Analysis of the dynamics of legal and illegal trade in Matamata turtles *(Chelus fimbriata* and *Chelus orinocensis)* in Peru, Colombia, and Brazil

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Abbreviations and acronyms

AMVA	Aburrá Valley Metropolitan Area, Colombia
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CORMACARENA	Corporation for the Sustainable Development of the La Macarena Special Management Area, Colombia
CORPOAMAZONIA	Corporation for the Sustainable Development of the South of the Amazon, Colombia
CPUE	Catch per Unit of Effort
DAGMA	Administrative Department of Environmental Management, Colombia
GLM	Generalized Linear Model
GORE	Regional government, Peru
IBAMA	Brazilian Institute of Environment and Renewable Natural Resources, Brazil
ICMBio	Chico Mendes Institute for the Conservation of Biodiversity (Instituto Chico Mendes de Conservação da Biodiversidade), Brazil
ING	Gross national income
IPAAM	Amazon Environmental Protection Institute, Brazil
LEMIS	Law Enforcement Management Information System
MADS	Ministry of Environment and Sustainable Development, Colombia
PPA	Purchasing Power Parity
rtPCR	Quantitative Polymerase Chain real- time feedback
SERFOR	National Forest and Wildlife Service (Servicio Nacional Forestal y de Fauna Silvestre), Peru
UICN	International Union for Conservation of Nature
UNEP-WCMC	World Conservation Monitoring Center
USFWS	US Government Fish and Wildlife Service

1

Introduction

Wildlife trade, including specimens and their derivatives, affects one in four vertebrate species on the planet (Scheffers et al., 2019). This trade has caused a decrease of more than 60% of populations and led to local extinctions of 16% of traded wild vertebrate species (Morton et al., 2021). Countries in Latin America, especially those containing the Amazon biome, are considered to be an important source of wildlife products for other continents through regulated trade and illegal trafficking (Scheffers et al., 2019; Esmail et al., 2020; Olsen et al., 2021).

The political and socioeconomic instability affecting certain Latin American countries has been identified as a factor that exacerbates the establishment of illegal markets or poorly inspected legal markets (Esmail et al. 2020). Border regions, especially the Peru-Colombia-Brazil triple border, stand out as areas highly vulnerable to potential flow of wildlife trafficking. For example, night monkeys (*Aotus* spp.) are trafficked in national and international markets to be used in biomedical research (Maldonado et al., 2009; Maldonado, 2011).

As banning unsustainable trade in wildlife species is often difficult to enforce, the strategy commonly employed by the governments of several countries, such as Argentina, the United States and China, is to establish rules for a certified legal trade. This market strategy has been adopted in large world markets, for example, to meet the demand for bear bile for medicinal use in Southeast Asia (Foley et al., 2011);

for porcupine use as food in Vietnam (Brooks et al., 2010), and for keeping reptiles as pets in Asia and Europe (Nijman and Shepherd, 2009). However, the existence of a legal trade itself may promote the coexistence of illegal trade rather than stop it, by creating or increasing demand and establishing or reinforcing a trade chain for the wildlife product.

A potential buyer must decide whether to buy from a legal or illegal source when both options are available. From a market perspective, products of genuine legal origin have a higher probability of being chosen instead of one of illegal origin when the legal product can compete with the illegal product in terms of quality and cost (Damania and Bulte 2007; Bulte and Damania, 2005; Challender et al., 2015). When we consider the trade of live specimens, quality can be perceived as health status, sanitary control, behavior (aggressiveness or docility), and intrinsic characteristics such as coat colors, scales, and feathers or song repertoire of specimens, or even, the possibility of the owner to keep the animal without fear of being persecuted. In case these aspects are not perceived or valued by the buyer, only the price will inform their decision. Often the cheapest option is the one that is purchased most often. However, offering legally sourced animals to the market at lower prices than those obtained illegally from the wild is not always easy to achieve, due to the high production costs of certain species in captivity.

The global monetary value generated by the duly regulated (and therefore legal) wildlife trade was estimated at more than US$323 billion in 2009, based on customs declarations on wildlife imports (Newton and Cantarello, 2014). More recently, the value of legal trade was estimated by Nijman (2021) at more than US$400 billion. On the other hand, the scale of the illegal wildlife trade remains difficult to measure due to several methodological obstacles, such as the absence of or difficulty in accessing official reports of trafficking records and investigations, low reliability of existing data, shortage of inspections and convictions, and potential risks for officials investigating the situation (Passas, 2003). Furthermore, estimates of the monetary value of the illegal wildlife trade are difficult to calculate, since they vary considerably between assessments, ranging from US$4 to US$23 billion annually ('t Sas-Rolfes et al., 2019). Leaders of organized groups and intermediaries are the actors who often benefit most economically from wildlife trafficking.

Currently, domestic and international turtle trade has been a major concern for the conservation of turtles, which are considered one of the most endangered groups of vertebrates in the world (Turtle Conservation Coalition, 2018). This group includes sea turtles, freshwater turtles, and tortoises (Rhodin et al., 2021). Turtle meat and eggs are consumed for subsistence and as a delicacy in many parts of the world, especially in the Amazon and West African regions (Morcatty et al., 2015; van Vliet et al., 2014; Chaves et al., 2021; Luiselli et al., 2021). Likewise, in other world markets, especially in more developed countries, turtles are highly desired as pets. In the pet market, the particularities associated with body shape, color patterns, geographic origin and rarity influence the desire to purchase animals, driving demand for the species and consequently increasing the price of the specimens sold (Regueira and Bernard, 2012; Shepherd et al., 2015). In this sense, special attention should be drawn to the species of Matamata turtles (*Chelus fimbriata* and *Chelus orinocensis*) which, due to their distinctive, iconic, and curious appearance, are highly coveted animals as pets, especially in international markets.

2

Background

2.1 Biological and ecological aspects

Although matamata turtles are traded internationally as pets, very little is known about their natural history, conservation status, and biogeography. Matamatas are famous for their very distinctive appearance, which is considered strange by consumers. The *Chelus* genus includes two species: *C. fimbriata* and *C. orinocensis*, the largest species of the entire Chelidae family, whose carapace reaches an average of 50 cm in length (Ferrara et al., 2017; Vargas-Ramírez et al., 2020). Its main morphological characteristics are the triangular head, small eyes, wide mouth, long tubular nose, and long neck, which, like the head, has skin covered by numerous papillae and folds. The shell is wide, flat and has three keels in the central part of each vertebral or costal shield with 12 or 13 pointed reddish-brown projections (Ferrara et al., 2017).

The appearance of its skin and its coloration, together with its slow movement, make the matamata specimens camouflage very well in the muddy bottoms, achieving the appearance of leaves deposited at the bottom of a watercourse. Matamata turtles are found in a wide range of aquatic habitats, along the banks of rivers, streams, lakes, backwaters, puddles, temporary ponds, or flooded forests, in shallow, turbid, low-flowing bodies of water, generally less than 1 meter deep (Pritchard, 2008; Vogt, 2008; Ferrara et al., 2017). These turtles tolerate a wide elevation gradient (from 50m to 917m), although much of the distribution of the genus is in sedimentary basins, at altitudes below 200m (Cunha et al., 2021).

They inhabit regions with different levels of pH and water temperature (Pritchard and Trebbau, 1984; Vogt, 2008; Cunha et al., 2021), although they are more common in white and black water bodies, they can also occur in clear water. They can walk on the bottom of bodies of water rather than swim, which may indicate poor swimming ability (Pritchard and Trebbau, 1984; Pritchard, 2008).

Matamatas are predators that wait and ambush their prey using a highly specialized suction technique made possible by morphological adaptations in the skull and hyoid bone (Pritchard, 1984; Rueda-Almonacid et al., 2007; Páez et al. al., 2012). Unlike most other extant turtles, matamatas are completely carnivorous. These feed mainly on live fish, although there are records of the consumption of small rodents, birds, frogs, and tadpoles (Ferrara et al., 2017; Pritchard, 2008). They can also have both diurnal and nocturnal habits.

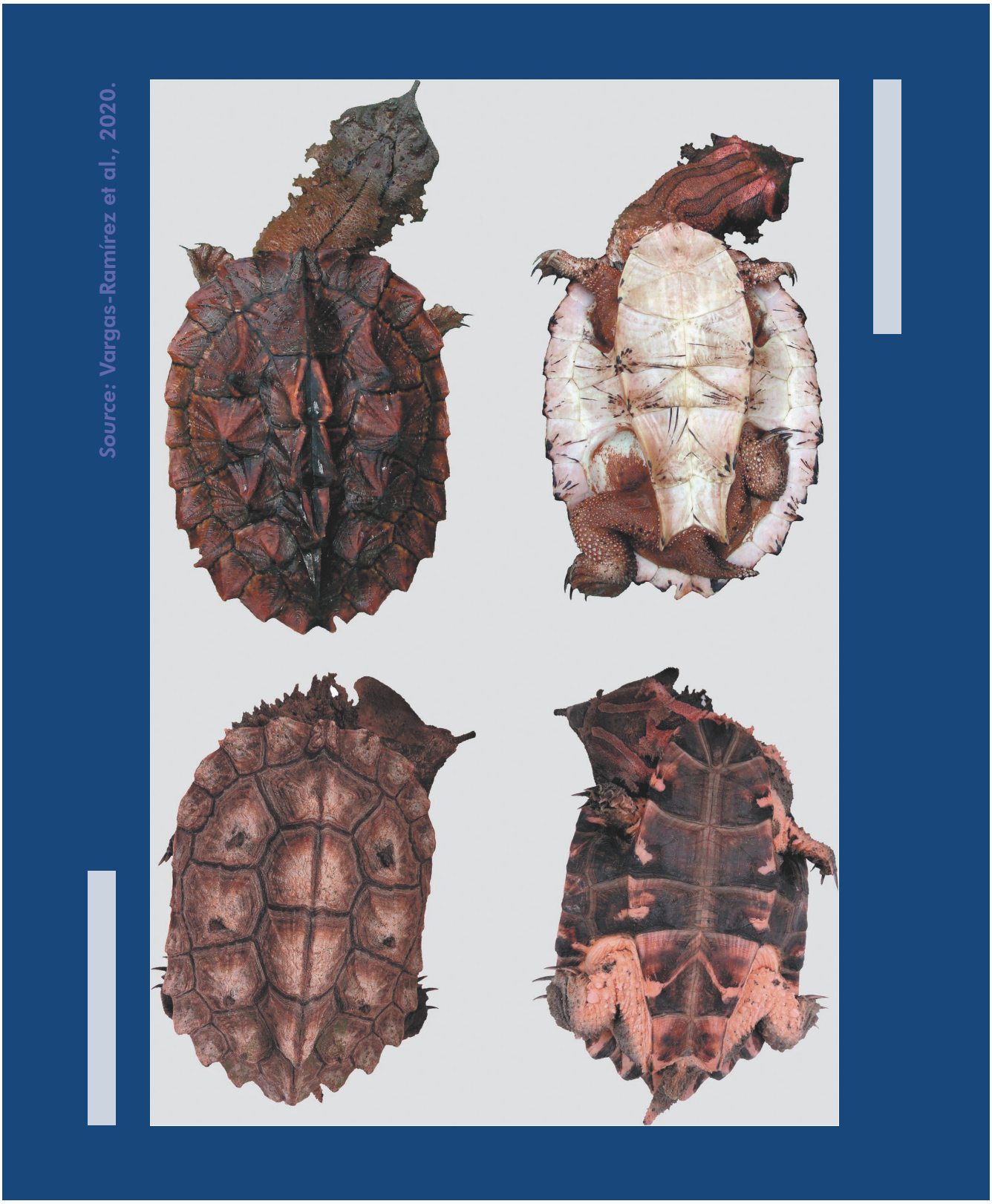
The reproduction of the matamata needs to be better studied, especially considering that it can potentially vary along the distribution basins and between the two described species. In Colombia, the spawning periods were recorded between October and December, while in the Guaporé river channel, Madera basin, in Brazil, the spawning period occurs between June and July (Ferrara et al., 2017). The females lay between 12 and 28 spherical eggs 35 mm wide. Eggs are commonly laid in nests built on sandy beaches or in ravines along the banks of streams. The estimated average incubation period is 200 days, although it can vary depending on soil characteristics and environmental temperature (Rueda-Almonacid et al., 2007), and potentially between species. For the matamata, sex determination is considered to occur genetically and is not dependent on temperature, as is the case for other turtles (Ferrara et al., 2017). For these species, sexual maturity, and the survival rate of infants to adulthood are not yet known.

There are no available population estimates for *C. fimbriata* or *C. orinocensis*. For a long time, the lack of studies and population estimates were attributed to the low density or rarity of the species. However, with larger amounts of records currently being collected, the lack of estimates is instead attributed to the exceptional camouflage of the animals in natural environments, which makes their detection difficult, as well as the low sampling effort, since they inhabit environments other than the other sympatric turtles (Rueda-Almonacid et al., 2007; Ferrara et al., 2017; Cunha et al., 2021).

2.2 Recent taxonomic aspects

In 2020, the species complex *Chelus fimbriata* was divided into two different species, with the description of a new species, *Chelus orinocensis*. According to genomic molecular markers (mitochondrial and nuclear DNA fragments, and SNPs), it is estimated that *C. orinocensis* and *C. fimbriata* diverged approximately 13 million years ago, at the end of the middle Miocene, corresponding precisely to the time of formation of the Orinoco basin (Vargas-Ramírez et al., 2020). *C. orinocensis* was restricted to the drainages of the Orinoco, Negro, and Essequibo rivers, while *C. fimbriata sensu stricto* is formed by the populations that occupy the drainages of the Amazon and Mahury rivers. Although the two species have morphological similarities, there are differences in the color and in the shape of their shells (see Figure 1; Vargas-Ramírez et al., 2020).

Figure 1. *Comparison of dorsal and ventral aspects of two subadult female Chelus orinocensis (top) and Chelus fimbriata (bottom), with observable differences in shell shape and color.*

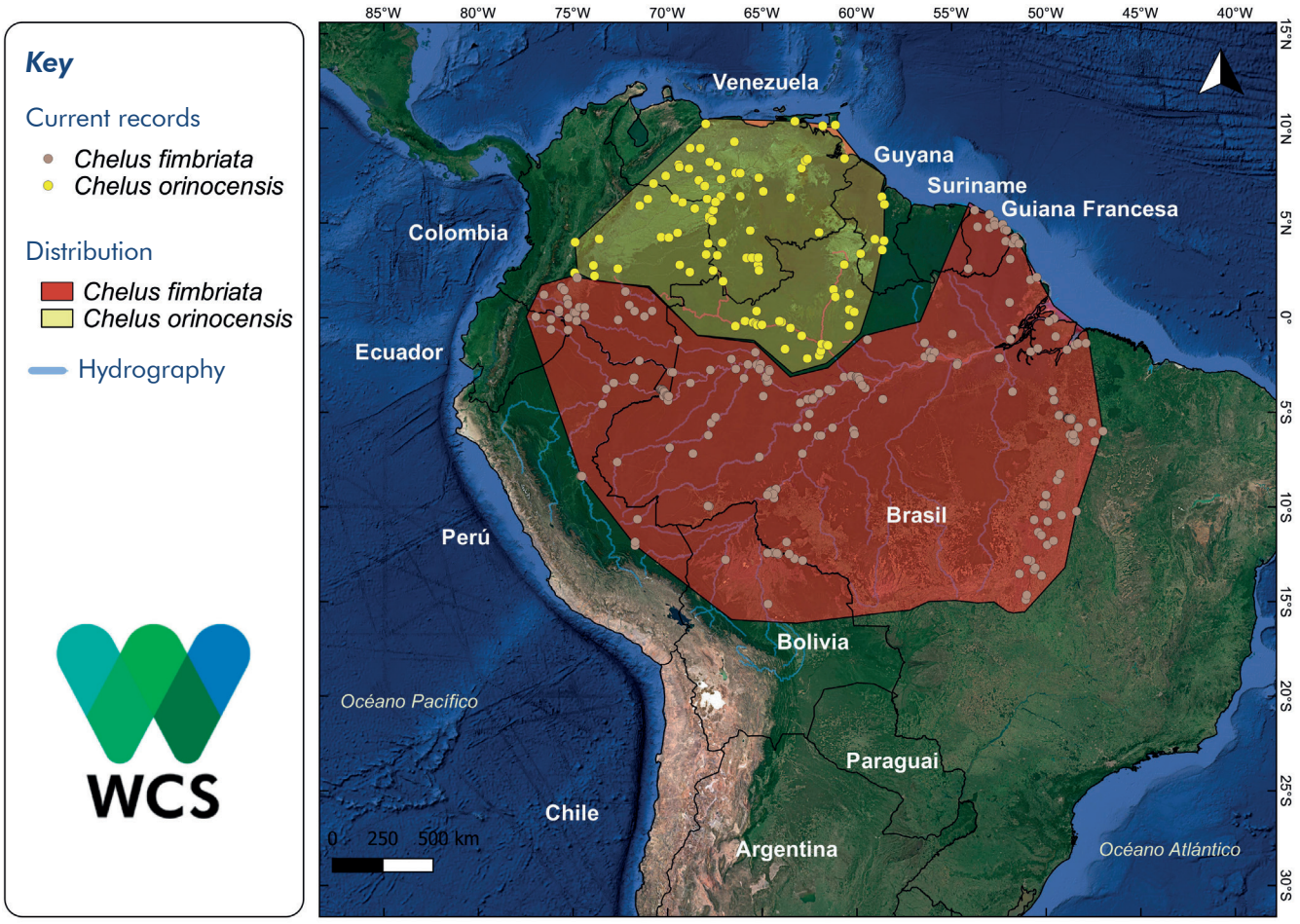


Source: Vargas-Ramírez et al., 2020.

2.3 Geographic distribution

The genus *Chelus* is widely distributed in the Amazon and Orinoco River basins (see Figure 2).

Figure 2. *Distribution map of species of the genus Chelus (C. fimbriata and C. orinocensis), showing their wide distribution in the Amazon Basin and the Orinoco Basin considering all known records up to December 2021.*



Chelus fimbriata has been reported in Bolivia (Beni, Pando, Santa Cruz), Brazil (Acre, Amapá, Amazonas, Goiás, Maranhão, Mato Grosso, Pará, Rondônia, Roraima, Tocantins), Colombia (Amazonas, Caquetá, Putumayo, Vaupés), Ecuador (Sucumbios, Napo, Orellana), French Guiana (Maripasoula, Arrondissement de Caiena), Peru (Amazonas, Huánuco, Junín, Loreto, Madre de Dios, San Martín, Ucayali), and possibly Suriname (Ferrara et al., 2017; Cunha et al., 2021; Rhodin et al., 2021). The presence of *Chelus orinocensis* has been confirmed in Brazil (Amazonas, Roraima), Colombia (Casanare, Guainía, Vichada, Meta, Arauca), Guyana (Cuyuni-Mazaruni, Ilhas Essequibo-West Demerara, Potaro-Siparuni, Upper Demerara-Berbice), Trinidad and Venezuela (Vargas-Ramírez et al., 2020; Cunha et al., 2021; Rhodin et al., 2021).

2.4 State of conservation

The two species of matamata turtles may be suffering different levels of threat and exploitation, making it necessary for different management and conservation strategies by species. When considered one single species with an extensive distribution, the matamata

was listed as Least Concern on the International Union for Conservation of Nature (IUCN) Red List and was not protected by national legislation. However, the recognition of two distinct species means a far restricted range for each species, and no conservation status review has been conducted for each species.

2.5 Main threats and evidence of trafficking

Matamata meat is consumed in rural areas in several Amazon countries (Alcalá, 2011; Morales-Betancourt et al., 2015; Trebbau and Pritchard, 2016; D'Cruze and Ccol, 2021), but due to its unusual appearance and strong smell, the consumption of matamatas is usually rare and may be considered taboo in many regions. For example, Pezzuti et al. (2010) reported that 35% of the inhabitants of Río Negro, in the Brazilian Amazon, avoided eating matamata meat because they considered its appearance repugnant.

Matamatas are, however, highly prized as pets and therefore may be threatened by illegal capture, especially aimed at supplying pet markets in large national urban centers, outside the region of Amazon (Ferrara et al. 2017). Colombia has been identified as a transit country for the illegal export of several native species, including matamatas, to other regions of South America and to other continents (Esguerra et al. 2020). For example, in the Colombian city of Leticia, on the border with Brazil, more than 2,118 hatchlings of matamata were seized between 2010 and 2018 (Esguerra et al., 2020); although there is no information on the geographical origin of these matamatas, Leticia is within the distribution of *C. fimbriata*.

In one of the seizures, a motorcyclist was transporting the animals after picking them up at the airport and reported that the animals came from Villavicencio (Meta), Colombia, in the Orinoco basin. The turtles were in a suitcase, packed in cardboard boxes. According to what was previously known (between 2010 and 2018), in the Colombia-Ecuador border region there were five seizures of matamata turtles in the departments of Puerto Asis, Valle del Guamuez and San Miguel (Esguerra et al., 2020). In 2019, 1,359 living specimens from matamatas were apprehended by the Environmental and Ecological Police and the Airport Police while they were being transported camouflaged with ornamental fish under the modality of parcels from Bogotá to Leticia, in a recognized parcel company (Barreto, 2019). In Peru, the matamatas are the second most seized species of aquatic turtle after yellow-spotted Amazon river turtles (*Podocnemis unifilis*) (Zariquiey et al., 2016). Between 2001 and 2020, around 1,000 live matamata specimens have been seized in forty-six seizures; 98% of those seizures occurred in the department of Loreto (Zariquiey et al., 2016). Coincidentally, Loreto is the region that supplies matamata specimens for legal export from Peru to other countries. The existence of illegal sales parallel to legal ones in the same region can offer ideal conditions for laundering animals. This laundering, like money laundering, occurs when specimens from illicit sources –frequently from nature– without management or sustainability control, receive legal documentation (that is, false permission) when entering a breeding farm, as if they had been born there, to later be legally sold. For example, the owner of a breeding farm located on the outskirts of the city of Iquitos frequently buys illegal animals from the wild (including matamata) in the Mercado de Belén, in Iquitos, illegally, to increase their captive breeding stock and legally trade them to other countries (personal observation TQ Morcatty).

Species from South America, such as matamata, are also entering the southeast Asian market as a replacement for the Chelonian species traditionally traded in this region, in response to the reduction in local populations and, consequently, in the supply of species in the region of Asia (Sigouin et al., 2017). Cardeñosa et al. (2021) mention that matamata reach some of the highest prices ($300 per specimen) in pet markets in the United States (Ceballos & Fitzgerald, 2004), Europe (Kopecký et al., 2003), Asia (Van Dijk et al., 2000) and the Philippines (Sy, E., 2015). In addition, there is evidence that matamatas are being offered in online markets. For instance, between the years 2013 and 2018, Van et al. (2019) detected four matamatas being offered for sale on Facebook pages in Vietnam, costing between US$72 and US$118 each. Although this number may not seem high, it shows the presence of the species in a foreign online market, which has great potential for growth given the increase in internet use.

2.6 Legal trade

Among the three countries, Peru, Colombia, and Brazil, only Peru has a legal trade in matamata turtles (according to the framework of the Forestry and Wildlife Law – Law No. 29763, and the

Regulation for the Management of Wildlife approved by Supreme Decree No. 019-2015-MINAGRI 12.01.2015). The export of matamata is prohibited in Colombia (under the "illegal use of renewable natural resources" Law 2111 of 2021, article 328A) and Brazil (which prohibits collection and sale under wildlife Protection Law No. 5197/67, and the breeding of reptiles in captivity for commercial purposes under IBAMA Normative Instruction No. 31/2002).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was created in 1975 to avoid unsustainable exploitation of wild species due to international trade, according to which all international trade (import, export, and re-export), as well as what comes from the sea, species included in the convention must be authorized through a licensing system. UNEP-WCMC manages the CITES International Trade in Species Database. Entries in the database can be entered by the importing country or the exporting country. However, neither of the two matamata turtle species is currently included in the CITES appendices, therefore, the recording, control, and monitoring of the volume of international trade is the exclusive responsibility of the exporting country, in this case Peru.

The matamata turtle was the main species exported by Peru among non-threatened species and not included in the CITES appendices between 2011 and 2018, coming from authorized breeding farms and *in situ* wildlife management areas in the department of Loreto. However, there is still no estimate of the volume that comes from *ex situ* and *in situ* management.

3

Objectives

3.1 Overall objective

- To analyze the dynamics of legal and illegal trade in matamata turtles (*Chelus fimbriata* and *Chelus orinocensis*) in Peru, Colombia, and Brazil.

3.2 Specific objectives

- Describe the volume of legal trade for exports of matamata turtles from Peru in the last decade.

- Describe the volume of illegal trade in matamata turtles in Peru, Colombia, and Brazil in the last decade.

- To compare legal and illegal trade in matamata turtles in Peru as a function of economic market forces and discuss the effectiveness of legal trade in stopping illegal trade.

4

Methodology

4.1 Seizure data in Peru, Colombia, and Brazil

To analyze the trends of the illegal trafficking of the matamata, we worked with the databases of seizures made by regional environmental authorities, provided by the corporations for the control of trafficking and illegal possession of wildlife in Peru, Colombia, and Brazil.

In Peru, information from the database of seizures and rescued specimens delivered by regional authorities is provided to the National Forestry and Wildlife Service (SERFOR), which is responsible for consolidating information in accordance with the Forest and Wildlife Law. The regional authorities that provided data were the Regional Management of Forestry and Wildlife Development by the Regional Government of Loreto and the Regional Government of Ucayali, and the Executive Directorate of Administration and Conservation of Natural Resources by the Regional Government of San Martín. In the databases provided, there were 900 records of seizures between the years 2010 to 2018.

In Colombia, data considered was obtained from the database of seizure reports submitted by the regional environmental authorities to the Ministry of Environment and Sustainable Development (Minambiente), pursuant to Resolution No. 2064 of 2010. The regional authorities that provided data were the Corporation for the Sustainable Development of the South of the Amazon (CORPOAMAZONIA), the Metropolitan Area of the Valle de Aburrá (AMVA), the Corporation for the

Sustainable Development of the La Macarena Special Management Area (CORMACARENA), the District Secretariat of Environment and the Administrative Department of Environmental Management (DAGMA). This database includes records of seizures, voluntary surrenders, and rescues. These databases had 7,559 records of seizures between the years 2010 to 2021.

In Brazil, different databases were considered, from federal agencies – Chico Mendes Institute for the Conservation of Biodiversity (ICMBio) and the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), to state agencies (environmental secretariats of the states where matamatas naturally occur). The state agencies considered were the Amazon Environmental Protection Institute (IPAAM), the Secretary of State for the Environment and Natural Resources of the State of Maranhão, the Secretariat of State for Environmental Development of Rondônia, and the Secretaries of the Environment of the State of Amazonas, Mato Grosso, Amapá, Pará, Roraima, Tocantins, Acre and Goiás. To complement the official databases, the database of illegal sale of matamatas from urban markets in the Amazon region (market monitoring by the Mamirauá Sustainable Development Institute and literature review), and online markets (e-commerce monitoring – Mercado Libre, OLX and pet classifieds, and social networks by TQ Morcatty between 2017 and 2021) was also considered. In these databases, 58 records of matamata seizures between the years 1989 to 2021 were found.

For the analysis of illegal trade, the variables year, locality (municipality and province/state) and the number of living specimens seized or illegally sold were considered. The databases presented slightly different time intervals, which varied between the years 1989 and 2021. The period between the years 2010 and 2018 is the most consistent period, in which all the databases had records, so the comparisons between countries were particularly focused on this period.

4.2 International seizure data

The two species of matamata prioritized in this work have never been evaluated by the IUCN to determine their global conservation status, nor are they included in the CITES Appendices. Previously, when considered as one single species, the matamata was listed as Least Concern by the IUCN. As the now separate species are pending assessment, there is no record of these in the CITES database.

Thus, to estimate the illegal or unregulated sale of matamata originating in Peru, Colombia or Brazil, this study used the United States database called Law Enforcement Management Information System (LEMIS), maintained by the Service of Fish and Wildlife of the United States government agency (USFWS). In this case, records of seizures of matamata when illegally entering the United States in the period between 2000 and 2014 were used.

4.3 Legal export data from Peru to other countries

Peru is the only country where the export of matamata turtles is legal and regulated, thus, the analysis of the legal market was restricted to this country only. In this case, the export data used here was provided by SERFOR through the framework of the Law of Transparency and Access to Public Information, based on the export permits granted until 2015, and by the Regional Government of Loreto, based on the visual inspection records of shipments in the period from 2016 to 2020. For the analysis, the variables year, importing country and the number of live specimens exported were considered.

4.4 Comparison of illegal trade and legal export in Peru

The comparison between illegal and legal trade of matamata was restricted only to Peru since it is the only country in which the export of matamata is authorized. To understand the value of legal and illegal trade for matamata in Peru, the market share (i.e., the proportion of legal sale or illegal sale based on all the matamatas sold) was calculated. The market share, also understood as market stake, is calculated by dividing the number of turtles sold in the legal market by the total number of those sold in both the legal and illegal markets; then the value obtained is multiplied by 100 and then the percentage is obtained. The same is done with the figure of the illegal market. Market share is an economic field measure to calculate dominance in terms of total sales of a specific source relative to competing sources. The participation of each source was calculated annually between the years 2010 and 2018 and for the entire period. This information

allows us to detect if the offer of matamatas is currently dominated by illegal sources or legal sources. The annual trend of the market share over the years can indicate whether legal trade is being effective in reducing illegal trade (in case of an increase in market dominance by legal sources over the years) or if legal trade may be fueling illegal trafficking (in the case of an increase in seizure dominance over the years).

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Results

5.1 Patterns and trends of matamata turtle trafficking in Peru, Colombia, and Brazil

In Colombia, between 2010 and 2021, 7,559 matamata turtles were seized for trafficking or illegal possession. These records come from 6 departments and 11 municipalities (see Table 1). Of the specimens seized, 97% (n = 7,327) were alive, while 3% (n = 231) were dead specimens (possibly related to meat consumption or other uses, such as medicinal). Leticia and Bogotá DC were the cities with the highest number of seizures, with 56% and 44%, respectively, of the total specimens seized in the country during that period.

In Peru, between 2010 and 2018, 432 matamata turtles and 468 matamata eggs were seized in situations of illegal trafficking. These records come from 4 departments and at least 6 municipalities (see Table 1). Of the seized specimens, 99% (n = 430) were alive, while only 1% (n = 2) were dead specimens (possibly related to meat consumption, medicinal or other uses, or animals that died due to stress or overcrowding in the marketing chain). The province of Maynas, in the department of Loreto, had the highest volume of seizures, representing 97% of the total specimens and 468 eggs, corresponding to all (100%) the eggs seized in the country in that period.

In Brazil, between 2010 and 2021, 42 matamata turtles were registered in situations of trafficking or

illegal possession. Before that, between 1989 and 2009, another 16 matamata turtles had been seized (see Table 1). Of the records that had identified the use (n = 48), 50% (n = 24) of the specimens were intended for the pet market, 43% (n = 21) were intended for human consumption (meat), and 6 % (n = 3) for handicrafts or use in a clandestine laboratory. Of the 58 specimens of matamata turtles recorded in Brazil, 62% (n = 36) were seizures and 38% (n = 22) were records of consumption for food or illegal sale, including online sale on social networks. These records come from at least 7 states and 22 municipalities (Table 1). The municipality of Tonantins, in Amazonas State, had the most records (19%, n = 11), followed by Cruzeiro do Sul, in Acre (7%, n = 4), Almeirim, in Pará (7%, n = 4) and Rio de Janeiro (5%, n = 3).

“In Colombia, between 2010 and 2021, 7,559 matamata turtles were seized for trafficking or illegal possession.”

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Table 1. *Matamata seizures by department/state and municipality/province by year between 1989 and 2021.*

Country	Department/ State	Municipality/ Province	Year														Total
			Before 2010*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	With no date	
Colombia	Amazon	Leticia	-	0	0	0	2	1	212	554	0	1550	0	1890	0	2	4211
	Antioquia	Medellin	-	13	7	3	1	3	0	3	0	0	0	0	0	0	30
		Sopetran	-	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Bogota	Bogota	-	0	0	0	0	0	0	0	0	0	1368	0	1936	0	3304
	Casanare	Yopal	-	0	0	0	0	0	1	0	0	0	0	0	0	0	1
	Meta	Villavicencio	-	0	0	2	0	0	0	0	0	0	0	0	0	0	2
	Putumayo	Valle del Guamuez	-	0	0	0	0	0	3	0	0	0	0	0	0	0	3
		Puerto Asis	-	0	0	1	0	0	0	0	0	0	0	0	0	0	1
		San Miguel	-	0	1	0	0	0	0	0	0	0	0	0	0	0	1
	Valle del Cauca	Cali	-	0	0	0	0	2	0	0	1	1	0	0	0	0	4
		Yumbo	-	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Total Colombia			-	13	8	6	3	6	217	557	1	1552	1368	1890	1936	2	7559
Peru	Junin	Huancayo	-	0	0	0	0	0	2	0	0	0	0	-	-	0	2
	Loreto	Alto Amazonas	-	0	0	0	1	0	0	0	0	0	0	-	-	0	1
		Maynas	-	16	0	362	0	0	33	4	2	0	0	-	-	0	417
		Nauta	-	0	0	0	0	0	0	0	1	0	0	-	-	0	1
		Not specified	-	0	0	0	1	0	0	0	0	0	0	-	-	0	1
	San Martin	San Martin	-	0	0	0	1	0	0	0	0	0	0	-	-	0	1
		Not specified	-	0	0	1	0	0	0	0	0	0	0	-	-	0	1
	Ucayali	Coronel Portillo	-	1	0	0	2	2	1	0	0	0	0	-	-	0	6
		Not specified	-	0	0	0	2	0	0	0	0	0	0	-	-	0	2
Total Peru			-	17	0	363	7	2	36	4	3	0	0	-	-	0	432

**Only Brazil provided a database with records before 2010. The analyzed databases from Peru and Colombia started in 2010.*

Country	Department/ State	Municipality/ Province	Year														Total
			Before 2010*	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	With no date	
Brazil	Acre	Cruzeiro do Sul	0	0	0	0	0	0	0	0	0	0	4	0	0	0	4
		Rio Branco	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	Amazonas	Barcelos	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Beruri	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Fonte Boa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Manaus	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
		Maraã	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
		Novo Airão	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Pauini	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Santa Isabel do Rio Negro	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
		Tapaua	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
		Tefe	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
		Tonantins	0	0	0	0	0	0	0	0	0	11	0	0	0	0	11
		No especificado	9	0	0	0	0	0	1	0	0	0	0	0	0	0	10
	Goias	Distrito Federal	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
		Uruaçu	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
		No especificado	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Para	Abaetuba	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Afuá	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
		Almeirim	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4
		Belem	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Parana	Curitiba	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
	Rio de Janeiro	Rio de Janeiro	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3
	São Paulo	São Paulo	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
	Not specified	Not specified	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total Brazil			16	0	0	4	1	2	5	1	3	14	4	0	8	0	58
grand total			**16**	**30**	**8**	**373**	**11**	**10**	**258**	**562**	**7**	**1566**	**1372**	**1890**	**1944**	**2**	**8049**

**Only Brazil provided a database with records before 2010. The analyzed databases from Peru and Colombia started in 2010.*

In Colombia and Brazil, the most recent years (2018-2021) were those with the highest number of seizures (89% and 62% respectively) between 2010 and 2021, with a significant increasing trend over the years (Colombia GLM est = 0.590, SE = 0.014, t = 410, $p < 0.001$, r 2 = 0.7, Brazil GLM est = 0.152, SE = 0.018, t = 84, $p < 0.001$, r 2 = 0.3; Figures 3 and 4). The statistical values, especially r 2, indicate that the increase over time occurs in both countries, but it is stronger for Colombia than for Brazil. In contrast, in Peru there was no evidence of an increasing trend in the seizures of matamatas over the years (see Figure 5). In Peru, the year 2012 stood out in the number of seizures, representing 84% of the total number of matamatas seized for the period between 2010 and 2018.

Figure 3. *Annual trend of matamata turtles seized in Colombia between 2010 and 2021. The shaded area represents the 95% confidence interval.*

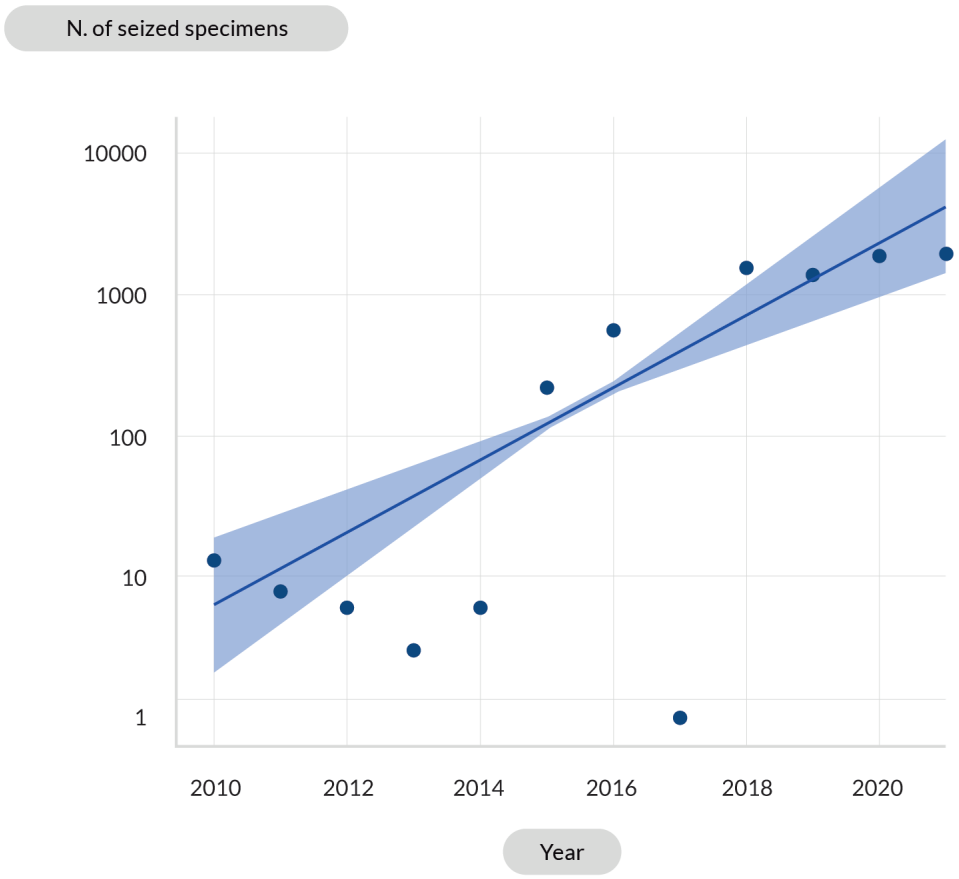


Figure 4. *Annual trend of matamata turtles seized in Brazil between 2010 and 2021. The shaded area represents the 95% confidence interval.*

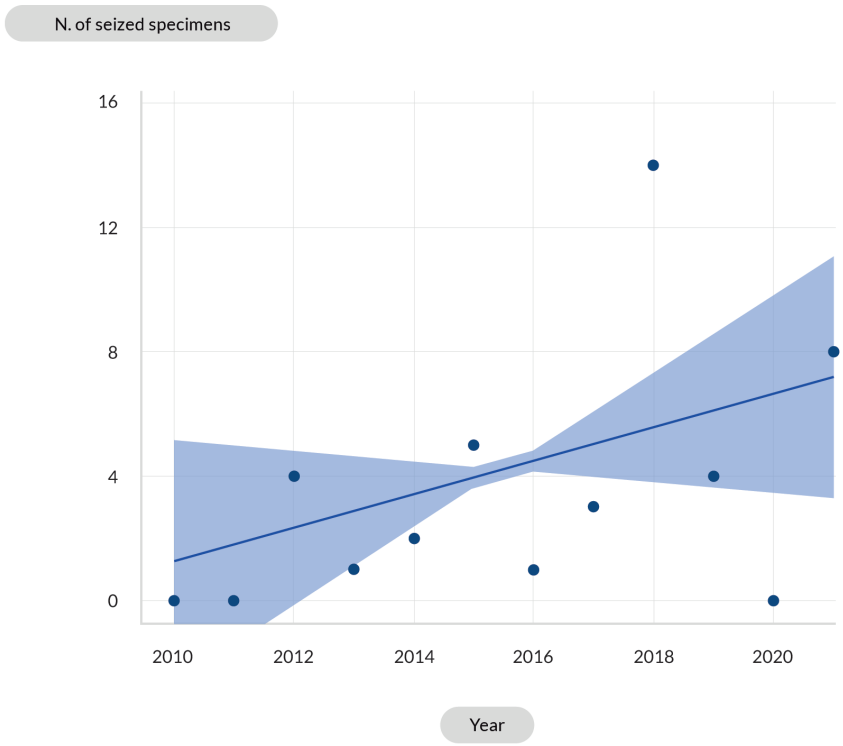
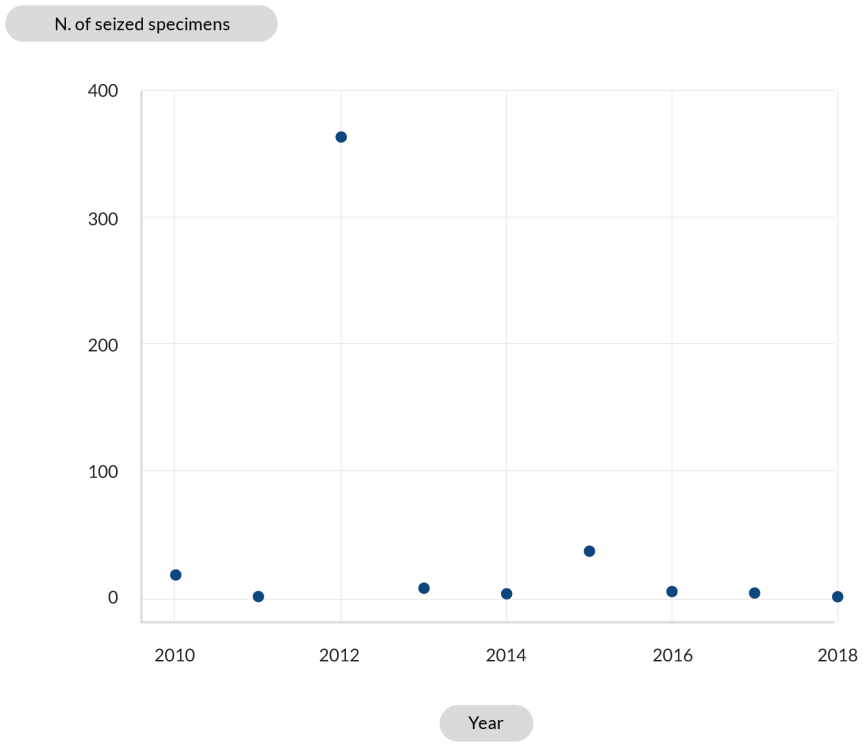


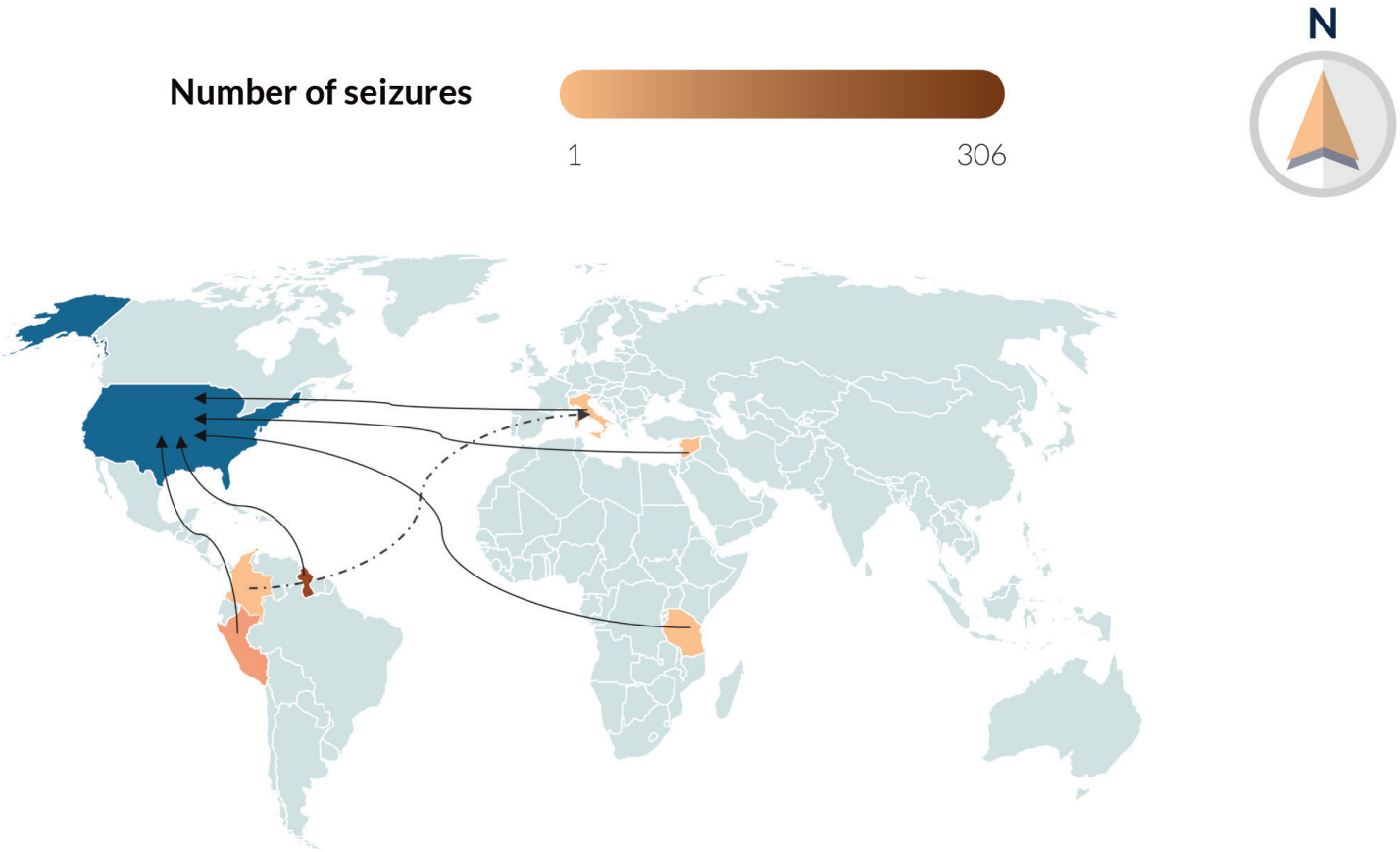
Figure 5. *Annual trend of matamata turtles seized in Peru between 2010 and 2018.*



5.2 International seizures

Both species of matamata may be traded in international pet markets, but there is no information on the differentiation between the two species yet. According to the LEMIS database (Law enforcement Management Information System), 380 specimens of matamata were seized entering the United States in 100 different events, mostly from Guyana (306 specimens) and, to a lesser extent, from Peru (50 specimens), Syria (1), Tanzania (1), and Italy (seizure of 1 animal originating in Colombia) (see Figure 6). However, there were no records referring to matamata originating from Brazil in this database. All registered animals entered the United States for commercial purposes. Besides the individuals imported from Italy native from Colombia, there are no details on the origin of the other specimens imported from countries outside the distribution area.

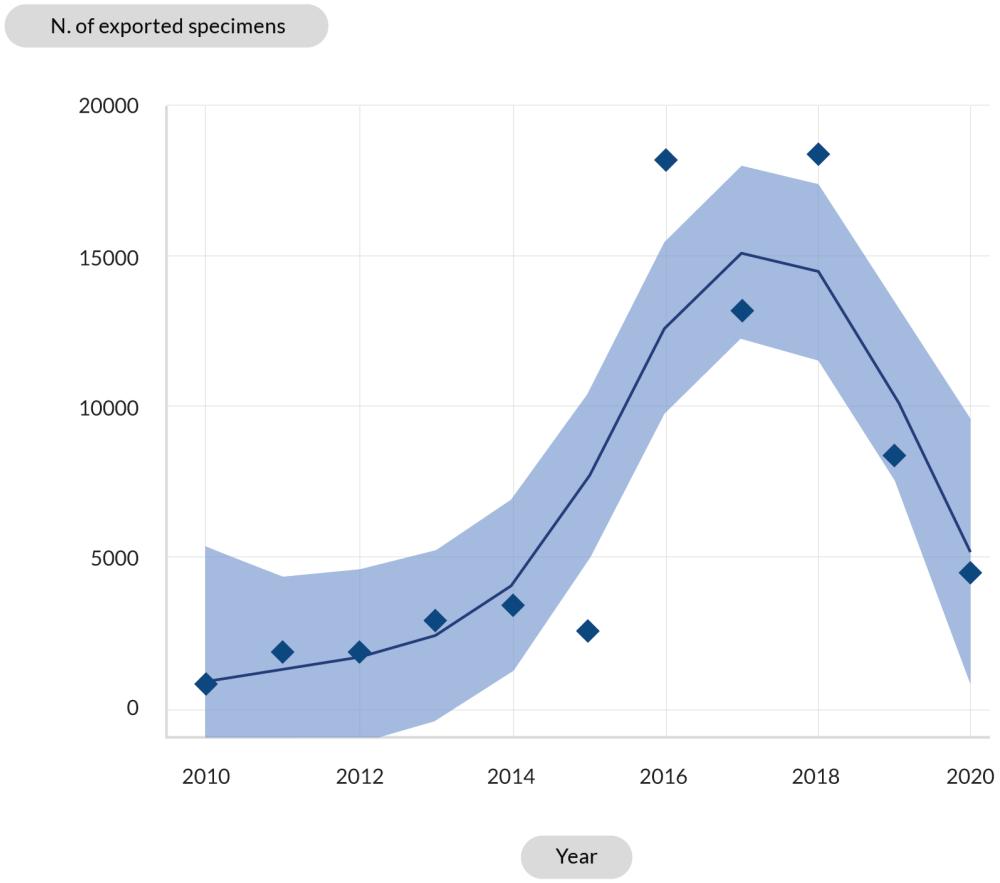
Figure 6. *Flow map with the routes of the matamata seized when illegally entering the United States for commercial purposes according to the LEMIS database (Law Enforcement Management Information System). The broken route represents illegal transportation from Colombia to Italy before entry into the United States.*



5.3 Summary of the legal sale of matamata in Peru

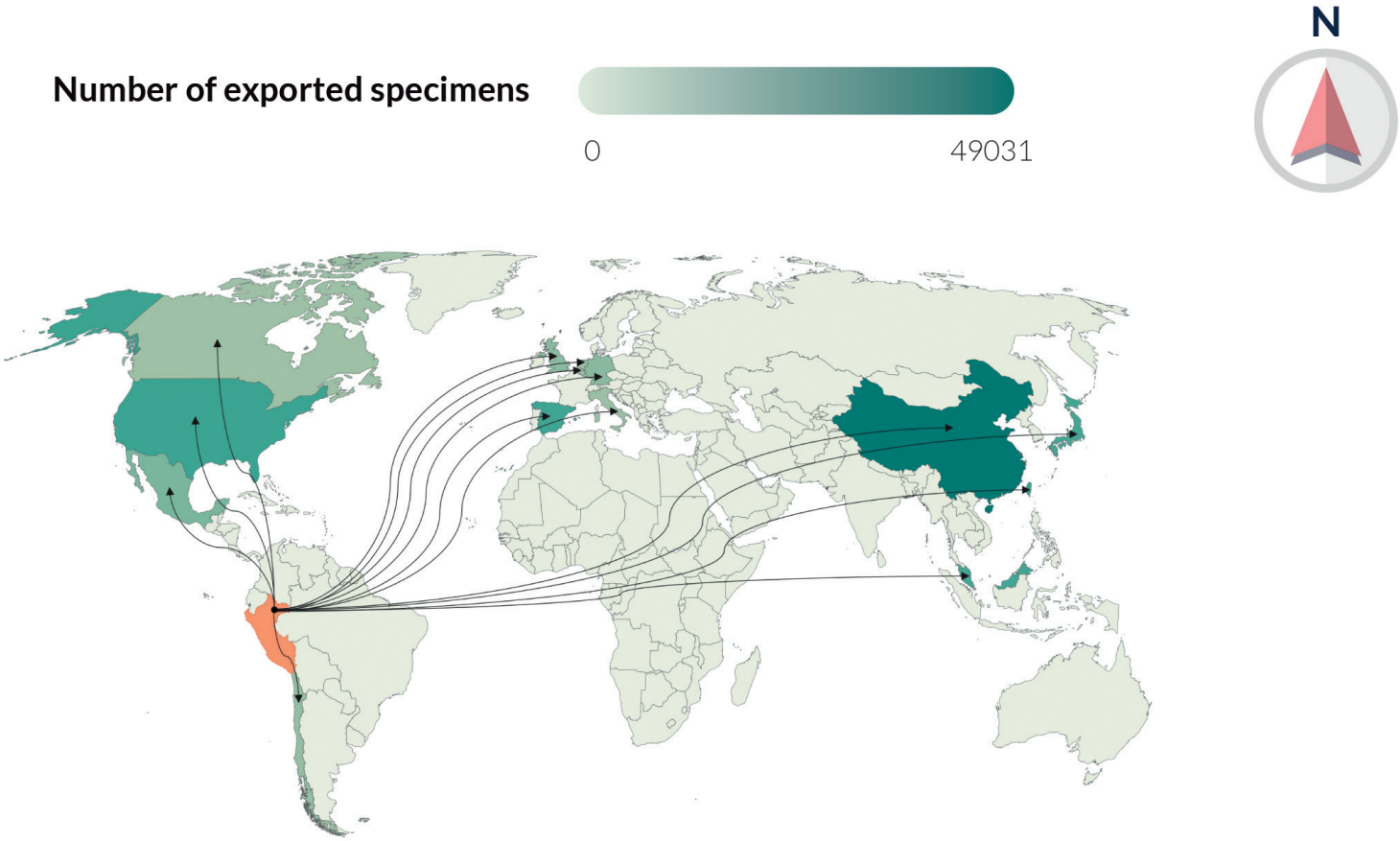
Matamata exports have grown steadily in recent years, although a drop is observed in 2019 and 2020 (GAM est = 1181, SE = 260, t = 4.5, p = 0.006, r^2 = 0, 81; see Figure 7).

Figure 7. *Annual trend of specimens of matamata turtles exported from Peru between 2010 and 2020. The shaded area represents the 95% confidence interval.*



The destinations were mainly North America, Europe, and Southeast Asia (see Figure 8 and Table 2). Based on the current known distribution range, legal exports only affect *C. fimbriata*. However, if there are cases of animal laundering, it is possible that *C. orinocensis* comes from Colombia or Brazil and is also exported. Further research is needed on that matter. Because matamata turtles are not yet listed under CITES, all export declarations come from the Peruvian regulatory agencies mentioned in the methodology. Between 2010 and 2020, Peru legally exported 75,738 live matamata specimens to 14 countries. There were no reports of exports of other products such as animal parts or derivatives during this period. All the live offspring currently exported come from the department of Loreto, where the animal breeding and authorized management areas are currently located.

Figure 8. *Map with the legal export routes of specimens of matamata turtles from Peru to the different countries of the world. The darker the color of the country, the greater quantity was imported in the period between the years 2010 and 2020. More details can be found in Table 2.*



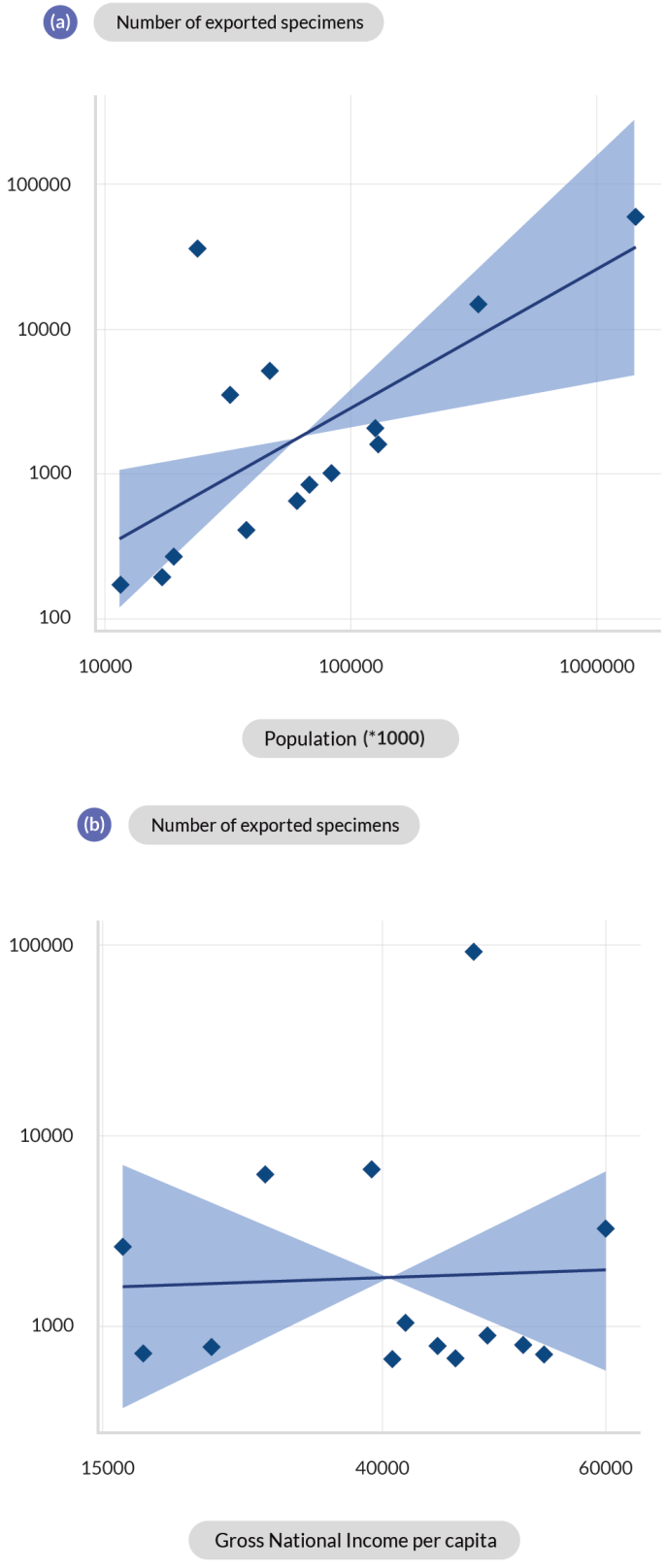
China is the country that imported the most matamatas from Peru, specifically importing 64.7% (n = 49,031) of the total number of specimens exported between 2010 and 2020, followed by the United States, with 19% of the exported specimens. However, in the years 2017 and 2019, the United States led the imports, being responsible for the purchase of 44% and 58% of all matamatas sold in those years, respectively. China and Japan are important importers, not only because of the volume imported, but also because of the regularity of purchase, having bought matamatas every year between 2010 and 2020. The United States, Taiwan and Spain also frequently buy matamata turtles (see Table 2).

Table 2. *Legal exports for commercial purposes of matamata from Peru to other countries between 2010 and 2020*

	Years											
Country	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
China	585	461	1213	2174	1636	1872	14506	4780	15330	2907	3567	49031
USA	57	0	0	0	272	400	241	5845	2675	4885	285	14660
Taiwan	0	950	300	0	50	0	1535	300	150	138	200	3623
Spain	0	168	41	285	843	142	150	1250	0	140	120	3139
Malaysia	0	65	0	0	0	0	1535	500	0	0	0	2100
Japan	97	112	130	201	307	100	120	229	100	120	100	1616
Mexico	0	0	120	200	200	0	0	0	100	0	0	620
Germany	0	0	0	0	0	0	0	0	0	156	200	356
United Kingdom	0	0	0	0	0	0	0	300	0	20	0	320
Chile	0	30	0	0	100	0	0	0	0	0	0	130
Belgium	0	0	0	0	0	0	100	0	0	0	0	100
Italy	0	0	30	0	0	0	0	0	0	0	0	30
Netherlands	10	0	0	0	0	0	0	0	0	0	0	10
Canada	0	3	0	0	0	0	0	0	0	0	0	3
Total	**749**	**1789**	**1834**	**2860**	**3408**	**2514**	**18187**	**13204**	**18355**	**8366**	**4472**	**75738**

The demand for matamatas by importing countries seems to be influenced by the size of the population in each country, but not by the purchasing power of the people (see Figure 9). The most populous countries bought larger quantities (GLM est = 0.960, SE = 0.302, t = 3.182, $p < 0.01$, $r^2 = 0.7$), while the Gross National Income (GNI) per capita, considering purchasing power parity (PPP – which considers the relative cost of living), did not seem to influence the demand for matamatas in importing countries (GLM est = 0.000004, SE = 0.00003, t = 0.136, p = 0.89).

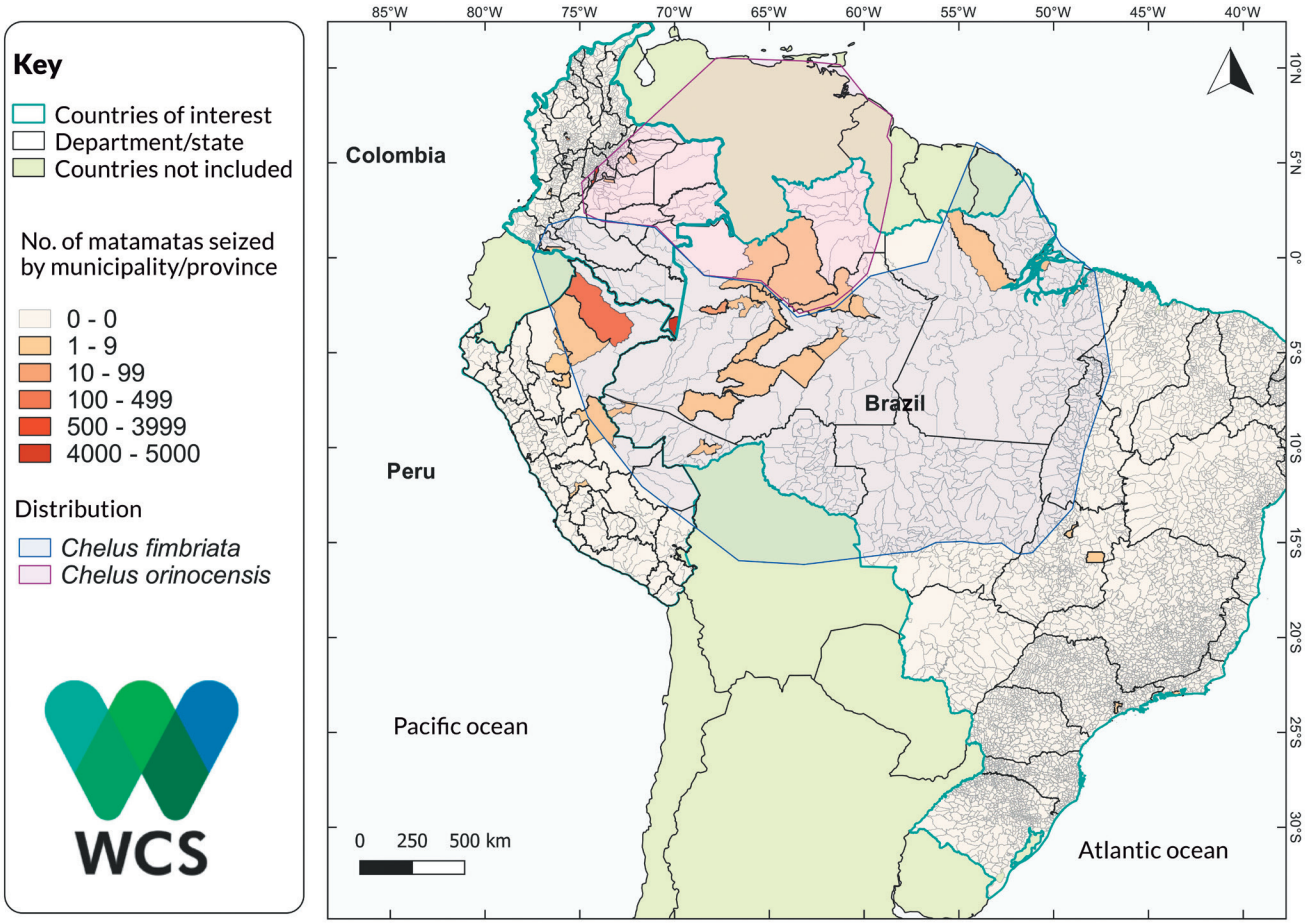
Figure 9. *Ratio of the number of specimens of matamata imported between the years 2010 and 2020 by country with (a) the size of its human population (social indicator) and (b) its Gross National Income (GNI) per capita (economic indicator). The shaded area represents the 95% confidence interval.*



5.4 Geographical distribution of records of use and trafficking of matamata in Peru, Colombia, and Brazil

When considering the seizures and records of illegal use of matamata in Peru, Colombia, and Brazil, it is evident that the illegal trafficking of matamata extends over a large area in the three countries (see Figure 10). The areas with the highest concentration of records of matamata turtle trafficking are the province of Maynas (capital of Iquitos) in Peru (see Figure 11), the municipalities of Leticia and Bogotá in Colombia (see Figure 12), and the municipality of Tonantins in Brazil (see Figures 13 and 14).

Figure 10. *General map with the geographical distribution of the illegal trafficking of specimens from matamata by municipality or province in the countries of interest, Peru, Colombia, and Brazil.*



It is evident that the areas with the highest concentration of illegal trade records are not necessarily the border areas. However, it is important to point out the high concentration of seizures in Leticia (triple border Colombia-Peru-Brazil), and in the municipality of Cruzeiro do Sul, in Acre, Brazil, which borders the municipality of Coronel Portillo, in Peru.

Most of the regions with records of illegal trade of matamata in Colombia, including the capital Bogota, and in the north of the state of Amazonas, in Brazil, are within the probable distribution of *C. orinocensis*. This could indicate that this species could be under a higher risk of overexploitation. Assessments of the wild populations are needed to define whether current levels of exploitation are within sustainable limits (although still illegal) or threaten the survival of populations. More efforts are needed to differentiate the two species, especially in the municipalities and provinces identified here as hotspots for the matamata trade.

Figure 11. *Map with the geographical distribution of the illegal trafficking of specimens from matamata by province in Peru.*

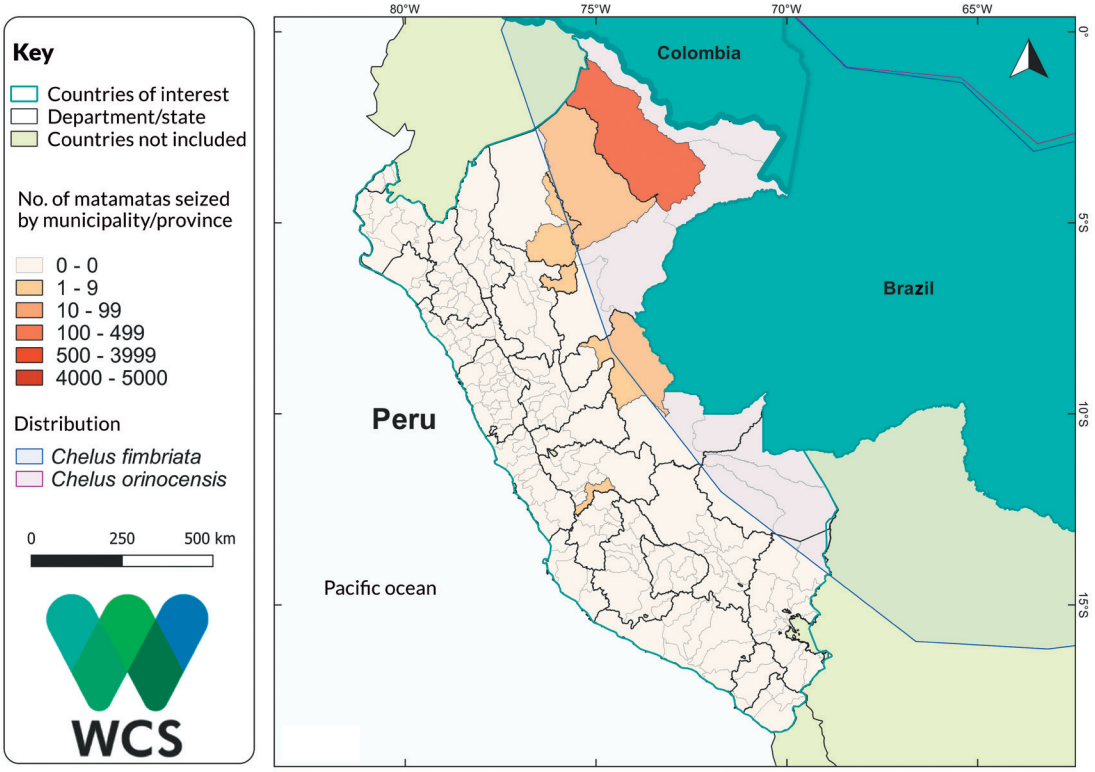


Figure 12. *Map with the geographical distribution of the illegal trafficking of matamata by department in Colombia.*

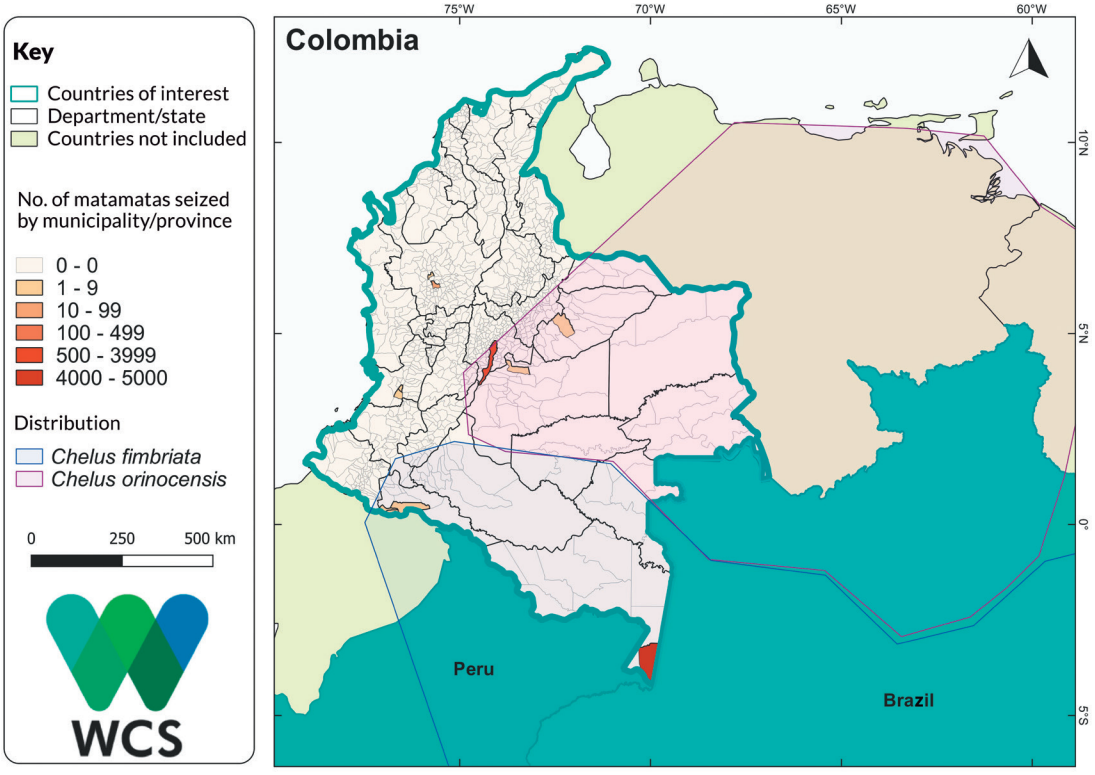


Figure 13. *Map with the geographical distribution of the illegal trafficking of matamata by province in the north and center-west region of Brazil.*

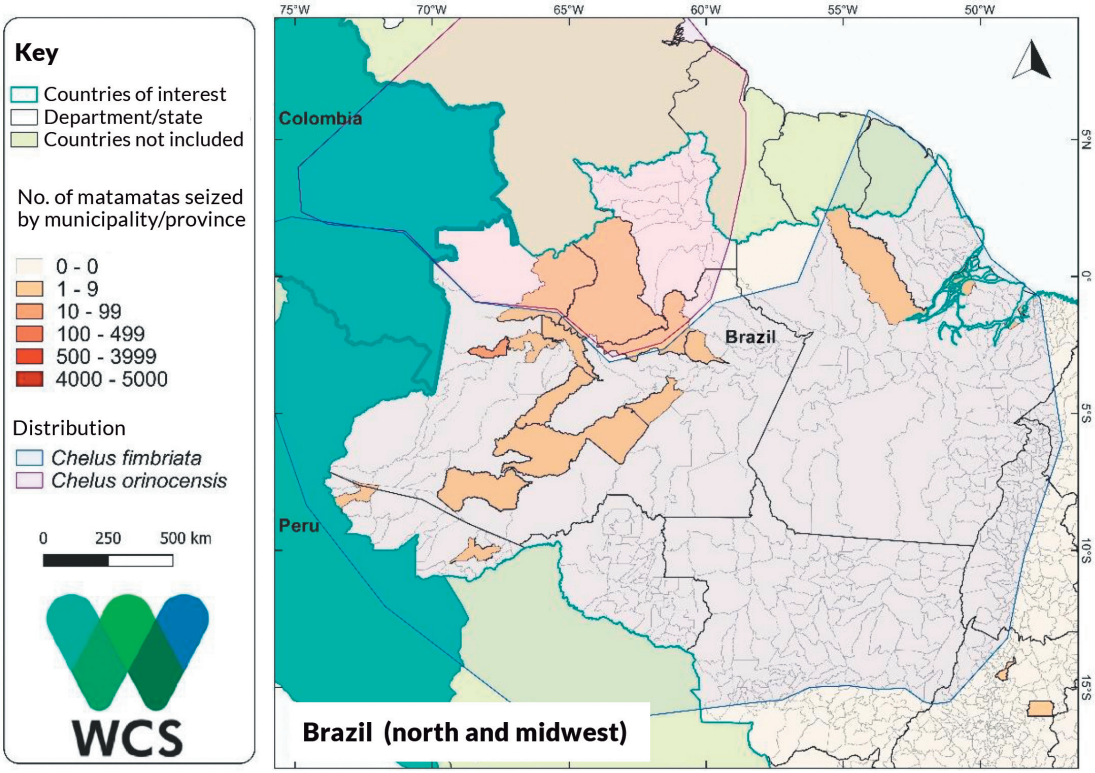
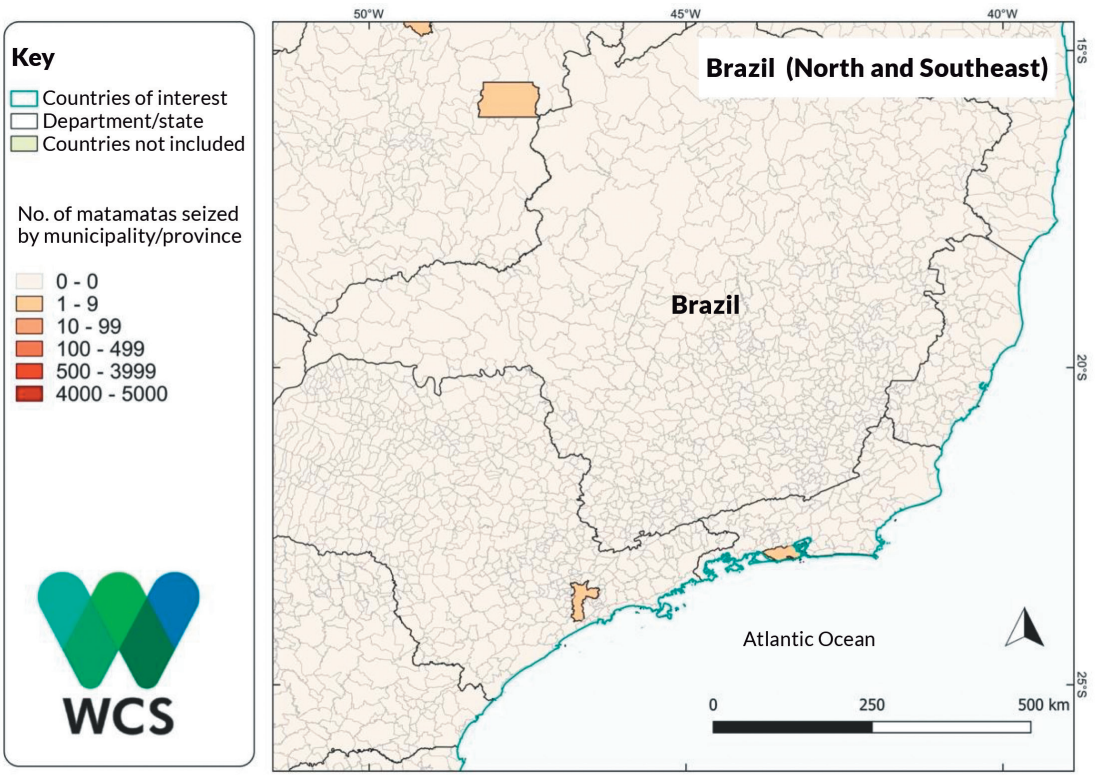


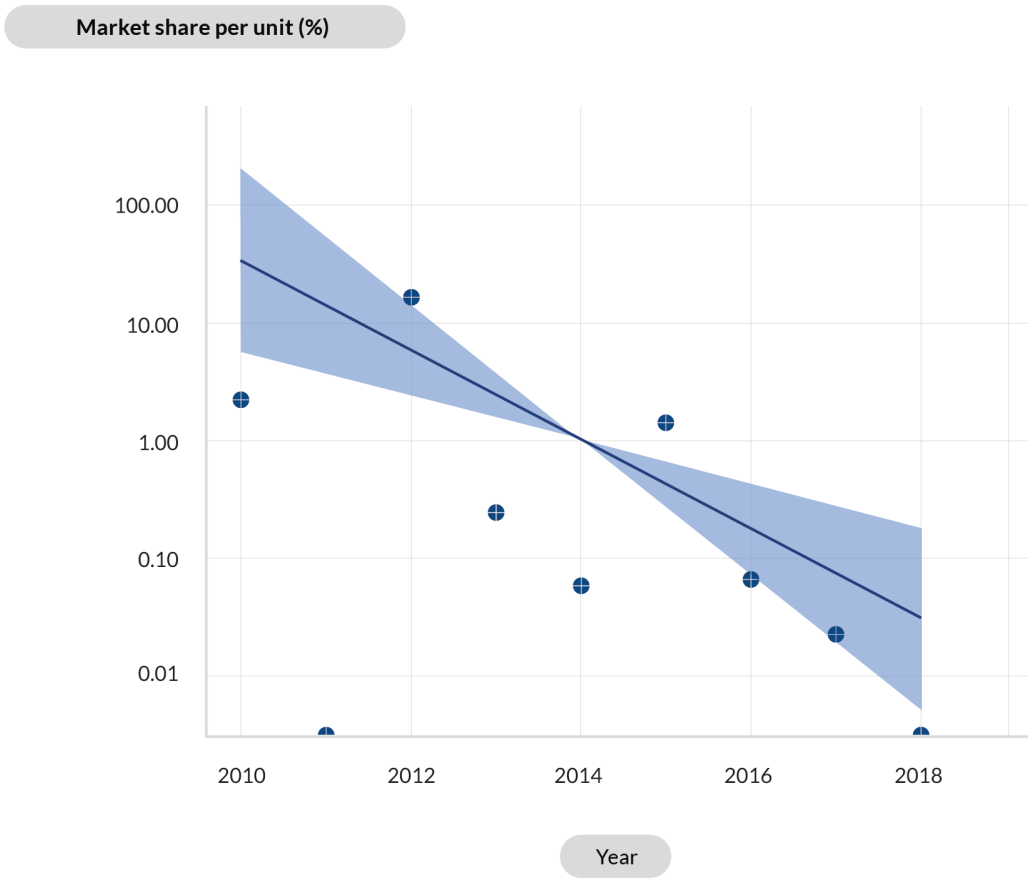
Figure 14. *Map with the geographical distribution of the illegal trafficking of matamatas by province in the southeastern region of Brazil.*



5.5 Comparison of legal and illegal trade in matamata in Peru

In Peru, legalized sources seem to dominate the matamata turtle market by 95.1%. Over the years, this prevalence has increased, as the proportion represented by illegal sources decreases steadily over time (GLM est = -0.087, SE = 0.002, t = -505, $p < 0.0001$, r 2 = 0.46, see Figure 15). This reduction may be due to both the preference for legal sources (risk reduction) over time and the increase in law enforcement that may have occurred; most likely it is a combination of both factors. This temporal pattern suggests that a large proportion of exported matamata comes from legal sources; but it must be considered that the estimate of the illegal sale was made through seizures, and these may not faithfully represent everything that is illegally sold within Peru or to other countries. Furthermore, if animal laundering is occurring and legal and illegal sources are mixed before export, it is difficult to ensure that all exported matamatas are effectively only from legal sources.

Figure 15. *Temporal trend of the annual market share (market share in economic terms) by legal market units in Peru between 2010 and 2018. The axis is presented on a logarithmic scale (ln). The shaded area represents the 95% confidence interval.*



5.6 Identification of problems and needs for improvement in the control and management of wildlife

The lack of standardization is a common problem in different seizure databases. Different agencies collect different types and levels of information when there is a seizure and aggregate it in different systems (on paper, Excel, or other software) or different format tables, making it difficult to combine different databases. Since illegal trafficking is estimated through seizure records, the number of records may be related to the effort of inspection and surveillance operations, in terms of the number of inspection operations carried out, the number of agencies responsible for performing controls and the size of the area covered in inspection operations. As there is no information on the operational effort for any of the three countries assessed, the comparison between years and countries is limited and may be subject to interpretation errors.

Detailed information on the circumstances surrounding the seizure is also often lacking for most records, such as the possible origin of the specimen and where they were being seized from, as well as the reasons related to trafficking (sale, domestic support, exposure), age of the matamata (information that may suggest the type of use to which the sample would be destined), mode of transportation of the seized sample (car, truck, boat, or plane), place of the seizure (road, rivers, proximity to ports or airports), any evidence of a link to international trafficking, or disposal of the specimen after the seizure. In this way, it is difficult to carry out a deeper analysis of the modus operandi of the traffickers of matamatas and guide future investigations and institutional interventions more effectively.

There are also limitations related to legal sale databases in Peru. The monitoring and control of the quantities exported are completely under the responsibility of the Peruvian regional institutions. However, with this level of export detected, the role of agencies such as the CITES Management Authority in Peru, SERFOR and GORE in Loreto, in this control would be very valuable. If the matamata were listed in CITES, it would be possible to have data declared both by the country of origin, in this case Peru, as well as by the importing countries, which would increase the possibilities of obtaining an estimate of the exports and the buying countries obtained from more than one source. In this case, if Peru does not report the correct information (for example, due to laundering of animals, differences in what was predicted to be marketed in the license and what was marketed, or due to declaration of loss), it is possible to compare the declarations made by two different countries for the same transaction and detect possible irregularities. It could also be understood if there are re-exports after the arrival of the matamata in the importing countries, something common that happens with other wild animals. In addition, if *C. fimbriata* and *C. orinocensis* were listed in CITES, the legal procedures required for export, in terms of documentation and shipping, would be more rigorous and controlled, which would facilitate both the identification of corruption and the effective monitoring of exported quantities. In this context of illegal sales parallel to legal ones, it is essential to strengthen inspections to avoid, as far as possible, animal laundering, where specimens from illegal sources receive legal documentation to be sold as coming from a legal source.

Another limitation linked to legal trade, which could be of interest to the responsible organizations, in this case the Regional Government of Loreto, is to keep track and provide data on the sale prices of legally exported specimens of matamatas. When the selling price is analyzed over the years, the temporary variation can indicate a lot about the dynamics of the market, such as an increase in demand or in the appreciation of the product, or even detect the Allee Effect, which refers to that the rarer a species becomes on the market, due to declines in natural populations, the specimens that are traded will tend to be more expensive over the years. The legal sale prices, when compared with the illegal sale prices, promptly and over the years, can indicate the interaction between these two chains, even being one of the indicators for the detection of animal laundering.

6

Discussion and recommendations

The locations of international seizures and the legal sale of matamatas to other countries from Peru show that people from various parts of the world have a great desire to obtain this animal. Given that most of the animals are sold live, it can be inferred that the main driver of exploitation of the matamata is their use as pets.

The same thing happens in the Amazon region, where despite the fact that the consumption of turtle meat is culturally widespread, the demand for matamata for meat consumption seems low. The strong odor and strange appearance of the matamata make them less appreciated as food, although meat and possibly eggs are consumed, as these products have been recorded in seizures in Brazil and Peru.

Matamata trafficking in Peru and Colombia occurs especially in the distribution areas of the species. However, in Brazil it is occurring at distances greater than 1000 km from the expected distribution, particularly in large cities such as Rio de Janeiro and São Paulo, in the southeastern region, and Curitiba, in the southern region of the country. There are no records in Brazil of seizures of large quantities of matamatas, as occurs in neighboring countries such as Peru and Colombia (Lasso et al., 2018; Restrepo et al., 2021), where seizures of hundreds or even thousands of matamatas are recorded annually. In addition, both Peru and Colombia are involved as countries of origin for matamatas seized in the United States, which shows that there are matamatas

that leave these countries illegally. As there are no international seizure databases available, apart from the LEMIS database, it is not possible to be sure that other countries also illegally receive matamatas of Peruvian and Colombian origin, but it is reasonable to consider that this could happen, especially in Asian markets. (e.g., China, Taiwan, Malaysia, and Japan) and Europeans (Spain, Germany, England) which are the large legal buyers of matamata or in countries such as Vietnam where trafficked matamatas have already been registered (Van et al., 2019). Although there is a legal source of matamata available to foreign countries from Peru, illegal trade could occur, due to the difference in price, bureaucracy, or limits on how much the legal source can produce and export, for example. Companies involved in the wildlife trade in other countries that operate illegally in their own country are generally not able to purchase through legal lines, but instead seek out illegal transactions.

Lasso et al. (2018) suggest that the fact that the sale of matamatas is regulated in Peru encourages the illegal collection of specimens in Colombia, where they are transported to Peru to enter the legal sales chain. It is suggested that the specimens are extracted from the Orinoquia, in the Inírida, Bajo Guaviare and Orinoco rivers and in Casanare, using the same modus operandi as ornamental fish, often being transported together. Matamata are transported using the modality of parcels through cargo companies camouflaged with fish to Bogotá, then to Leticia, and later to Peru, where they would be commercialized taking advantage of the legality of animal breeding and export activities (Policía Nacional, 2020; Esguerra et al., 2020). Among the existing records, no indications were found that the same thing happened in Brazil on the triple border Peru-Colombia-Brazil. As can be seen in Figures 10 and 12, apart from Leticia in Colombia, there is not a large occurrence or concentration of records of trafficking in matamatas in border regions between the three Amazonian countries studied. It should be noted that the border municipalities of Cruzeiro do Sul in Brazil and Coronel Portillo in Peru show a similar level of seizures of matamatas. This corridor between Brazil and Peru may also represent a route where Brazilian matamatas are illegally taken to Peru to enter the legal sales chain.

The fact that in Colombia a substantial number of matamatas have been seized in cities such as Leticia, while in Brazilian or Peruvian records there are very few seizures in border cities, such as Coronel Portillo and Cruzeiro do Sul, may indicate an imbalance in the inspection effort between these countries. This imbalance in inspection capacity can be explained by the difference in the border line to be monitored between countries. For example, there is a huge border perimeter to be patrolled in the Brazilian Amazon, stretching from French Guiana in the north to Bolivia in the south-west of the region. Likewise, the administrative headquarters and control bodies are located very far from the borders, while the other countries have substantially smaller perimeters to be patrolled. Just as it is important to invest in recurrent inspection in border areas, key municipalities along rivers and main highways should also be prioritized, even if they are not on the border with the countries. In addition, it is recommended that research and intelligence sampling is done by the competent authorities, ideally with the support of academics, experts, or conservation institutions, so that efforts to collect and analyze information on possible and main flow directions of matamatas at regional and international level can be maximized among the countries involved in its legal and illegal trade.

Few control and surveillance posts in the Amazon region of Peru, Colombia, and Brazil considerably hinders the fight against the illegal trafficking of matamata turtles, as well as other wild species. Moreover, the authorities in charge of inspections in border regions, are, for example, the army (for Brazil), the Border Directorate of the Loreto Police Region (for Peru) and customs in the three countries, and not agencies related to the environmental sectors. This means that border inspection actions and efforts are more directed at arms, drug, and human trafficking, while specialized actions against illegal wildlife trafficking are limited. For this reason, at least the training of border forces on wildlife trafficking issues should be promoted, to collect relevant information that can be shared with environmental authorities, in the event of a possible seizure of wild animals in operations.

There is also no consistent data to suggest that *C. orinocensis* populations are experiencing higher levels of exploitation than *C. fimbriata* populations. However, as it occurs in a smaller range, even lower levels of exploitation can be quite alarming for *C.*

orinocensis. On the other hand, despite having a distribution over a wider area, *C. fimbriata* inhabits many of the regions that suffer from the synergy of other anthropogenic impacts, such as deforestation, hydroelectric power plants, and urban expansion.

The different appearance of the matamata with other chelonians facilitates their correct identification at the genus level (*Chelus*) by inspection officers, through rapid training or the use of an appropriate guide (as Ferrara et al. 2017). However, with the recent description of *C. orinocensis*, identification at the species level by non-specialists becomes more difficult, due to the morphological similarity between them, mainly in hatchlings, which are potentially the most commercialized. Therefore, it is important to note that although geographic location was used in this report as a possible surrogate for identification between *C. fimbriata* and *C. orinocensis*, this resource is quite limited in terms of reliability when it comes to trafficking studies. Contrary to ecological studies, it is assumed that, in case of trafficking, especially when it involves considerable monetary sums, specimens are taken to different regions outside their range, and even to ranges of similar species. Therefore, it is not reliable to assume that all matamata seized or recorded commercially within the range of *C. fimbriata*, for example, is this species, as *C. orinocensis* may have previously been transported from its range.

One way to detect if the laundering of animals from Colombia and Brazil to be sold in Peru is occurring, with a mix of legal and illegal chains, would be to investigate/identify if *C. orinocensis* is being bred in captivity for export by certified exporters, and if they are legally exporting them from Peru. As there is no expected occurrence of *C. orinocensis* in Peru, this would be an indication of irregularity that would merit further investigation.

Therefore, rapid, and relatively low-cost genetic tests, such as real-time PCR (rtPCR), are effective alternatives to reliably differentiate the two species, and could be used by law enforcement agencies. the law, researchers and members of the conservation and institutions that act in the registry of trafficked matamatas (Cardeñosa et al. 2021). Correct identification is crucial to support the return of seized specimens to the wild and, above all, to assess the level of pressure and exploitation that each species is under, to provide a more accurate assessment of the conservation status, as well as to develop conservation and management strategies in accordance with the levels of threat that each one of them suffers.

The constant growth of the legal sale of matamatas in Peru points to three important alerts, where consideration is recommended: 1) the demand for matamatas in the world may be increasing, which may threaten the natural populations under in situ management in the communities in case extraction is unsustainable. To guarantee that in situ extraction does not affect the natural populations of the species even though it is legal, there must be rigorous studies that evaluate the sustainability of the extraction, by monitoring the size of the population, or through a combination of sustainability indicators, such as the change in recruitment rate (number of hatchlings produced and number of nests laid) or catch per unit effort (known as CPUE) over the years. 2) If there is a laundering of matamata that involves in situ management communities or ex situ breeding farms, legal sale has great potential to threaten populations in natural environments since illegally sourced matamata would supply the growing market lawfully. 3) Greater densification of specimens in shipping packages and in breeding farms can compromise animal welfare (Baker et al., 2013).

Poor shipping conditions can also contribute to the spread of diseases of medical interest (such as salmonellosis from turtles, Sodagari et al., 2020), caused by viruses and bacteria that can be carried by the matamata and could result in the dissemination of zoonotic diseases, even resulting in pandemics, such as Covid-19 and others (Bezerra-Santos et al., 2021).

Comparison of legal and illegal wildlife markets is crucial to guide decision-making and strategies to reduce illegal trade (Fukushima et al. 2021). To make a reliable comparison of the markets in the case of matamata, the next steps should be to ensure that the seizure effort has been sufficient to reflect the illegal market where it exists and to investigate the existence and extent of animal laundering in the matamata legal trade in Peru.

Although the regulation for the sale of wildlife in Peru resulted from a policy of social market economy

and the promotion of private investment enshrined in the Peruvian Constitution of 1993, this cannot be detrimental to the survival of the wild species. On the one hand, this report seems to show that the efforts of the Peruvian government to regulate breeding companies and the extraction of matamatas may be effective since most of this market seems to be made up of legally traded animals. Illegal sources represent less than 5% of the unitary market share of matamatas (i.e., the proportion of matamata from illegal sources within all matamata traded in Peru), and their share has decreased over the years. However, for the result obtained in the market comparison to be truly reliable, it is very important to ensure that the inspection efforts are truly effective in detecting illegal traffic in matamatas when it exists.

As there is still no reliable estimate of the inspection effort over the years, this comparison should be viewed with caution. The reduction in the share of the illegal sale in Peru may be due to both the increase in preference for legal sources over time and the increase in law enforcement that may have occurred. It is most likely a combination of both, as if there were to be an increase in law enforcement, the fear of being prosecuted for having an illegally sourced matamata should increase and this would ultimately lead to people (owners of animal breeding facilities and collectors, for example) or countries to prefer to buy from legal sources more frequently. Greater inspection efforts are recommended, especially in the department of Loreto, and complementary sampling of illegal markets, such as in the Belen and Modelo markets in Iquitos, which can help identify the real potential of the illegal market in the region and have more complete conclusions.

Furthermore, it is important to fight corruption, for example when an animal laundering route is identified by the police, but there is no seizure due to bribery, not only in Peru but also in Brazil and Colombia. Corruption allows the illegal chain to become stronger in the three countries. In terms of the level of transparency, Peru ranks 105th out of 180 countries worldwide (transparency index of 36), Brazil ranks 96th (transparency index 38) and Colombia ranks 87th (transparency index 39) according to Transparency International (2021). This index ranges from 0 to 100, where values close to zero indicate a higher perceived level of corruption. The three countries analyzed are well below 50.

On the other hand, it is common to use false licenses and permits to sell specimens captured in the wild or illegally raised, as if they were of legal origin. Although not evaluated here, the animal laundering process is not limited to illegal vendors; It can also be used by certified breeders and with State participation. For example, one in five certified farmers in Vietnam admitted to continually buying wild-caught porcupines to maintain the stock (Brooks et al., 2010). Lyons and Natusch (2011) also tracked 60 wild-caught green python specimens in Indonesia, which were later advertised in stores and on breeding farms as captive-bred specimens.

Any legal wildlife market can only be an effective conservation tool when illegal capture of wild specimens is prevented and controlled and there is no laundering of animals. Unfortunately, the same may be happening with the market for matamata, as it is believed that they may be illegally bred or captured from the wild in Colombia, Ecuador, and Bolivia (and now from Brazil), and shipped to Peru to be sold in the legal market, taking advantage of the existence of legal animal husbandry and export activities in this country (Esguerra et al., 2020). Distinguishing specimens genuinely born from legal on-site breeding or management from those born illegally or removed from the wild, outside of regulated management programs, remains one of the greatest global challenges in curbing illegal trade (Stärk et al., 2018) demonstrating that this is an essential action that control authorities must take.

With the existence of licit trade, interventions on the demand side are a bit more complex and lack a construction of bilateral agreements between exporting countries and importing countries. If the laundering of matamatas occurs in the country of origin, the importing country may have no way of detecting it. However, if importing countries (especially if they are developed countries) are interested in maintaining sustainable legal trade, they can support (intelligently or financially) actions in range countries to detect and prevent matamata laundering. On the other hand, if the entire transaction occurs illegally (i.e., companies/ specimens in other countries are knowingly buying illegal matamata from Peru, Colombia, Brazil, or another South American country), these importing

countries can help to stop trafficking, making the entrance of matamata without permission an illegal activity, penalizing those involved and cooperating with investigations of routes and modus operandi. However, more effort is still required to identify the main countries where the matamatas are entering illegally.

As a final recommendation, it is concluded that it is important to allocate funds for the evaluation of the conservation status of the two species, *C. fimbriata* and *C. orinocensis*, to determine the possible impacts of legal and illegal trade more clearly on natural populations. It is essential to detect, evaluate and prevent the laundering of matamata, especially identifying if other countries are supplying matamata to Peru and if *C. orinocensis* appear in legal or illegal sale in Peru, since it is not expected to occur in this country. For this, it is necessary to invest in popularizing the use of genetic tools for proper identification, both in research and inspection. It is also essential to guarantee the sustainability of *in situ management in* operation, so that legal sale does not become the main threat factor for the species in its natural environment. Therefore, it is essential to know several aspects of the natural history of the species that are still unknown, especially those related to reproduction, such as the determination of sexual maturity, the seasonality of egg-laying and the rate of recruitment of infants in different basins and for the two species.

Finally, in the control agencies, it is important to invest in those agencies responsible for controls, to make inspections more efficient and improve counter wildlife trafficking in the region; promote the training of agents in charge of seizures (including border forces) to correctly identify species; fight corruption and monitor the sale prices of matamatas legally exported from Peru to other countries, to better understand the dynamics of the market.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