%, n = 13), followed by 'food' (11.8%, n = 2) (Fig. 3) [the purpose of sale was not evenly distributed amongst vendors ($X^2 = 24.2$, df = 3, $P < 0.001$)]. The most expensive live animals sold were 'common boa' (90.7 USD per animal), 'scarlet macaw' (*Ara macao*) (30.3 USD per animal), and 'parrot' (22.2 USD per animal) (Fig. 3; Appendix A2).

3.5. Increased rarity (animal derivatives and live animals)

The most frequently mentioned common names for the 'ten species which have become either 'extremely rare or unavailable' in the last five years' [when considering only the top ranked responses (23 common names from 74 vendors)] were 'lowland paca' (12%, n = 9), followed by 'deer' (Cervidae) (11%, n = 8), 'yellow-footed tortoise' (12%, n = 9) and 'jaguar' (8%, n = 6)

Fig. 1. Frequency each species was cited at each rank (respondent could list up to 10 species for each question) across the three main questions – "Most profitable wild animal body part", "Species becoming rare or unavailable" and "Most profitable live wild animal".

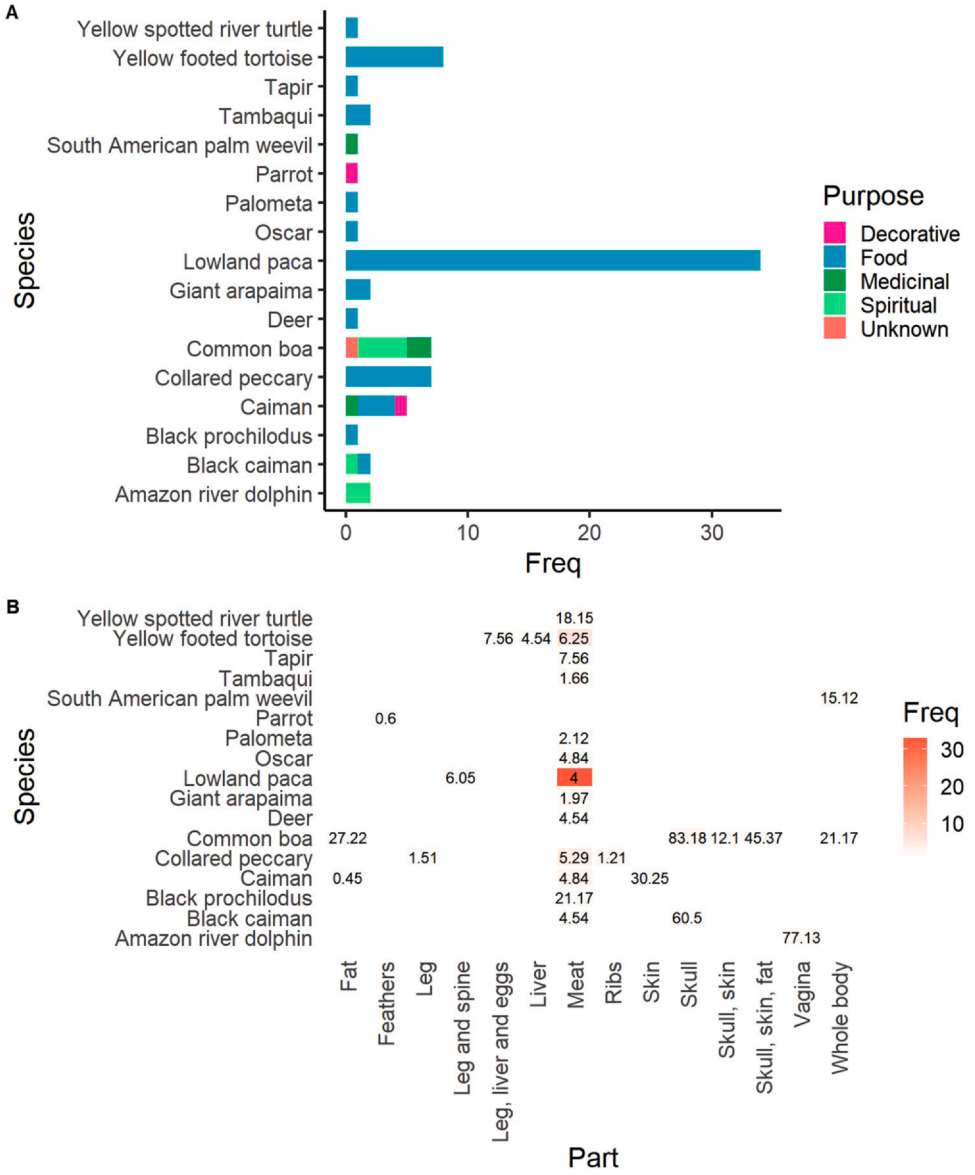

Fig. 2. (a) Frequency of responses for species cited as most profitable for wild animal body parts split by the associated purpose categories. (b) Frequency of species as most profitable for body parts split by body part. Values in each cell represent the mean sale price in USD for this species by body part.

(Fig. 4). The frequency of species listed was not evenly distributed amongst vendors (X^2 = 45.9, df = 22, P = 0.002). Across all market locations surveyed, the most frequently cited purpose of sale of species perceived as becoming rarer in the last 5 years was as 'food' (85%, n = 61), followed by 'decorative' (10%, n = 7), 'spiritual' (4%, n = 3), 'pet' (3%, n = 2) and 'medicinal' (1%, n = 1) (Fig. 4) [the purpose of sale was not evenly distributed amongst vendors (X^2 = 181.7, df = 4, P < 0.001)]. The most expensive rare animals sold were 'jaguar' (121 USD per animal), 'snake' (Serpentes) (45 USD per animal), and 'common boa' (30 USD per animal) (Fig. 4; Appendix A2).

3.6. Conservation status

Overall, we estimate that the 44 distinct common names provided by vendors to refer to the wildlife species traded [excluding invertebrates (e.g., 'ants'), fish, and common names that refer to level of taxonomic class (e.g., 'birds')] potentially refer to at least 205 different extant species in the forest habitat of Peru, including 39 birds (Aves), 63 mammals (Mammalia) and 103 reptiles (Reptilia) (assuming that a common name could refer to multiple species in the same taxa, for example, order, family or genus) (Appendix A4). With regards to international conservation status, 4 (2%) of these species are currently considered to be

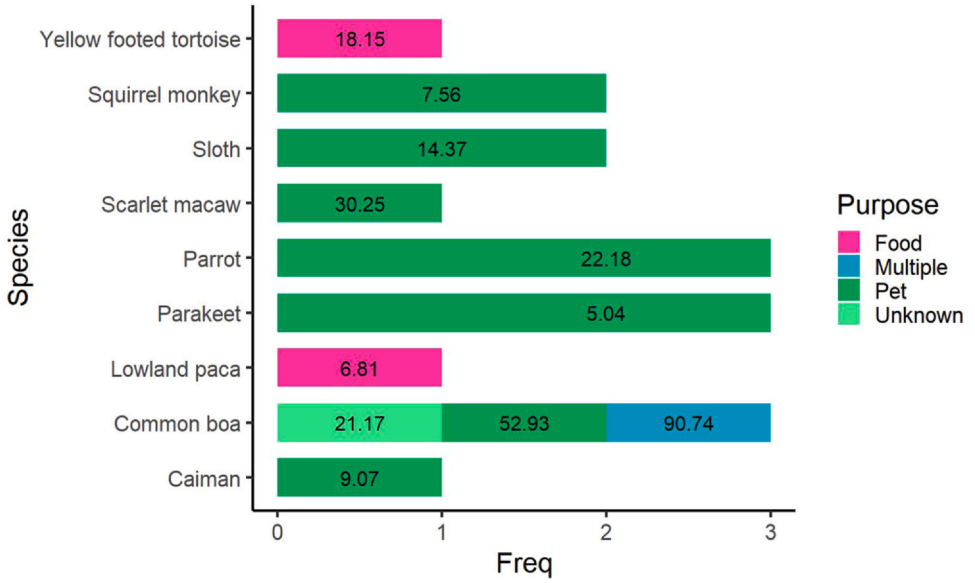

Fig. 3. Top cited most profitable live wild animal species sold split by purpose. Values in each cell represent the mean sale price in USD for this species by purpose.

Endangered [Amazon river dolphin, black spider monkey (*Ateles chamek*), silvery woolly monkey (*Lagothrix lagothricha* ssp. *poeppigii)*, and white-bellied spider monkey (*Ateles belzebuth*)], 15 (7%) are Vulnerable, 11 (5%) are Near Threatened, 160 (78%) are Least Concern, 9 (4%) are Data Deficient, and 4 (2%) are Not Evaluated [matamata turtle (*Chelus fimbriata*), *Boa constrictor* spp., *Boa c. constrictor*, and green anaconda (*Eunectes murinus*) (Appendix A4)].

With regards to their population trends, one (<1%) inferred species [the dusky-headed parakeet (*Aratinga weddellii*)] has wild populations considered to be increasing, 85 (42%) have wild populations that are stable, 71 (35%) that are decreasing, and 48 (23%) have an unknown population status (Fig. 5; Appendix A4). With regards to international legal trade status, 9 inferred species are currently listed on CITES Appendix I, 2 species have populations listed on Appendix I and Appendix II [jaguarundi (*Herpailurus yagouaroundi*) and black caiman], 56 species are listed on Appendix II, 2 species are listed on Appendix III [lowland paca, white-tailed deer (*Odocoileus virginianus*), and South American coati (*Nasua nasua*)], and 132 species are not currently listed on any of the CITES Appendices (see Fig. 5; Appendix A4). Vendors also inferred an additional 13 species (6%) that are not currently considered as threatened (according to the IUCN Red List), but have greatly increased in rarity from their perspective (Fig. 4).

4. Discussion

Our study provides new insights into the diversity and potential use of wildlife being offered for sale at the urban markets in Iquitos, which arguably represent the largest and most important wildlife trade hub in the Peruvian Amazon. In identifying the species involved that are potentially threatened by over-exploitation due to population trends and/or their perceived increased rarity in recent years, our findings represent valuable information that can be used to help inform future efforts to protect wildlife in the surrounding areas of Peru.

4.1. Urban meat & fish sales

During our study, we found that "food" was the most frequently stated purpose of sale of wild animals by vendors in Iquitos (when asked to name wild animals that they deemed to be the most profitable in terms of their derivatives), and some of the most frequently identified taxa were mammal species, such as the lowland paca and collared peccary [which were just two of the six different local names provided during this study relating to mammals, potentially corresponding to an estimated nine species (Appendix A4)]. These findings support existing research that has previously reported urban wild mammal meat sales in Iquitos as an important source of income locally (e.g., see Bodmer and Lozano (2001), Mayor et al. (2019)). In the late 1990s, for example, Bodmer and Lozano (2001) documented 16 mammalian species being sold, equating to 72,972 kg of wild meat sales in 1996 alone, and with an estimated value of 250,268 USD at that time. More recently, Mayor et al. (2019) reported on the wild meat sales of seven mammalian species; with reported sales equating to 288,336 kg of wild meat between 2017 and 2018, and with an estimated value of approx. 1,741,730 USD. According to their study, between 2006 and 2007, meat of the collared peccary and paca was the most traded, while the white-lipped peccary, brocket deer (*Mazama* sp.), capybara (*Hydrochoerus hydrochaeris*), and South American tapir (*Tapirus terrestris*) had intermediate sales rates, and Woolly monkey (*Lagothrix* sp.) had the lowest sale rate (Mayor et al., 2019). It is important to note that our study focused on gaining insight into the diversity of (and most profitable) wildlife being offered for sale by the vendors in Iquitos, rather than the most traded species.

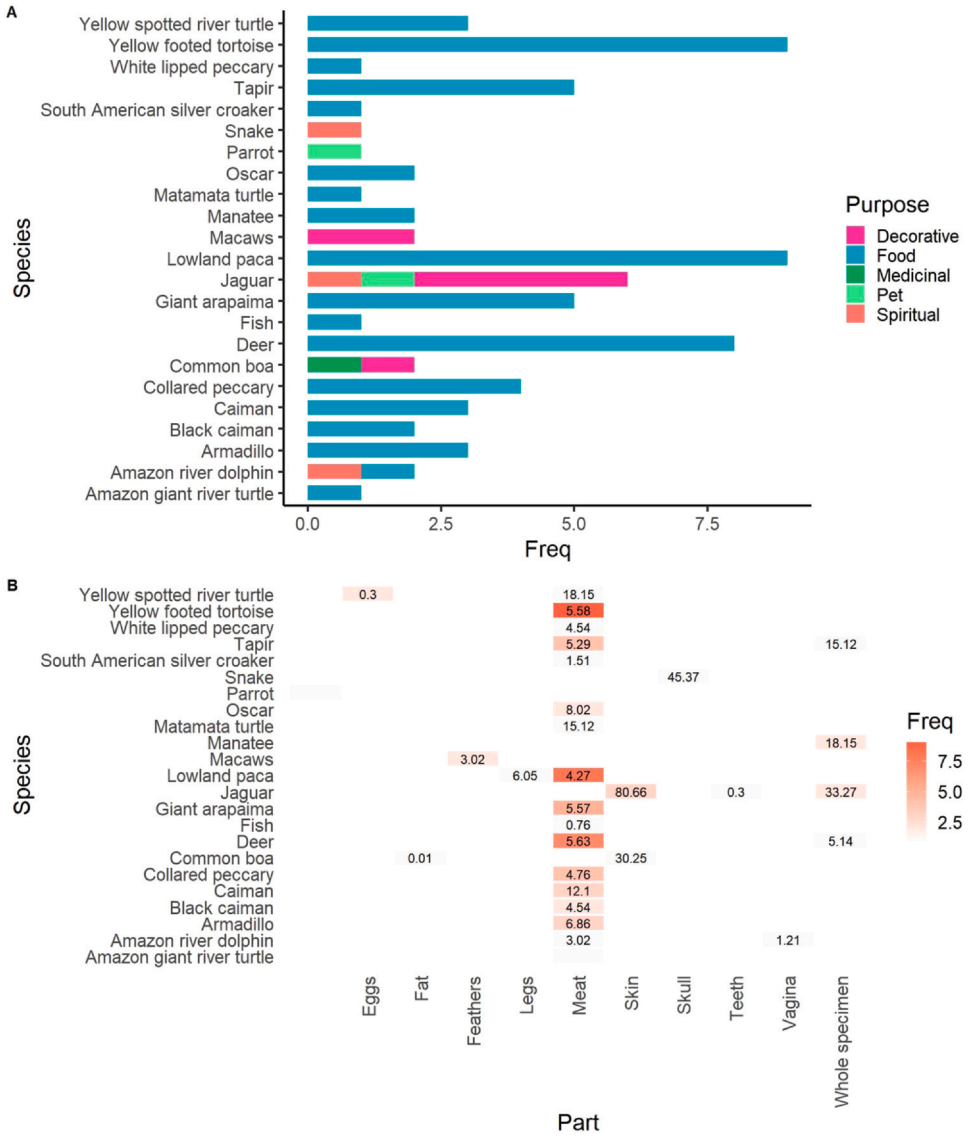

Fig. 4. Frequency of responses for species cited as becoming rare or unavailable in the last five years, split by (a) the associated purpose, and (b) body part. Values in each cell represent the mean sale price in USD for this species by body part.

However, our study confirms that beyond mammals, a much wider array of species across other taxonomic classes is being sold for food at the urban markets in Iquitos. Specifically, 9 different local names relating to reptiles [potentially corresponding to an estimated 13 species (Appendix A4)] sold as food were provided by vendors during this study. In particular, three reptile related common names ['yellow footed tortoise', 'caiman'" (Alligatoridae sp.), and 'yellow spotted river turtle' (*Podocnemis unifilis*)] were among those most frequently provided by vendors when questioned on the most profitable wildlife species sold. In a previous study, van Vliet et al. (2014) also noted that chelonians such as the yellow-footed tortoise are sometimes more frequently traded as a food source than other mammal species in Peruvian markets due to local consumption preferences (van Vliet et al., 2014). In addition, several common names relating to fish [including 'black prochilodus' (*Prochilodus nigricans*), 'oscar' (*Astronotus ocellatus*), 'piraracu' (*Arapaima* sp.), 'piranha' (Serrasalmidae sp.), and 'tambaqui' (*Colossoma macropomum*)] were identified as being among the most profitable types of wild animal being sold for food.

4.2. Decoration and belief-based sales

Our study also confirms that, in addition to wild meat and fish, the live sale of wildlife and derivatives for decoration and belief-based use remains an ongoing source of economic income in Iquitos. During our study, "decorative" and "belief-based" use were frequently stated as the purpose of sale by vendors when asked to name wild animals that they deemed to be the most

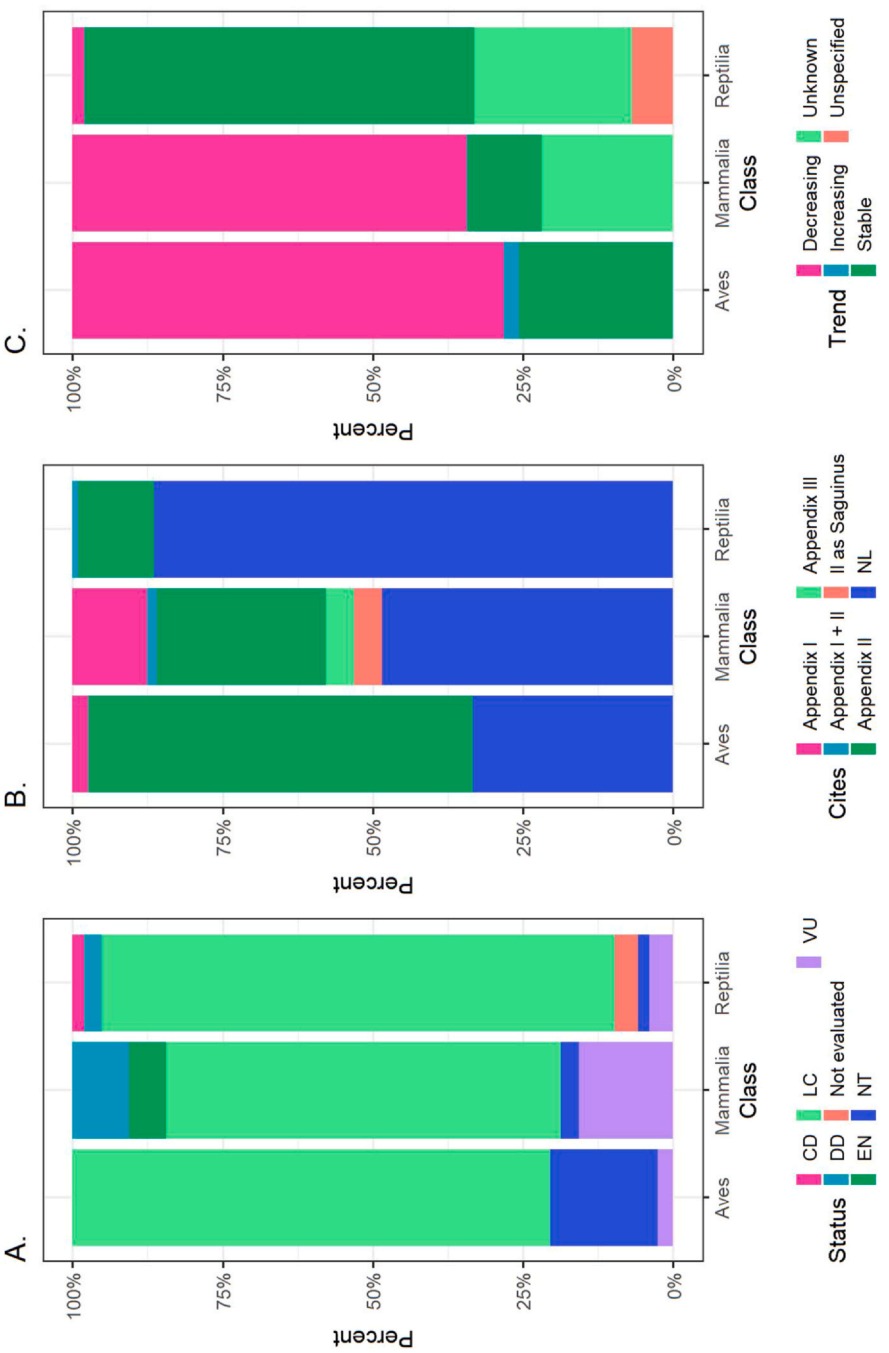

Fig. 5. Proportion of wild animal species potentially referred to using common names split by (a) Class and IUCN status, (b) CITES designation, and (c) Population Trend. For both IUCN status and population trend, where cited wild animals had multiple possible species and designations, the lowest risk category was used in each case.

Fig. 6. Top right, live parakeet (Psittacidae sp.) intended for commercial sale; top left yellow footed tortoise (*Chelonoidis denticulata*) meat intended for commercial sale; bottom left caiman head (Alligatoridae sp.) intended for commercial sale; bottom right deer meat (Cervidae sp.) intended for commercial sale, Iquitos, Peru. Images Fernando Carniel Machado/World Animal Protection.

profitable in terms of their derivatives. With regards to decorative use, "parrots" were identified as being one of the most profitable types of wild animal. Specifically, vendors referred to the use of the feathers that are sold to both regular customers and to tourists as souvenirs. Interestingly, none of the most profitable wild animal species identified by vendors were being sold due to consumer demand for their pelts and skins, despite this being previously identified in the scientific literature as being a profitable endeavour (Bodmer and Lozano, 2001). Whether this is in response to increased enforcement activity, decreased local consumer demand, or diversion to meet international consumer demand (e.g., see Bodmer et al. (2004), Fang and Bodmer (2011)) warrants further investigation.

With regards to belief-based use, the 'Amazon river dolphin' (*Inia geoffrensis*) was identified as a highly profitable wild animal. Specifically, vendors referred to the use of the dolphin's sexual organs and eyes, along with other ingredients, to create an aphrodisiacal perfume called "pusanga" [a generic name for a belief-based item used to retrieve or increase luck, ensure seduction or neutralise it when its misuse has caused harm (Shepard, 2016)]. However, the 'common boa' and 'caiman' were also frequently identified as being profitable, with the preserved and decorated heads of both (and juveniles of the latter) sold as amulets for protection and prosperity, and also reportedly used to draw the attention and curiosity of passers-by (Fig. 6). The 'South American palm weevil' (*Rhynchophorus palmarum*) was also identified as being a particularly profitable form of income, with customers purchasing the larva for use as a health supplement [due to their rich content of vitamins A and E, and other minerals (Cerda et al., 2001)].

Animal parts have historically been sold as jewellery, souvenirs and for medicinal/spiritual purposes in Iquitos (Bodmer and Lozano, 2001; Figueroa, 2014; Laso, 2009; Robinson and Redford, 1991). For example, in the late 1990s, Bodmer and Pezo Lozano (2001) reported the illegal sale of mammalian products, such as pelts, skulls, and teeth from jaguars (*Panthera onca*), ocelots (*Felis pardalis*), and pumas (*Puma concolor*) in the tourist markets of Iquitos. They described this trade as being "rather small" and directed toward U.S. military personnel, who purchased jaguar products (Bodmer and Lozano, 2001). However, a new wave

of illegal trade in jaguars has been detected in the recent years (Morcatty et al., 2020), linked to Chinese demand for their teeth, that has been causing an increase in exploitation rates of the species and may threaten jaguar populations. Among the 19 Central and South American countries evaluated, Morcatty et al. (2020) concluded that Peru was the country with the third highest number of seized jaguars. Jaguar body parts have also been found frequently on sale to tourists in Iquitos and Pucallpa (Braczkowski et al., 2019). Furthermore, another recent investigation into the commerce of Andean bears (Figueroa, 2014) described how some cubs are traded as pets across the rainforest and highlands. Many bears are sacrificed once they become a nuisance, with their body parts utilized for medicinal purposes (Figueroa, 2014).

4.3. Pet sales

Our study also confirms that the sale of live wild animals remains an ongoing source of economic income in Iquitos. During our study, "pets" was the most frequently stated purpose of sale by vendors (when asked to name wild animals that they deemed to be the most profitable in terms of live sale), and some of the most frequently identified taxonomic groups were common names relating to 'parrots', 'primates', 'sloths', 'agouti', 'caiman', and 'snakes'. Interestingly, our study found that, although they were sold alive, 'yellow-footed tortoises' are often intended for use as food, rather than for use as exotic pets, with customers slaughtering these reptiles themselves (although vendors are also known to commonly receive live tortoises, slaughter and sell their parts on the market stalls too). In addition, many vendors stated that 'common boas' were sold primarily due to their ability to serve as "pest control" (i.e. via the predation of rodents).

Our findings support previous research reporting on the trade of live wild animals in Iquitos as a component of the wider wildlife commerce in Peru. For example, more than 40 years ago, it was reported that 130 live species were being exported out of Iquitos annually (Dourojeanni, 1974). However, in the late 1990s, Bodmer and Lozano (2001) reported that the live trade in mammals was not a major economic activity and included only a small proportion of the total number of mammals being sold there. For example, they found that the largest legal trade in live mammals (the trade of primates for biomedical research) only accounted for an estimated 2% of the primates being sold (Bodmer and Lozano, 2001). It is noteworthy that none of the vendors in our study described the sale of live primates as being a profitable endeavour. More recently, in the Belén market, Paredes and Mejia (2010) reported 60 descriptive common names regarding live animals that were available for sale at that time as pets, with the most frequently observed taxonomic groups sold (generally juvenile specimens) being parrots, primates, sloths, owls, agouti caiman, freshwater turtles and tortoises (Paredes and Mejia, 2010). A recent review of impounded wildlife in Lima also found that 81,564 animal products and 17,932 live animals were confiscated from 2000 to 2007 (Quevans et al., 2013).

4.4. Conservation concerns

Our study reiterates conservation concerns associated with the current commercial sale of live wild animals and their derivatives in Iquitos (e.g., Quevans et al. (2013)). According to the IUCN Red List, a considerable proportion of the wild animals, thought to be sold in Iquitos, are already considered as threatened (9%; 19 inferred species) (Appendix A4). In particular, some of the common names provided by respondents refer to a single identifiable species of current conservation concern globally, including the 'Amazon river dolphin' (which is currently classified as Endangered), and five species [the 'manatee' (*Trichechus inunguis*), 'tapir' (*Tapirus terrestris*), 'white lipped peccary', 'yellow footed tortoise', and 'yellow spotted river turtle'] that are currently classified as Vulnerable (IUCN, 2020). For these species, already considered at higher risk from extinction, even relatively low-level trade (as reported for pets or for belief-based use) can have highly detrimental impacts on their conservation status. In addition to this, our findings also indicate a positive relationship between the declared most profitable species and those that were stated by vendors as becoming increasingly rare. This suggests that the higher value wildlife species on sale at the markets in Iquitos are potentially at a greater risk from extinction.

Furthermore, it is concerning that at least 12 of the species identified in this study (inferred from the common names provided by vendors) are considered at a higher risk from extinction nationally [according to the Peruvian Red List 2018 (SERFOR, 2018)] than globally (according to the IUCN Red List) (Appendix A4). Notably, of the species identified, the big-headed Amazon River turtle (*Peltocephalus dumerilianus*) is considered to be Critically Endangered in Peru but is currently listed as Vulnerable on the IUCN Red List, and the red-chested mustached tamarin (*Saguinus labiatus*), common woolly monkey (*Lagothrix lagothricha*), South American River turtle (*Podocnemis expansa*) and dwarf caiman (*Paleosuchus palpebrosus*) are all considered Endangered on the Peruvian Red List (2018) but either have a Vulnerable, Least Concern, or Unspecified conservation status globally (Appendix A4). Also of note is that the body parts of the Amazon river dolphin were found to be a particularly expensive individual item sold for spiritual/belief-based use (151 USD per genitalia), and this species was also among those perceived to have increased most in rarity in recent years. Yet, although the Amazon river dolphin is currently considered Endangered globally with decreasing populations in the wild, it's conservation status within Peru is unknown (Data Deficient) (SERFOR, 2018).

In addition, vendors' inferred trade in an additional 71 species (35%) that are not currently listed on the IUCN Red List as threatened but have wild populations that are considered to be in decline (Appendix A4). In particular, some of the common names provided by respondents refer to a single identifiable species, including the 'jaguar' which is currently considered as Near Threatened but is listed on CITES Appendix I, and several mammal species (including the 'lowland paca', 'deer' and 'collared peccary') which are currently classified as Least Concern but which have been identified to be at risk of local extirpations due in part to unsustainable hunting for their meat to feed urban clientele (Mayor et al., 2019). Vendors' also inferred trade in reptile

species that are not considered to be globally threatened or to have wild populations in decline, but that have greatly increased in rarity from the vendors' perspective, such as 'caiman' and 'common boa' (Fig. 1). According to the Peruvian Red List (2018), the dwarf caiman (*Paleosuchus palpebrosus*) and the subspecies of Boa constrictor, *Boa constrictor ortonii*, are considered to be Endangered in Peru, which could explain the perceived increased rarity of such animals by traders. For these taxa, arguably caution should also be applied to their on-going commercial exploitation at current levels given the potential for local extirpations.

4.5. Animal welfare & public health

Our research also draws attention to the animal welfare concerns associated with the current commercial sale of live wild animals and their derivatives in Iquitos. Capture methods of particular concern that have been documented in the Amazon region include the use of harpoons to capture Amazon river dolphins (Alves et al., 2012), tree felling to aid the collection of live sloths (Daly, 2017), and multiple gun shots to kill jaguars (Jędrzejewski et al., 2017). In many cases, the captured wildlife remains alive during transport that can involve physical restraint (e.g., in plastic bags) (Daly, 2017) before they reach vendors several days later. During survey work in Iquitos, researchers observed slaughter methods (e.g., decapitated snakes) and captive conditions (e.g., small barren dirty cages, cloth bags and plastic buckets often out of sight from visiting customers) that raise substantial animal welfare concerns. In addition, from a public health perspective, given the diversity of wildlife products available for sale, apparent lack of appropriate sanitation measures, and the large number of people present in the markets each day (in some cases including international workers and tourists), the potential zoonotic disease risk posed by these wildlife trade hubs is of considerable concern.

4.6. Limitations

Wildlife trade surveys that touch upon aspects related to illegality and/or unsustainable exploitation should be interpreted with care; not least because markets are complex systems that can vary over time (due to a variety of different factors) and vendors may distrust or have poor memory recall (D'Cruze et al., 2018; Mayor et al., 2019; Newton et al., 2008). However, that 99 vendors were willing to talk to us, and openly admitted to their involvement with forbidden trade of wildlife at urban markets, suggests that they were being truthful. Moreover, while there is a risk that our data may underestimate or overestimate the impact on wildlife in Iquitos and surrounding areas of Peru, it is important to clarify that our aim was not to assess the full extent of impact on wild populations or individual animal welfare. Rather, our intention was to gain new insights into the diversity of wildlife being offered for sale (by vendors), to better understand what they might be used for (by consumers), and to identify those wildlife species that might potentially be at risk. Likewise, a full inventory of wildlife being sold at Iquitos, including identifying species that are most traded and the frequency of trade, was beyond the scope of this study. Specifically, we acknowledge that our use of local names to infer the species sold cannot be considered a complete taxonomic account, and that in some cases vendors may be referring to only one particular species that is not threatened by extinction or vice versa.Yet, despite the limitations of a "snapshot" survey-based approach, we believe that our findings represent valuable information that can be used to help provide information for future efforts to protect wildlife in Iquitos.

4.7. Recommendations

Despite the substantial economic returns, the trade in wild animal products at urban markets is forbidden in Peru (Law No 29763). Yet the wildlife trade is poorly monitored in Peru (Leberatto, 2017), and enforcement is hindered by a number of factors including logistical limitations, financial constraints, and on-going consumer demand (Mayor et al., 2019). In addition to improved enforcement and awareness campaigns aimed at changing both vendor and consumer behaviour, increased governance of wildlife in non-urban source areas, and increased research effort focusing on the impacts of wildlife trade in Iquitos (including conservation, animal welfare, and public health impacts) is also required. We recommend that those wild animals already considered threatened by extinction (19 inferred species, including the Amazon river dolphin), and those with populations already thought to be in decline (71 inferred species) should be made a particular priority. However, we would also like to highlight that non-threatened wild animals, stated to have increased in rarity, specifically those that are also considered to be highly profitable (such as the lowland paca, deer and collared peccary), should also not be overlooked in this regard. We note that any initiatives focused on protecting wildlife would likely benefit from identifying alternative humane sustainable sources of income for those currently dependent on the wildlife trade as a main source of income given the substantial financial incentives.

Finally, given the risks that urban wildlife markets pose to public health, we also recommend that future surveillance efforts in Iquitos should also extend to zoonotic diseases. In fact, the Belén market has been reported to be closed for much of 2020 and 2021 as part of the reaction to the COVID-19 pandemic, the emergence of which has been directly linked to wildlife trade. As and when the Belén market will reopen will remain to be seen, but implementing these recommendations will be critical to protect people and wildlife.

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CRediT authorship contribution statement

Conceptualization NDC, DM, EC, JN; Data curation FERG, EC, JN, HREB, SM, AE; Formal analysis EC, JN; Funding acquisition DM; Investigation FERG, OB, NCM; Methodology NDC, DM, EC, JN; Project administration AE; Resources NDC, FERG, OB, DM; Software EC, JN, AE; Supervision NDC; Validation DM; Visualization EC, JN; Writing - original draft NDC, AE; Writing - review & editing NDC, FERG, OB, HREB, SM, AE, NCM, JN, EC, DM.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.gecco.2021.e01631.

References

Aguirre, A.A., Catherina, R., Frye, H., Shelley, L., 2020. Illicit wildlife trade, wet markets, and COVID-19: preventing future pandemics. World Med. Health Policy 12, 256–265. https://doi.org/10.1002/wmh3.348

Alves, L.C.P., de, S., Zappes, C.A., Andriolo, A., 2012. Conflicts between river dolphins (Cetacea: Odontoceti) and fisheries in the Central Amazon: a path toward tragedy? Zoologia 29, 420–429. https://doi.org/10.1590/S1984-46702012000500005

Asprilla-Perea, J., Díaz-Puente, J.M., 2019. Importance of wild foods to household food security in tropical forest areas. Food Secur. 11, 15–22. https://doi.org/10.1007/s12571-018-0846-8

Baker, S.E., Cain, R., Van Kesteren, F., Zommers, Z.A., 2013. Rough trade: animal welfare in the global wildlife trade. BioScience 63, 928–938. https://doi.org/10.1525/bio.2013.63.12.6

Bodmer, R.E., Lozano, E.P., 2001. Rural development and sustainable wildlife use in Peru. Conserv. Biol. 15, 1163–1170. https://doi.org/10.1046/j.1523-1739.2001.0150041163.x

Bodmer, R.E., Pezo Lozano, E., Fang, T.G., 2004. Economic analysis of wildlife use in the Peruvian Amazon. In: People in Nature: Wildlife Conservation in South and Central America. Columbia University Press, New York, pp. 191–207.

Braczkowski, A., Ruzo, A., Sanchez, F., Castagnino, R., Brown, C., Guynup, S., Winter, S., Gandy, D., O'Bryan, C., 2019. The ayahuasca tourism boom: an undervalued demand driver for jaguar body parts? Conserv. Sci. Pract. 1. https://doi.org/10.1111/csp2.126

BSA [British Sociological Association], 2017. Statement of Ethical Practice. BSA Publications. URL www.britsoc.co.uk/media/24310/bsa_statement_of_ethical_practice.pdf.

Can, Ö.E., D'Cruze, N., Macdonald, D.W., 2019. Dealing in deadly pathogens: taking stock of the legal trade in live wildlife and potential risks to human health. Glob. Ecol. Conserv. 17, 00515. https://doi.org/10.1016/j.gecco.2018.e00515

Cerda, H., Martinez, R., Briceno, N., Pizzoferrato, L., Manzi, P., Ponzetta, M.T., Marin, O., Paoletti, M.G., 2001. Palm worm: (*Rhynchophorus palmarum*) traditional food in Amazonas, Venezuela—nutritional composition, small scale production and tourist palatability. Ecol. Food Nutr. 40, 13–32. https://doi.org/10.1080/03670244.2001.9991635

D'Cruze, N., Niehaus, C., Balaskas, M., Vieto, R., Carder, G., Richardson, V.A., Moorhouse, T., Harrington, L.A., Macdonald, D.W., 2018. Wildlife tourism in Latin America: taxonomy and conservation status. J. Sustain. Tour. 26, 1562–1576. https://doi.org/10.1080/09669582.2018.1484752

D'Cruze, N., Assou, D., Coulthard, E., Norrey, J., Megson, D., Macdonald, D.W., Harrington, L.A., Ronfot, D., Segniagbeto, G.H., Auliya, M., 2020. Snake oil and pangolin scales: insights into wild animal use at "Marché des Fétiches" traditional medicine market. Togo. NC 39, 45–71. https://doi.org/10.3897/natureconservation.39.47879

Daly, N., 2017. Witness the Harrowing Capture of a Wild Sloth for the Black Market. National Geographic. https://www.nationalgeographic.com/news/2017/10/wildlife-watch-sloth-video-capture-black-market-amazon-animal-welfare/. (Accessed 2 February 2021).

Daut, E.F., Brightsmith, D.J., Mendoza, A.P., Puhakka, L., Peterson, M.J., 2015. Illegal domestic bird trade and the role of export quotas in Peru. J. Nat. Conserv. 27, 44–53. https://doi.org/10.1016/j.jnc.2015.06.005

Dourojeanni, M.J., 1974. Impacto de la produccion de la fauna Silvestre en la economia de la Amazonia Peruana. Revta For. Peru. 5, 1–14.

Dutton, A.J., Gratwicke, B., Hepburn, C., Herrera, E.A., Macdonald, D.W., 2013. Tackling unsustainable wildlife trade. Key Top. Conserv. Biol. 2, 74–91. https://doi.org/10.1002/9781118520178

Espinosa, M.C., 2008. What has globalization to do with wildlife use in the remote amazon? exploring the links between macroeconomic changes, markets and community entitlements. J. Dev. Soc. 24, 489–521. https://doi.org/10.1177/0169796X0902400404

Fang, T.G., Bodmer, R.E., 2011. Peccary pelt certification helps to conserve Amazon forests. https://www.biodiversityscience.com/2011/04/27/peccary-pelt-certification/. (Accessed 1 February 2021).

Figueroa, J., 2014. Tráfico de partes e individuos del oso andino Tremarctos ornatus en el Perú. Rev. Acad. Colomb. Cienc. Exact. Fis. Nat. 38, 177. https://doi.org/10.18257/raccefyn.62

Gastañaga, M., Macleod, R., Hennessey, B., Núñez, J.U., Puse, E., Arrascue, A., Hoyos, J., Chambi, W.M., Vasquez, J., Engblom, G., 2011. A study of the parrot trade in Peru and the potential importance of internal trade for threatened species. Bird Conserv. Int. 21, 76–85. https://doi.org/10.1017/S0959270910000249

Harris, J.B.C., Green, J.M.H., Prawiradilaga, D.M., Giam, X., Giyanto, Hikmatullah, D., Putra, C.A., Wilcove, D.S., 2015. Using market data and expert opinion to identify overexploited species in the wild bird trade. Biol. Conserv. 187, 51–60. https://doi.org/10.1016/j.biocon.2015.04.009

IUCN, 2020. The IUCN Red List of Threatened Species. [WWW Document]. URL https://www.iucnredlist.org. (Accessed 29 September 2020).

Jędrzejewski, W., Carreño, R., Sánchez-Mercado, A., Schmidt, K., Abarca, M., Robinson, H.S., Boede, E.O., Hoogesteijn, R., Viloria, Á.L., Cerda, H., Velásquez, G., Zambrano-Martínez, S., 2017. Human-jaguar conflicts and the relative importance of retaliatory killing and hunting for jaguar (Panthera onca) populations in Venezuela. Biol. Conserv. 209, 524–532. https://doi.org/10.1016/j.biocon.2017.03.025

John, F.A.V.St, Brockington, D., Bunnefeld, N., Duffy, R., Homewood, K., Jones, J.P.G., Keane, A.M., Milner-Gulland, E.J., Nuno, A., Razafimanahaka, J.H., 2016. Research ethics: assuring anonymity at the individual level may not be sufficient to protect research participants from harm. Biol. Conserv. 208–209. https://doi.org/10.1016/j.biocon.2016.01.025

Laso, F., 2009. Challenges to the Conservation of River Turtles (spp. Podocnemis) in the Peruvian Amazon. https://doi.org/10.7916/D8MW2GSF.

Leberatto, A.C., 2017. A typology of market sellers of protected wildlife across Peru. Deviant Behav. 38, 1352–1370. https://doi.org/10.1080/01639625.2016.1254963

Mayor, P., El Bizri, H.R., Morcatty, T.Q., Moya, K., Solis, S., Bodmer, R.E., 2019. Assessing the minimum sampling effort required to reliably monitor wild meat trade in urban markets. Front. Ecol. Evol. 7, 180. https://doi.org/10.3389/fevo.2019.00180

Morcatty, T.Q., Bausch Macedo, J.C., Nekaris, K.A., Ni, Q., Durigan, C.C., Svensson, M.S., Nijman, V., 2020. Illegal trade in wild cats and its link to Chinese-led development in Central and South America. Conserv. Biol. 34, 1525–1535. https://doi.org/10.1111/cobi.13498

Newing, H, 2011. Conducting research in conservation: a social science perspective. Routledge, Abingdon. https://doi.org/10.4324/9780203846452

Newton, P., Nguyen, T.V., Roberton, S., Bell, D., 2008. Pangolins in peril: using local hunters' knowledge to conserve elusive species in Vietnam. Endanger. Species Res. 6, 41–53.

Paredes, P., Mejia, K., 2010. La Biodiversidad en el Mercado de Belen-Iquitos. Rainforest Conservation Fund. http://www.rainforestconservation.org/articles/la-biodiversidad-en-el-mercado-de-belen-iquitos/. (Accessed 1 Febraury 2021).

Pineda-Catalan, O., Mendez, M., Gleizer, A., García-Dávila, C., Aguirre, A.A., Pinedo-Vasquez, M., Amato, G., 2012. Conservation genetics of harvested river turtles, *Podocnemis expansa* and *Podocnemis unifilis*, in the Peruvian Amazon: all roads lead to Iquitos. Mitochondrial DNA 23, 230–238. https://doi.org/10.3109/19401736.2012.674115

Quevans, N., Falcón, N., Elías, R., 2013. Wild fauna and derived products seized during the period 2000-2007 Lima - Peru. Technol. Vet. Health 1, 14–18.

R Core Team, 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Reuter, A., Kunen, J., Roberton, S., 2018. Averting a Crisis: Wildlife Trafficking in Latin America. New York, NY: WCS. https://c532f75abb9c1c021b8c-e46e473f8aadb72cf2a8ea564b4e6a76.ssl.cf5.rackcdn.com/2018/05/07/1z4xctqtig_LACP_CWT_White_Paper_FINAL.pdf. (Accesses 1 Febraury 2021).

Robinson, J.G., Redford, K.H., 1991. The use and conservation of wildlife. Neotrop. Wildl. Use Conserv. 3–5.

Rodríguez, L.O., Young, K.R., 2000. Biological diversity of Peru: determining priority areas for conservation. AMBIO: J. Hum. Environ. 29, 329–337. https://doi.org/10.1579/0044-7447-29.6.329

SERFOR, 2016. Supreme Decree that approves the "National Strategy to Reduce Illegal Traffic of Wildlife in Peru, period 2017 - 2027 and its Action Plan 2017 - 2022." https://busquedas.elperuano.pe/normaslegales/decreto-supremo-que-aprueba-la-estrategia-nacional-para-red-decreto-supremo-n-011-2017-min-agri-1553973-1/.

SERFOR, 2018. Libro Rojo dela Fauna Silvestre Amenazada del Perú. Primera edición. Serfor (Servicio Nacional Forestal y de Fauna Silvestre), Lima, Perú, 1–548.

Shepard, J.R., 2016. Desire, botanies of. "chapter four botanies of desire: fragrance, healing and sexual attraction in two amazonian societies. In: Words for Odours: Language Skills and Cultural Insights. CSP, pp. 69–89.

van Halle, O., 2002. Preliminary Assessment of the Environmental and Socio-Economic Impact of Wild Meat Harvesting in South American. Links between Biodiversity Conservation, Livelihoods and Food Security: The Sustainable Use of Wild Species for Meat. Occasional Paper of the IUCN Special Survival Commission, 61–69.

van Vliet, N., Mesa, M.P.Q., Cruz-Anita, D., de Aquino, L.J.N., Moreno, J., Nasi, R., 2014. The uncovered volumes of bushmeat commercialized in the Amazonian trifrontier between Colombia, Peru & Brazil. Ethnobiology and Conservation 3. https://doi.org/10.15451/ec2014-11-3.7-1-11

Venero, J.L.G., 1998. Uso de animales en la cuenca del Vilcanota, Cusco (Perú). Estud. Atacameños 16, 203–208.

Watsa, M., Wildlife Disease Surveillance Focus Group, 2020. Rigorous wildlife disease surveillance. Science 369, 145–147. https://doi.org/10.1126/science.abc0017

Zapata-Ríos, G., Urgilés, C., Suárez, E., 2009. Mammal hunting by the Shuar of the Ecuadorian Amazon: Is it sustainable? ORX 43, 375. https://doi.org/10.1017/S0030605309001914