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A Review of the Trade in Toucans (Ramphastidae): Levels of Trade in Species, Source and Sink Countries, Effects from Governance Actions and Conservation Concerns

Angus I. Carpenter [1,*] and Jennifer Slade [2]

[1] Institute of Science & Environment, University of Cumbria, Ambleside LA22 9BB, UK
[2] School of Animal, Rural & Environmental Sciences, Brackenhurst campus, Nottingham Trent University, Southwell NG25 0QF, UK
* Correspondence: carpenter.angus@gmail.com

Abstract: Utilising wildlife as natural resources has a long history and wide appeal for many nations, while seeking international wildlife that is sustainably managed is the primary responsibility of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). However, data-driven trade reviews are required, utilising CITES data to increase our understanding of the trade and facilitate evidence-based conservation planning. This study presents the first trade review for Toucans utilising CITES import reported data. The total number of Toucans exported was over 22,000, which subsequently generated a retail 'real price' value of nearly US $72 million. The countries accounting for the majority of Toucan exports were Guyana (39%), Suriname (33%) and Nicaragua (14%), while the main importing country was The Netherlands (nearly 25%). Toucan species traded were Ramphastos vitellinus (accounting for 21.5%), Ramphastos toco (19%) and Ramphastos tucanus (17%), making the top three while trade was recorded in 10 species. However, successfully identifying economic values for 15 species highlights that trade exists within non-CITES listed Toucan species too. Therefore, the levels of trade in non-CITES-listed Toucan species need urgent attention, as do the non-detrimental findings that underpin the CITES quotas set for each species, given the species' importance ecologically.

Keywords: Toucan; wildlife trade; CITES; conservation; wildlife trade structures; wildlife trade economics

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1. Introduction

Human use of wildlife has existed for millennia [1,2], the impacts of which have been cited as contributing to biodiversity loss [3–5]. There has been a long-standing ambition of International Governmental Organisations (IGOs), NGOs and governments to seek the alignment of conservation actions with poverty alleviation to engender mutual benefits from wildlife resources [6–9]. Trade in wildlife resources has been reported to provide direct use value to local communities [10–13] and as having conservation benefits when traded within a sustainable management framework [9,14,15] following the 'lose it or use it' agenda [16,17]. However, relatively few case studies reported within the literature highlight the difficulties in achieving such aims. This was often due to either social or biological factors or a combination of both [18–20].

Trade in wildlife species to supply global pet market demands has been reported across many taxa groups [21], such as snakes [22], shrimps [23], primates [24], crayfish [25], chameleons [26,27] and amphibians [28,29]. Global conventions exist to monitor the sustainability of the international wildlife trade, principally the Convention on the International Trade of Endangered Species of Wild Fauna and Flora (CITES), with member states reporting on international trade in species listed on any of the Convention's three Appendices, including exports, imports, and re-exports [30–32]. Following CITES interventions, trade-related impacts on the traded resource, which can include individuals and/or their derivatives, have been shown to have variable effects, both predicted and unpredicted [27,33–35]

and countries have been reportedly expanding commercial activities in their wildlife. For example, Argentina's annual trade in wildlife was reported to be worth millions of US dollars and one of the principal industries on the continent, significantly depleting the wildlife populations of South America [10]. Furthermore, it has been stated that within Latin American countries, weak enforcement of environmental laws was one of the major reasons for facilitating the over-exploitation of wildlife [36–38].

Avian taxa have been extensively utilised within the pet trade, with varying factors driving the demand, such as rarity value, singing abilities, aesthetic desirability, etc. [21,32,39–45]. It has been estimated that approximately 45% of bird species were overexploited by the wildlife trade [46]; however, the total number of individual birds involved in the trade and the values they generate vary greatly between species. For example, [47] estimated that four million birds were legally traded annually. Brazil alone has been stated to supply up to 50,000 wild songbirds worth US $630,000.00 year-1 [40], while in Indonesia, at least 300 bird species were traded in wildlife markets and contributed US $80 million to the national economy annually [48]. Parrot and parakeet species were commonly cited as those in greatest demand [21,42], with Peru, Bolivia and Argentina recorded as major source countries [49] and a greater demand reported for larger sized or rarer species [45,50]. For example, estimated retail values of between US $5000–$12,000 per hyacinth macaw and $60,000–$90,000 per lear macaw were reported in 2003 [51], which equate to US $7257–17,417 per hyacinth and $87,083–130,624.24 per lear macaw in 2021.

However, no study has previously investigated, longitudinally, the levels of trade in Ramphastidae, a family of medium to large birds consisting of toucans, toucanets, mountain toucans and aracaris [52]. Six genera exist in the Ramphastidae family (from here on referred to as Toucans), all relatively long-lived, slow breeding, frugivorous birds synonymous with tropical forests and considered keystone species and amongst the most endangered species of Neotropical Aves [53–58] (Figure 1). The levels of conservation status vary across species, as does their IUCN RED list status and whether CITES is listed or not (Table 1), while alternative governance mechanisms also exist (see Table 2). Despite Toucans being highly charismatic and trade reported within these species from the 1960s, there have been only a few accounts of trade. However, commonly, data presented were for very short periods, and the best historical dataset is a total of 2441 Toucans exported between 1968 to 1991 across a minimum of 24 species [59]. More recently, it has been reported that *Ramphastos tucanus* and *R. vitellinus* were of conservation concern in Ecuador due to the trade [60], and stated how international trade had contributed to *Andigena laminirostris*, *R. ambiguous* and *R. culminatus* population declines [61]. Alternatively, *R. sulfuratus* was sold for up to US $2000 in domestic markets within El Salvador [62]. Despite the scarcity of literature on the Toucan trade, it had still been reported that *R. sulfuratus* and *R. swainsoni* were cited as species at risk from trade under the Central America Free Trade Area-Dominican Republic (CAFTA-DR) [63]. Legislation has been reported to affect wildlife trade dynamics in various ways [27], and many of the Toucan range states have existing legislation protecting them [59].

Therefore, this study aimed to comprehensively review the extent and dynamics of commercial trade through the analysis of secondary datasets. The aim was directed to identifying the spatial and temporal trends, focusing on: (1) the major countries contributing to the supply and demand of Toucans, and primary sourcing methods, (2) notable trade routes, (3) significantly featured species, and (4) estimating the economic value of the Toucan. The entire CITES database record was analysed and presented to commence addressing this research gap.

The aim of this study was to robustly investigate the size of the trade in Toucans, highlighting those species in high demand, identifying the main export and import countries, the structure of the trade network and the economic value of the trade. Presently, these data and information are lacking in the literature and thus are not considered in current conservation management plans. Therefore, this study will fill current knowledge gaps to allow better future conservation plans and actions.

Table 1. The current IUCN Red List conservation status and CITES Appendix listing, including review dates, for all Ramphastidae species. Top 10 species are CITES-listed, while the remaining species are all unlisted on CITES (Source: IUCN Red list, 2020; UNEP-WCMC CITES database, 2020; CITES, 1992-Microsoft Word-E-Amendments.doc (cites.org)).

Species Taxonomic Name	Common Name	CITES App. Listing	Year Listed	CITES Notes	IUCN Redlist Status	IUCN Redlist Population Trend	Date of Last IUCN Redlist Review	IUCN Notes
Baillonius bailloni (synonym Pteroglossus bailloni)	Saffron toucanet	III	1992	No previous entry	NT	Decreasing	2016	First addition 2004-status remains unchanged
Pteroglossus aracari	Black-necked aracari	II	1992	No previous entry	LC	Decreasing	2016	First addition 2004-previously unknown
Pteroglossus castanotis	Chestnut-eared aracari	III	1992	No previous entry	LC	Decreasing	2016	First addition 2004-status remains unchanged
Pteroglossus viridis	Green aracari	II	1992	No previous entry	LC	Stable	2016	First addition 2004-status remains unchanged
Ramphastos dicolorus	Red-breasted toucan (aka green-billed toucan)	III	1992	No previous entry	LC	Decreasing	2018	First addition 2004-status remains unchanged
Ramphastos sulfuratus	Keel-billed toucan	II	1992	App III from 23/4/81	LC	Decreasing	2016	First addition 2004-status remains unchanged
Ramphastos toco	Toco toucan	II	1992	No previous entry	LC	Decreasing	2016	First addition 2004-status remains unchanged
Ramphastos tucanus	Red-billed toucan	II	1992	No previous entry	VU	Decreasing	2016	Classified as LC in 2004, then Not Recognised in 2008 and VU 2014
Ramphastos vitellinus	Channel-billed toucan	II	1992	No previous entry	VU	Decreasing	2016	First addition in 2014 as VU

Table 1. *Cont.*

Species Taxonomic Name	Common Name	CITES App. Listing	Year Listed	CITES Notes	IUCN Redlist Status	IUCN Redlist Population Trend	Date of Last IUCN Redlist Review	IUCN Notes
Selenidera maculirostris	Spot-billed toucanet	III	1992	No previous entry	LC	Decreasing	2016	First addition 2004-status remains unchanged
Andigena cucullata	Hooded mountain-toucan	N/A	N/A	No history of addition	LC	Stable	2016	First addition 2014-previously unknown
Andigena hypoglauca	Grey-breasted mountain-toucan	N/A	N/A	No history of addition	NT	Decreasing	2016	First addition 2004-status remains unchanged
Andigena laminirostris	Plate-billed mountain-toucan	N/A	N/A	No history of addition	NT	Decreasing	2016	First addition 2004-status remains unchanged
Andigena nigrirostris	Black-billed mountain-toucan	N/A	N/A	No history of addition	LC	Decreasing	2018	NT in 1988, then reclassified LC in 2004
Aulacorhynchus albivitta	Greyish-throated toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged
Aulacorhynchus atrogularis	Black-throated toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus caeruleogularis	Blue-throated toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus calorhynchus	Yellow-billed toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus coeruleicinctis	Blue-banded toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged
Aulacorhynchus cyanolaemus	Black-billed toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown

Table 1. *Cont.*

Species Taxonomic Name	Common Name	CITES App. Listing	Year Listed	CITES Notes	IUCN Redlist Status	IUCN Redlist Population Trend	Date of Last IUCN Redlist Review	IUCN Notes
Aulacorhynchus derbianus	Chestnut-tipped toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus haematopygus	Crimson-rumped toucanet	N/A	N/A	No history of addition	LC	Stable	2016	First addition 2004-status remains unchanged
Aulacorhynchus huallagae	Yellow-browned toucanet	N/A	N/A	No history of addition	EN	Decreasing	2016	Classified NT in 2008, unknown in 1994 and EN in 2000
Aulacorhynchus prasinus	Emerald toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus sulcatus	Grove-billed toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus wagleri	Wagler's toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Aulacorhynchus whitelianus	Tepui toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Pteroglossus azara	Ivory-billed aracari	N/A	N/A	No history of addition	LC	Stable	2016	First addition 2008-previously not recognised
Pteroglossus beauharnaisii	Curl-crested aracari	N/A	N/A	No history of addition	LC	Stable	2016	First addition 2004-status remains unchanged
Pteroglossus bitorquatus	Eastern red-necked aracari	N/A	N/A	No history of addition	EN	Decreasing	2016	First addition 2014-previously unknown

Table 1. *Cont.*

Species Taxonomic Name	Common Name	CITES App. Listing	Year Listed	CITES Notes	IUCN Redlist Status	IUCN Redlist Population Trend	Date of Last IUCN Redlist Review	IUCN Notes
Pteroglossus erythropygius	Pale-billed aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	Classified as LC 2004, not recognised in 2008 and again LC in 2014
Pteroglossus frantzii	Fiery-billed aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged
Pteroglossus humboldti	Humbolt's aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Pteroglossus inscriptus	Lettered aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Pteroglossus pluricinctus	Many-banded aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged
Pteroglossus sanguineus	Stripe-billed aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Pteroglossus sturmii	Western red-necked aracari	N/A	N/A	No history of addition	NT	Decreasing	2016	First addition 2014-previously unknown
Pteroglossus torquatus	Collared aracari	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Ramphastos ambiguus	Yellow-throated toucan	N/A	N/A	No history of addition	NT	Decreasing	2016	First addition 2014-previously unknown
Ramphastos ariel	Ariel toucan	N/A	N/A	No history of addition	EN	Decreasing	2016	First addition 2014-previously unknown

Table 1. *Cont.*

Species Taxonomic Name	Common Name	CITES App. Listing	Year Listed	CITES Notes	IUCN Redlist Status	IUCN Redlist Population Trend	Date of Last IUCN Redlist Review	IUCN Notes
Ramphastos brevis	Choco toucan	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged
Ramphastos citreolaemus	Citron-throated toucan	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2014-previously unknown
Ramphastos culminatus	Yellow-ridged toucan	N/A	N/A	No history of addition	VU	Decreasing	2016	First addition 2014-previously unknown
Ramphastos cuvieri	Curvier's toucan	N/A	N/A	No history of addition	LC	Decreasing	2016	Classified as LC 2004, not recognised in 2008 and again LC in 2014
Selenidera gouldii	Gould's toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged
Selenidera langsdorffii	Green-billed toucanet	N/A	N/A	No history of addition	LC	Unknown	2016	First addition 2014-previously unknown
Selenidera nattereri	Tawny-tufted toucanet	N/A	N/A	No history of addition	LC	Unknown	2016	First addition 2004-status remains unchanged
Selenidera piperivora	Guianan toucanet	N/A	N/A	No history of addition	LC	Stable	2016	First addition 2004-status remains unchanged
Selenidera reinwardtii	Golden-collared toucanet (synonym Red-billed)	N/A	N/A	No history of addition	LC	Unknown	2016	First addition 2014-previously unknown
Selenidera spectabilis	Yellow-eared toucanet	N/A	N/A	No history of addition	LC	Decreasing	2016	First addition 2004-status remains unchanged

Table 2. Relevant legislation and treaties that potentially impact the trade in Toucans.

Legislation	Year Enforced	Description	Applicable Region	References
Lacey Act	1900	The 1981 and 1988 amendments to this conservation law, predominantly enforced by USFWS, prohibits the harvesting, possession and trade of illegally sourced animals and products, whilst additionally enabling the ability to prosecute importers.	US	[64,65]
Hunting Law	1954	Hunting activities were restricted for specific species, including birds, with stipulations as to the requirement of licences and methods to be used, however is reported as outdated to the latest understanding of sustainable hunting.	Suriname	[66,67]
Wild Bird Conservation Act	1992	Enforced to reduce high importation volumes of non-indigenous birds into the US, allowing only species with predetermined, sustainable management plans. Approved captive-bred list of CITES Appendix species are detailed, of which Ramphastids are not included.	US	[68–70]
Wild Birds Protection Act (WBPA)	1997	This amendment (71:07) to the 1919 Guyanan Act promoted the conservation of schedule 1 and 2 listed wild birds, requiring licence authorisation for exportation. Ramphastids are schedule 1 species, protected within open and closed seasons.	Guyana	[71,71]
Species Protection Regulations (SPR)	1999	Enacted to implement more efficient enforcement of CITES regulations, following accusations of wildlife poaching and laundering. A management authority for wildlife protection was established, however regulation was repealed following enforcement of the Wildlife Management and Conservation Regulations.	Guyana	[61,73]
Wild Bird Trade Ban	2005	The discovery of avian influenza within imported specimens within Britain encouraged this temporary trade ban, which permanentized in 2007, allowing only the importation of captive-bred birds from approved countries.	EU	[70,74]
Wildlife Management and Conservation Regulations	2013	Replacing the SPR, additionally improvements were developed to attempt to meet CITES requirements through the continuing quota system use and addressing illegal activities.	Guyana	[73]

Figure 1. Ramphastidae distribution across Central and Latin American countries (Adapted from IUCN, 2020).

2. Materials and Methods

The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) was established to permit monitoring of trade in these resources to ensure its sustainability (www.CITES.org (accessed on 14 May 2020)). Party states submit yearly trade reports to a species trade database maintained by United Nations Environment Program-World Conservation Monitoring Centre (UNEP-WCMC) (https://trade.cites.org/ (accessed on 14 May 2020)), on behalf of the CITES Secretariat, which is open access and dynamic [31].

Data on the 'commercial trade' (CITES purpose code 'T') between 1975 to 2019 were collated and downloaded from the CITES database on 14 May 2020. The search criteria used in the collation of these data have been displayed in Table 3 and covered all species listed within the Ramphastidae family. Due to the greater level of fluctuation in trade data contained within the 'export reported' trade column, only 'import reported' trade values were used in the following analyses [26,29,31,75].

Economic data (retail trade prices) were collated using online search engines for each species and were collected on 4 July and 19 September 2020. Price data were recorded in US dollars (US $), where prices were extracted from websites using other monetary units. The prices were converted to US dollars ($). For prices preceding 2020, an appropriate inflation calculation was performed on the data to obtain the 'real price', representing the current market value adjusting for monetary inflation and then values were converted to US $ (util-

ising https://www.usinflationcalculator.com/ (accessed on 19 September 2020)). Where several prices existed for a species, an average, current retail price was then calculated.

Table 3. Criteria selected prior to performing the data collation for Toucan trade within the CITES trade database (Source: UNEP-WCMC, 2020).

Database Field	Search Input
Year range	1975–2019
Exporting countries	All countries
Importing countries	All countries
Source	All sources
Purpose	Commercial trade
Trade terms	Live, specimens, bodies
Taxon	Ramphastidae

3. Results

A total of 22,218 individual toucans were exported between 1985, the first reported trading events, to 2018, the latest reported trading events, using the importer-reported CITES dataset. The majority of these individuals were reported as sourced from the wild (n = 18,080, 81.4%), followed by ranched (n = 2234, 10.1%), then captive bred (n = 1349, 6.1%) with the remaining categories accumulatively accounting for 147 (0.6%) individuals. The 22,218 individuals traded were recorded across 10 species (Table 4), with *Ramphastos vitellinus* accounting for the most individuals (n = 4783, 21.5%), followed by *Ramphastos toco* (n = 4276, 19.3%) and *Ramphastos tucanus* (n = 3809, 17.1%) making up the top three most traded Toucan species.

The four major export countries were all native range state countries of Toucans and together accounted for nearly 89% of the total exports (Table 5); these being Guyana (n = 8703 individuals; 39.2%) followed by Suriname (n = 7422; 33.4%), Nicaragua (n = 3100; 14.0%) and Paraguay (n = 521; 2.34%). A total of 47 countries reported exporting or re-exporting Toucans, with those contributing >1% to the trade presented in Table 5. Conversely, a total of 61 countries were reported importing Toucans, with 21 of those countries contributing >1% to the total number imported (Table 6). Of those importing countries presented in Table 6, European countries accounted for over 51% of the imported Toucan trade, with the Netherlands alone accounting for nearly 25% of imports.

Table 4. The Toucan species reported in the CITES trade data set between 1985 to 2018 and the number of individuals traded in each species with the percentage value.

Species	Total Number of Individuals	Percentage of Individuals	Total Number of Years Traded	Yearly Average Number Traded	Number of Trading Events	Average Number per Trading Event
Ramphastos vitellinus	4783	21.5	27	177.1	345	13.9
Ramphastos toco	4276	19.2	27	158.4	325	13.2
Ramphastos tucanus	3809	17.1	27	141.1	319	11.9
Pteroglossus aracari	3791	17.1	27	140.4	189	20.1
Ramphastos sulfuratus	3442	15.5	23	149.7	152	22.6
Pteroglossus viridis	1964	8.8	27	72.7	158	12.4
Ramphastos dicolorus	67	0.3	8	8.4	14	4.8
Pteroglossus castanotis	62	0.3	6	10.3	8	7.8
Baillonius bailloni	15	0.1	4	3.8	4	3.8
Selenidera maculirostris	9	0.0	4	2.3	4	2.3

Table 5. The 7 exporting countries contributing >1% towards the total number of individual Toucans exported as recorded in the import reported CITES trade dataset between 1985 to 2018 (Source: UNEP-WCMC CITES, 2020).

Export Countries (CITES Country Code)	No. of Individuals Exported	% of Total Exported Individuals	Cumulative %	Region
Guyana (GY)	8703	39.17	39.17	Central and South America and the Caribbean
Suriname (SR)	7422	33.41	72.58	Central and South America and the Caribbean
Nicaragua (NI)	3100	13.95	86.53	Central and South America and the Caribbean
Paraguay (PY)	521	2.34	88.87	Central and South America and the Caribbean
Netherlands (NL)	508	2.29	91.16	Europe
Argentina (AR)	420	1.89	93.05	Central and South America and the Caribbean
South Africa (ZA)	258	1.16	94.21	Africa

Table 6. The 21 importing countries contributing >1% towards the total number of individual Toucans exported as recorded in the import reported CITES trade dataset between 1985 to 2018 (Source: UNEP-WCMC CITES, 2020).

Importing Countries (CITES Country Code)	No. of Individuals Imported	% of Total Imported Individuals	Cumulative %	Region
Netherlands (NL)	5517	24.831	24.8	Europe
United States (US)	1501	6.756	31.6	North America
Spain (ES)	1438	6.472	38.1	Europe
South Africa (ZA)	1197	5.388	43.4	Africa
Singapore (SG)	1190	5.356	48.8	Asia
Japan (JP)	1177	5.298	54.1	Asia
United Kingdom (GB)	1069	4.811	58.9	Europe
Mexico (MX)	935	4.208	63.1	North America
China (CN)	861	3.875	67.0	Asia
United Arab Emirates (AE)	831	3.740	70.7	Asia
Turkey (TR)	739	3.326	74.1	Europe
Belgium (BE)	706	3.178	77.2	Europe
Portugal (PT)	669	3.011	80.3	Europe
Oman (OM)	603	2.714	83.0	Asia
Germany (DE)	498	2.241	85.2	Europe
Italy (IT)	466	2.097	87.3	Europe
Thailand (TH)	460	2.070	89.4	Asia
Malaysia (MY)	424	1.908	91.3	Asia
Denmark (DK)	314	1.413	92.7	Europe
Hong Kong (HK; dependent territory of China)	307	1.382	94.1	Asia
Dominican Republic (DO)	256	1.152	95.2	Central and South America and the Caribbean

The trade dynamics of both the most commonly exported species (Figure 2) and major export countries (Figure 3) can be observed in the temporal trends of the trade. Also displayed in Figures 2 and 3 are relevant legislation/governance and when they were introduced. The period of trade can be divided into three using major legislative changes, these being; (1) pre Toucans being listed on CITES (pre CITES); (2) post CITES pre EU WBTB and (3) post EU WBTB (Table 7). The 'pre CITES' section refers to a time period before any Toucans had been listed in CITES' Appendices. The second period, 'post CITES

pre EU WBTB', refers to a period after Paraguay's CITES Management Authority (MA) had submitted a proposal to list 23 Toucan species (11 Pteroglossus spp and 12 Ramphastos spp) to CITES Appendices at the eighth meeting of the Conference of the Parties (CoP8) held in Kyoto, Japan in March 1992. A total of 10 Toucan species were successfully adopted to CITES Appendix II or III (Table 1). At the beginning of this period, there was a rapid, positive linear increase in the number of Toucans reported as exported between 1992 and 1997, which was best described by the linear regression equation log y = 264.34x + 526,302 when 1992 was taken as the year 0 (adjusted $R^2 = 0.95$, $n = 6$, $p < 0.007$). The third period is posting the introduction of the 'European Communities (Avian Influenza) (Precautionary Measures) Regulations Order, 2005 (S.I. No. 678 of 2005)', which witnessed the cessation of importing wild birds into member states. Across the three periods, the second period accounted for over 65% (14,523 individual Toucans), compared with 0.5% (period 1) and 34% (period 3), of the total number of Toucans being exported, equating to an average of over 1117 individuals exported per year within period 2 compared to just 25 in period 1 and 542 in period 3 (Table 7).

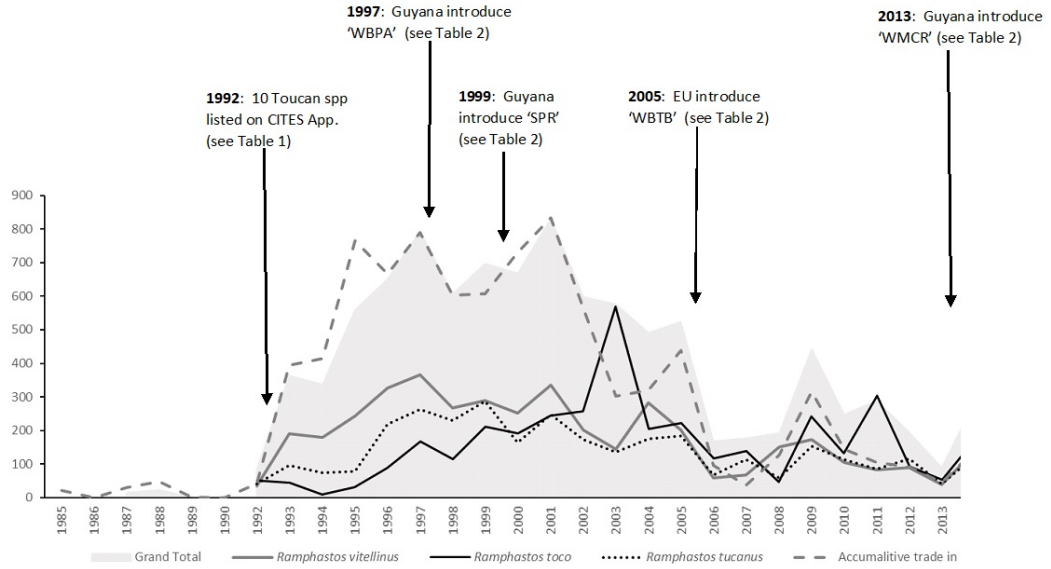

Figure 2. Yearly export values showing the temporal trends of the main three species and accumulative for the remaining species involved in the trade in Toucans between 1975 to 2019 as reported by the importer reported dataset within the CITES trade database. The shaded area (on the secondary 'y' axis) represents the total yearly values over the period (Source: UNEP-WCMC CITES database, 2020).

Table 7. Three legislative periods of the export of Toucans between 1985 to 2018 (Data source: UNEP-WCMC CITES, 2020).

Period	No. Years in Period	Number Exported	% of Individuals	Number of Years Traded	Yearly Average Number Traded	Total Number of Trading Events	Average Number per Trading Event
Pre CITES listing (1985–1991)	6	102	0.5	4	25.5	6	17.0
Post CITES listing/Pre EU 'WBTB' (1992–2004)	13	14523	65.4	13	1117.2	894	16.2
Post CITES listing & EU 'WBTB' (2005–2018)	14	7593	34.2	14	542.4	618	12.3

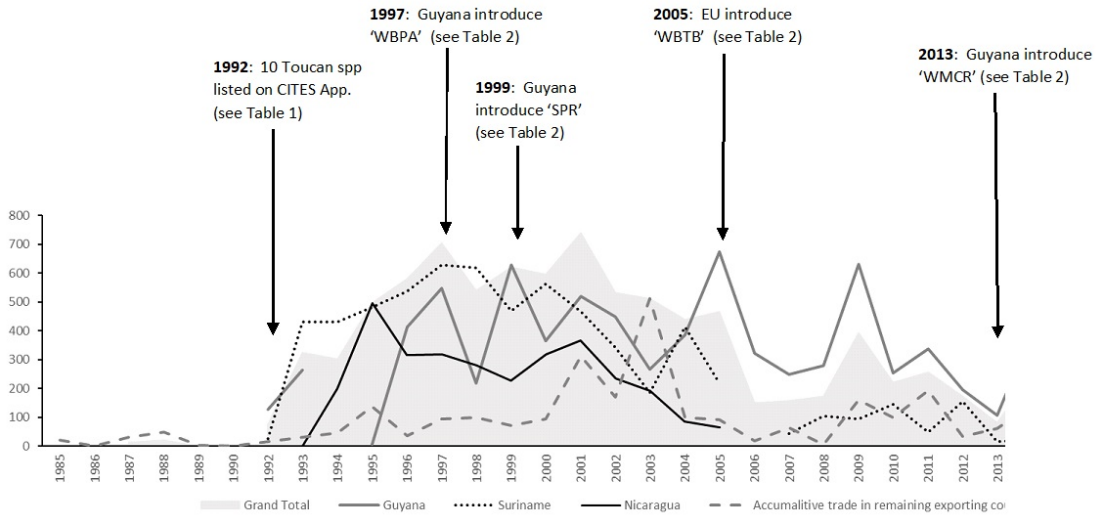

Figure 3. Yearly export values showing the temporal trends for the export countries involved in the trade in Toucans between 1975 to 2019 as reported by the importer reported dataset within the CITES trade database. The shaded area (on the secondary 'y' axis) represents the total yearly values over the period (Source: UNEP-WCMC CITES database, 2020).

A total of 24 online sites were found selling Toucans dated 2019 and 2020, advertising 15 species of Toucan. Retail prices ranged from the lowest for *Pteroglossus viridis* at US $440.62 up to US $13,400 for *R. toco*, with an average price of US $4495.75 (Table 8). Using the average 2020 Toucan retail price, a yearly real price value was calculated (in US $), adjusting for inflation, which was then used to calculate the total yearly trade value for each trading year (calculated yearly real price × number traded in that year). The retail value of the trade varied across the three regulatory/legislative time periods, with the trade being valued at over US $200,000, period 2 at over US $42 million, and period 3 at nearly US $29.5 million. The total real price valorisation of the Toucan trade was nearly US $72 million at the retail scale.

Table 8. The average retail prices for different Toucan species and the total species valorisation at the 2020 retail price level.

Species	Average Retail 'Real Price' in 2020 (US $)	Number Exported	Total 2020 Retail Value (US $)
R. toco (CITES II; Redlist LC)	12,450.00	4276	53,236,200.00
R. vitellinus (CITES II; Redlist VU)	10,000.00	4783	47,830,000.00
R. tucanus (CITES II; Redlist VU)	7816.67	3809	29,773,696.03
R. sulphuratus (CITES II; Redlist LC)	3083.33	3442	10,612,821.86
P. aracari (CITES II; Redlist LC)	1620.69	3791	6,144,035.79
P. viridis (CITES II; Redlist LC)	440.62	1964	865,377.68
R. dicolorus (CITES III; Redlist LC)	10,000.00	67	670,000.00
P. castanotis (CITES III; Redlist LC)	4000.00	62	248,000.00
B. bailloni (CITES III; Redlist NT)	4500.00	15	67,500.00
A. haematopygus (CITES n/l; Redlist LC)	2500.00		0.00
A. Prasinus (CITES n/l; Redlist LC)	1200.00		0.00
P. torquatus (CITES n/l; Redlist LC)	2175.00		0.00
P. azara (CITES n/l; Redlist LC)	2150.00		0.00
P. beouharnaesii (CITES n/l; Redlist LC)	4000.00		0.00
Average 2020 price (US $)	4495.75		

The structural network (trade routes) of the trade at the international scale followed a similar pattern between four of the top six most heavily traded species (*R. vitellinus*, *R. tucanus*, *P. aracari*, *P. viridis*; Figures 4–7; Table 4). For these four species, exports originated

mainly from Guyana and Surinam, with destinations spread around the globe and fewer re-export country destinations observed. The international structural networks for *Ramphastos toco* (Figure 8) displayed a much wider geographic spread with exports sourced from south, central, and northern Latin American countries. Alternatively, *R. sulfuratus* (Figure 9) was majorly sourced from Nicaragua with globally spread destination countries. The Netherlands was a major and consistent destination country for these exports across all species as well as being a major re-exporting country itself. However, despite the high economic gains, the CITES quotas were not exceeded in the years reviewed (Table 9), suggesting the countries traded within CITES defined sustainable levels providing robust 'non-detrimental findings' (NDFs) were conducted.

Table 9. CITES export quotas (unshaded) and import reported numbers (shaded) for Ramphastidae for the period 2015–2020 (Source: cites.org).

Country	Species	CITES Exp. Term	Year					Year				
			2015	2016	2017	2018	2020	2015	2016	2017	2018	2020
Guyana												
	Pteroglossus aracari	Live.	300	300	300	300	300	87	/	/	/	
	Pteroglossus viridis	Live.	52	52	52	52	52	4	3	/	/	
	Ramphastos toco	Live.	200	200	200	200	200	103	155	77	96	
	Ramphastos tucanus	Live.	170	170	170	170	170	123	101	34	50	
	Ramphastos vitellinus	Live.	120	120	120	120	120	83	69	13	32	
	Yearly Total		842	842	842	842	842	400	328	124	178	
Suriname												
	Pteroglossus aracari	Live.	/	225	225	/	/	80	80	74	56	
	Pteroglossus viridis	Live.	/	225	225	/	/	54	63	8	18	
	Ramphastos tucanus	Live.	/	188	188	/	/	/	/	/	/	
	Ramphastos vitellinus	Live.	/	263	263	/	/	/	263	263	/	
	Yearly Total			901	901			134	406	345	74	
Nicaragua												
	none listed		/	/	/	/	/	/	/	/	/	/

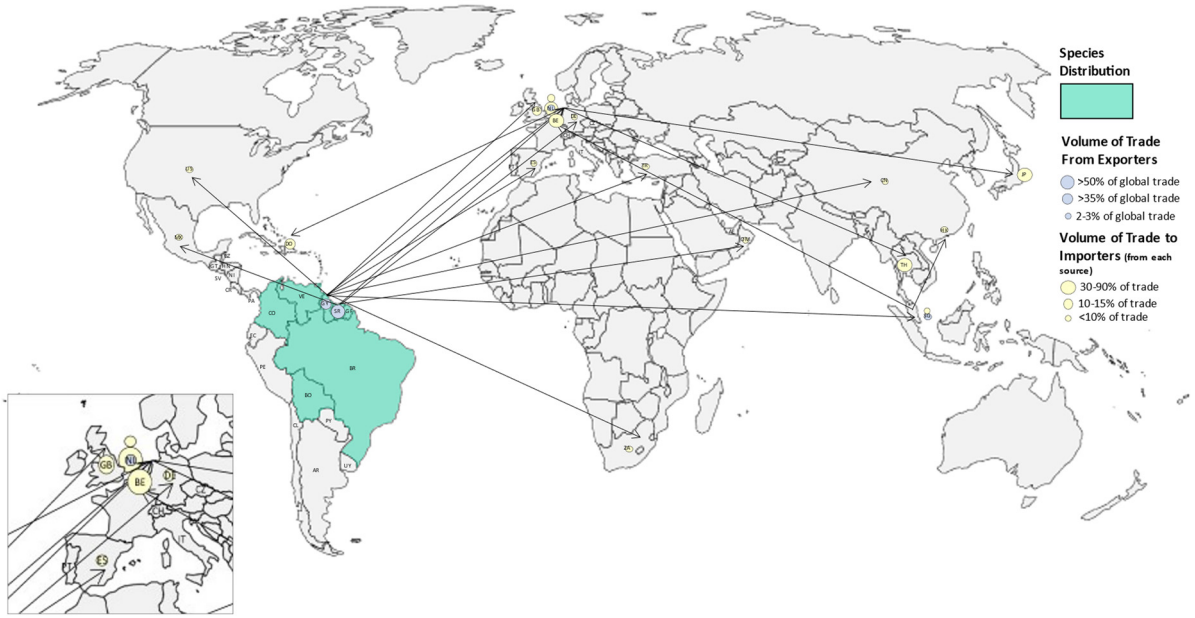

Figure 4. The structural network (trade routes) for *Ramphastos vitellinus* Toucans between 1975 to 2019 showing export and destination countries as reported by the importer-reported dataset within the CITES trade database. The inset map shows an enlarged area of western Europe in greater detail (Source: UNEP-WCMC CITES database, 2020).

Figure 5. The structural network (trade routes) for *Ramphastos tucanus* Toucans between 1975 to 2019 showing export and destination countries as reported by the importer reported dataset within the CITES trade database. The inset map shows an enlarged area of western Europe in greater detail (Source: UNEP-WCMC CITES database, 2020).

Figure 6. The structural network (trade routes) for *Pteroglossus aracari* Toucans between 1975 to 2019 showing export and destination countries as reported by the importer reported dataset within the CITES trade database. The inset map shows an enlarged area of western Europe in greater detail (Source: UNEP-WCMC CITES database, 2020).

Figure 7. The structural network (trade routes) for *Pteroglossus viridis* Toucans between 1975 to 2019 showing export and destination countries as reported by the importer reported dataset within the CITES trade database. The inset map shows an enlarged area of western Europe in greater detail (Source: UNEP-WCMC CITES database, 2020).

Figure 8. The structural network (trade routes) for *Ramphastos toco* Toucans between 1975 to 2019 showing export and destination countries as reported by the importer reported dataset within the CITES trade database. The inset map shows an enlarged area of western Europe in greater detail (Source: UNEP-WCMC CITES database, 2020).

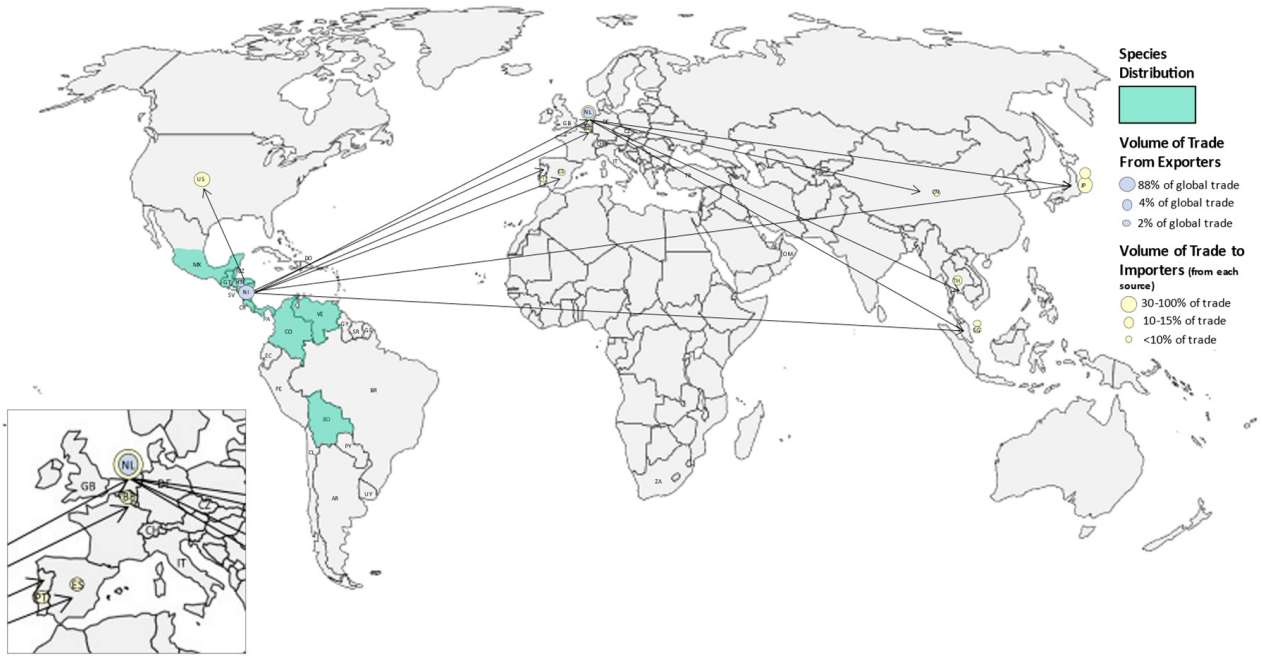

Figure 9. The structural network (trade routes) for *Ramphastos sulphuratus* Toucans between 1975 to 2019 showing export and destination countries as reported by the importer reported dataset within the CITES trade database. The inset map shows an enlarged area of western Europe in greater detail (Source: UNEP-WCMC CITES database, 2020).

4. Discussion

It has been stated that Toucans perform important seed dispersal tasks within forest systems; such ecosystem services were not so well recognised before 1992. Furthermore, given their large size, slow growth rates and low fecundity [53–58], it would be prudent to consider their regional population densities to be relatively low too. In addition to low population sizes, population declines have been reported across several Toucan species. For example, *Ramphostos toco* has become rare in some northern localities of Argentina while an 11-year study in Paraguay reported sharp population declines in *R. toco*, *R. dicolorus* and *P. castanotis* due to both habitat destruction and harvesting individuals for the pet trade [59]. Similarly, IUCN Redlist assessments conducted in 2016 and 2018 (Table 1) reported all but one species (*P. viridis*; stable) of the 10 CITES-listed species as having decreasing populations while, of the remaining 40 species, 32 had decreasing populations, 5 * stable and 3 * unknown with many of these statuses not having changed from previous assessments in 2014. (Table 1). Whilst there were a few species-specific variations, Guyana, Surinam and Nicaragua were the major exporting countries reporting over 86.5% of the exported birds (Table 5). Therefore, even without knowing local trade structures, it would be only logical to consider those countries as having reduced Toucan populations regionally and, potentially, nationally, which means rewilding projects could be hindered or miss certain floral species, especially dominant tree species, within forest communities for those flora species where Toucan species performed as dispersal agents [56–58].

With over 99% of Toucan exports being reported post the CITES listing and an incredibly rapid rate of increase, essentially from zero to over 1117 years per year within 5 years and continuing for the following 13-year period (Table 7; Figures 2 and 3). Support for the trade in Toucan species was well established before the CITES listing, hence Paraguay's rationale for its proposal to CITES CoP8. However, trade data presented by Paraguay were patchy, utilising import data reported by the US mainly, which reported 9821 individuals between 1968 to 1972 and 3427 individuals between 1984 to 1991 in 3 known Toucan species [59]. For the period where reported exports overlap, the pre-CITES period, Paraguay's CITES proposal recorded a total of 1899 individuals exported compared with

just 102 (Table 7) within the CITES dataset. Additionally, Paraguay's CITES proposal named three species being exported that were listed as endangered, EN (*P. bitorquatus*), vulnerable, VU (*R. culminatus*) and near threatened, NT (*R. ambiguus*), with all three species reported as having decreasing populations (Table 1). Therefore, Paraguay's actions in 1992 should be viewed positively for facilitating data capture, which has permitted a more robust review and, therefore, managed the legal trade. Concomitantly, a more robust review promotes a greater understanding of any conservation needs. Ten species of Toucan recorded a minimum of 22,218 individuals exported, which was much greater than previously presented values. This highlights that much greater conservation efforts need to be afforded towards Toucans and that these need to start at the earliest opportunity, which could be listing all the remaining Toucan species on CITES Appendices at CITES Cop19.

Whilst national legislation exists within many Toucan range state countries, concerns have been raised as to how well enforced such national legislations were [36,37,51,59]. For example, of the imports to the US between 1984–91, 48.6% were from Argentina despite explicit protective legislation being in place. It has been commonly reported that local and regional trade network actors will utilise 'traditional' trade routes that, depending upon the locality, will often cross regional and national borders [38,41,59]. However, it has also been reported that due to the inherent secrecy around wildlife trade, it was often extremely difficult to obtain detailed information about networks, legal and illegal, both structural and economic, who filled the different actor roles, etc., which places serious constraints on any potential conservation initiatives [27,29,41]. It should be deemed as a high priority to seeking to obtain data that allow the mapping of who occupies which actor roles, especially from collection to export, and the economics of the trade, which will be variable both across species and geographies. However, without this detailed information, it is unable to know whether the nearly US $72 million generated by the trade at the retail level could be better distributed along the structural trade network and, thus, offer both greater economic opportunities to local communities' concomitant with conservation benefits through habitat protection.

Whilst it was reported that national legislation within exporting countries was not being adhered to consistently [36,37,51,59], the trade's dynamics (Figures 2 and 3) were affected by legislation impacting import countries, highlighting three legislative periods (Table 7). Focusing on the third of these, the 'post CITES listing & EU WBTB' period, the Netherlands, a European region country, was the major importing country, accounting for nearly 25% of the reported total exports. Thus, with the emergence of several temporally and geographically spread avian influence outbreaks across Europe, the EU legislation banning wild bird imports was strictly enforced on the occasions of such outbreaks, which meant the cessation of imports to the Netherlands that could result in the peaks and troughs observed post-2005 (Figures 2 and 3). However, despite these national/regional legislation impacts, the export of Toucans was still averaging over 542 individuals per year over those 14 years in just the 10 CITES-listed species. Considering Toucans are a slow-growing and breeding species, 542 individuals removed from the wild would have a significant impact on survival. Therefore, given the wide distribution of Toucans across many Central and Latin American countries, the management mechanisms responsible for wildlife trade, such as the Central American Wildlife Enforcement Network (ROAVIS) and South American Wildlife Enforcement Network (SudWEN), need greater commitment. Alternatively, biodiversity concerns can be written into trade agreements or partnerships (e.g., FTAs or TPAs), ensuring Parties adopt laws and measures to fulfil obligations under multilateral environmental agreements (MEAs), such as CITES [51] or more broadly reaching agreements, such as the 'Economic Commission for Latin America and the Caribbean' (ECLAC) or MERCOSUR agreement to which Guyana and Surinam are associate states. Furthermore, it has been proposed that FTAs/TPAs could operate as the framework to address the illegal wildlife trade in future agreements with countries that have a significant illegal wildlife trade, such as within U.S.-Peru TPA [51].

Finally, it should be highlighted again here that this study has utilised and presented values developed from the imported reported CITES data. One should be aware of its implications, not least that the values presented should be considered minimum values. Also, at no point has the study presented aspects of illegal wildlife trade (IWT) whilst being fully aware that they are interlinked [38] and were likely to be significant for Toucans that were high in individual value. Furthermore, it is important to note that domestic trade and confiscations of illegal birds were not included here, which could constitute a sizeable demand in itself, especially in regard to cultural dress, utilises the feathers of these and other bird species, and demand for pets. Thus, this study should be viewed as only just starting to highlight the need for much greater conservation attention and research orientated at Toucans as a matter of urgency. A review of the CITES NDFs for each of the main species is a good starting point to ensure trade is within sustainable levels, especially given the ecosystem services the species provide.

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