Malagasy Amphibian Wildlife Trade Revisited: Improving Management Knowledge of the Trade

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Article

Malagasy amphibian wildlife trade revisited: Improving management knowledge of the trade

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Simple Summary: There is much debate about the wildlife trade with arguments made both for and against the trade. If wildlife trade is to continue there needs to be both knowledge of species and their population status as well as confidence within the global mechanism that monitors and manages the wildlife trade. Using Madagascar's amphibian trade, this study investigates this. Findings from the study highlights the need to maintain awareness of changes to species descriptions, the relevance of cross referencing with population status, such as IUCN Redlist, but significantly against CITES quota and the quality of the NDFs that support them. It was seen in this study that Madagascar appeared to improve its management of the amphibian trade over time, but that new species were being described consistently over time that could add complications to the management of the trade.

Abstract: Madagascar is a biodiversity hotspot with a long history of trading in its wildlife, especially its hyper diverse Amphibian taxa. Due to globally raised concerns over the conservation for harvested amphibian species on Madagascar, CITES was introduced as a global mechanism to monitor and regulate the trade. Utilising data collated from the CITES Trade database, this study sought to investigate the trade and CITES effectiveness in managing the trade. Over the 28 year period investigated, 20 known amphibian species were exported from Madagascar with a total of nearly 271,000 individuals. Formal descriptions of Malagasy amphibian species has and continues to increase greatly over time, there has not been a concomitant, longitudinal relationship in the numbers of individuals traded. Overall, the numbers of individuals traded has declined over time but, where assessments were provided by the IUCN Redlist, population declines were reported in all but one species of Malagasy amphibian. *Mantella* (97.5%) continue to dominate the trade with certain, high conservation concern species continuing in the trade. Despite early concerns over the effectiveness of CITES actions, after concerted efforts it appears that CITES actions were having an impact in regulating the trade. However, going forward, concerns remain over the appropriateness of the quotas set and the robustness of their underpinning NDFs. Furthermore, with the increase in recognised species raises the potential for incorrect species labelling on CITES permits that needs attention.

Keywords: wildlife trade; Madagascar; Amphibians; CITES; IUCN Redlist; conservation.

1. Introduction

Academics may debate the existence of the Anthropocene [1], but no such debate rages around the extinction crisis currently being experienced globally [2]. Certain taxa have been reported as being more exposed to extinction risk than others due to a variety of pressures [1,3]. One such taxa group would be the Amphibians, having experienced high extinction rates globally due to a range of factors [4,5], such as climate and habitat change [6], chytrid [7] or overharvesting [8] to name a few.

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Madagascar has been identified as a biodiversity hotspot [9], especially for its amphibians with more than 365 recorded species to date, but with many more species yet to be formally described [10]. Conservation pressures affecting amphibians on Madagascar have been reported to include habitat change [11,12], diseases [13,14] alien species [12,15,16] and the wildlife trade, supplying both bushmeat [8] and demands for the pet trade [8, 17,18,19]. However, many of the studies investigating the levels of wildlife trade in amphibians destined for international pet markets were conducted over 10-15 years ago. For example, in 1994, just one Mantella species was traded, but this number jumped to 14 known species in 2002/2003 while between 1994 and 2003, in just the Mantella genus, 233,893 individuals were reported traded [20,21]. However, using CITES import data, for the period 1994 and 2006 a total of 162,000 individuals were reported traded across 18 species; while Malagasy government data reported trade between 2000 to 2006 of over 221,000 individuals across 91 species [20,21]. In a global review of amphibians, between 1978 and 2007, the genus Mantella was the most heavily traded genus with 193,600, in 14 species, accounting for 40% of the global trade figure, while *Dyscophus* were traded in 1 species and 999 individuals and just *Scaphiophryne gottlebei*, 2339, the only other Malagasy species on the list [8]. More recently, between 2007 and 2018, reported exports were stated at 71,050 individual amphibians, with the genus Mantella accounting for nearly 97% of the trade followed by *Scaphiophryne* (3%) and *Dyscophus* (0.5%), while the top three traded species were *M. betsileo* (n = 22,737, 33%), *M. baroni* (31%), and *M. nigricans* (11%) [21]. However, whilst values reported were appropriate at the time, the wildlife trade was recognised as highly dynamic in its nature. For example, it has been reported that the demand in species was driven by multiple factors [22], such as what was fashionable at that time [23,24], dynamic changes of trade networks, both financial and actor level participant involvement, can impact trading [17,19,20,21,25], while national or international legislation changes also can affect trading [18,20,26,27], etc..

Legislation change may have global application, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), or have regional affect, such as the European Union (EU). For example, within the EU, conservation legislation sets and dictates what member states must implement and act on. Regarding trade in wildlife, Council Regulation (EC) No 338/97 of 9 December 1996 on the protection of species of wild fauna and flora regulates trade, specifically procedures within Article 189c and Article 4(6) [28]. These refer to 'Introduction into the Community' with Article 4(6) stating: "In consultation with the countries of origin concerned, in accordance with the procedure laid down in Article 18 and taking account of any opinion from the Scientific Review Group, the Commission may establish general restrictions, or restrictions relating to certain countries of origin, on the introduction into the Community:" [28]. Annex A of Article 4 list species, which can change according to the information available, that were allowed or restricted entry to the EU as directed in the documentation. For example, *M. aurantiaca* was listed under Article 4(6) code 'd' (which stated "of live specimens of species for which it has been established that their introduction into the natural environment of the Community presents an ecological threat to wild species of fauna and flora indigenous to the Community."), but has since changed to code 'b' ("on the basis of the conditions referred to in paragraph 1(e) or paragraph 2(a), of specimens of species listed in Annex B; and") [29]. Such changes in coding, highlight the highly dynamic conditions within which the wildlife trade operates, especially on Madagascar.

Many factors have changed since previous studies into Malagasy amphibian trade were conducted. For example, political leadership has changed while greater and more coordinated strategic conservation efforts have been made [30,31,32]. The latter actions having been supported through multi-national environmental agreements (MEAs), such as CITES and the greater number of Malagasy species, with varying conditions applied to them, listed within CITES Appendices [33,34]. While the reported numbers of Malagasy amphibian traded has increased so to has the number of described species; from 133 species in the 1990s to 244 around 2010 to 292 in 2014 and 365 in 2022 [10]. This expansion in described species affects both the number and levels of trade being reported, whilst also impacting its management, through many ways, such as misidentification opportunities, taxonomic reclassifications, etc.. Furthermore, the pet trade has been recognised and reported as a fickle trade in terms of the species in demand [22,23,24]. A further consideration that needs careful handling

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would be the open and dynamic nature of CITES data sets, which, while often used for trade reviews, contain inherent associated issues [25]. Therefore, require knowledgeable handling when analysing and interpreting these data [25], in order to assess the efficacy of CITES management and allow robust evidence-based approach to either adapting, removing or increasing the conservation efforts afforded species.

Therefore, this study aims to provide the most up-to-date and comprehensive review of the global trade in CITES-listed amphibian species exported from Madagascar. This information will establish a platform of knowledge from which appropriate conservation actions can be developed and implemented to improve Malagasy amphibian conversation. The study seeks to identify the countries involved and the types, levels and complexities of the international trade in amphibians. Specifically, we aim to answer the following questions: (1) What are the levels, dynamics and trends in the trade? (2) Which species feature significantly in the trade conducted and what is their conservation status? (3) What is the effectiveness of CITES actions on the trade?

2. Materials and Methods

The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) was established to facilitate the monitoring of trade in wildlife based resources with the aim of securing its future sustainability (www.CITES.org (accessed on 14/05/2022)). Nation states, registered as party members, submit yearly trade reports that provide details of both imports and exports conducted within the year to CITES. These data would then be collated and stored on a trade database, which is maintained by United Nations Environment Program-World Conservation Monitoring Centre (UNEP-WCMC) in Cambridge, UK (https://trade.cites.org/ (accessed on 25/02/2023)) on behalf of the CITES Secretariat [25].

Data on trade conducted between 1975 to 2022 were collated and downloaded from the CITES database on 25th Feb. 2023. The search criteria and terms used in the collation of these data have been presented in Table 1 and covered all CITES listed species of Malagasy amphibian. Due to the well reported permutations, vagaries and lack of congruence between the CITES 'export reported' and 'import reported' trade values, which has often been an oversight in many such studies reporting on wildlife trade, only the import reported trade data set was utilised in the following analyses [8,25,33]. CITES quota data and status for each species was extracted from Species+ (https://www.speciesplus.net/species; accessed 05/03/2023), while their IUCN Redlist status was extracted from the IUCN Redlist (https://www.iucnredlist.org/; accessed 05/03/2023).

Table 1. Criteria selected prior to performing the data collation for Toucan trade within the CITES trade database (Source: UNEP-WCMC, 2023).

Database Field	Search Input
Search date	25/02/2023
Year range	1975 - 2022
Exporting countries	Madagascar
Importing countries	All countries
Source	Wild (W), Ranched (R), Source unknown (U)
Purpose	Commercial (T), Breeding in captivity or artificially propagation (B), Botanical garden (G), Circus & travelling exhibitions (Q), Personal (P)
Trade terms	Live (LIV), Specimens (SPE), Bodies (BOD)
Taxon	Amphibia (Amphibians)

Variables were investigated using the non-parametric tests, such Spearman rho correlation to investigate for significant relationships between variables and Mann-Whitney U test for any significant differences between variables.

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3. Results

Data collated for levels of trade between 1975 and 2022 recorded the first trading event in 1994 and the last data reported was in 2021, resulting in a data period covering 28 years. During this period, a total of 20 known Malagasy amphibian species, plus two unknown listings (recorded as 'genus spp'), and a total of 270,963 individual amphibians were reported being exported from Madagascar (Table 2).

Table 2. The species and number of individual Malagasy amphibians reported exported from Madagascar by each year over the period 1994 to 2021 (Source: UNEP/WCMC, 2023).

Amphibian species	Year																												
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Dyscophus antongilii					20			75																				
Dyscophus guineti																								170	437	202	30	182
Dyscophus insularis																								62	286	215	60	108
Dyscophus spp.				45																								
Mantella aurantiaca	100	5515	6185	10720	13403	7815	5676	7545	1450	2681						135	1490	396	230	341	170	13	298	191	176	119	38	58
Mantella baroni									10	650	313	2670	1359	1570	2237	1872	2100	415	2302	3005	2880	1142	2003	1584	1642	1811	80	160
Mantella bernhardi						30	440	543	400	60	105	60					88	49	14	82	12							
Mantella betsileo				1000	435	175	872	2926	460	1490	995	3110	1599	2238	1340	1818	1845	3396	2366	2239	2187	1331	2423	1248	1472	1551	22	392
Mantella cowanii					52	150	170	434	241	500	120																	
Mantella crocea					395	250	763	1223	330	125	1020	2295	346	425	410	436												
Mantella expectata				100	624	105	220	660	1390	1125	1280	2475	272	278	145	219			45	147	11							
Mantella haraldmeieri								180		350	410																	
Mantella laevigata				100	435	415	869	2155	533	1606	1795	2910	991	665	973	808	813											
Mantella madagascariensis				125	2192	1535	450	3231	3325	4873	4245	3235	329	212	192	203	102	85	53	81	50	73	105	20	20	8		9
Mantella milotympanum									710	1780	850	1575	304	400	267	157												
Mantella nigricans											200	315	150	382	192	272	144	1421	721	556	853	709	1048	721	716	956	204	282
Mantella pulchra					784	905	270	1658	1870	2585	2205	3455	1269	868	1197	1480	1116	241	297	193	184	78	193	122	68	97		12
Mantella spp.				330	820	260	6779	9738	545	1366	255	200														50		
Mantella viridis				125	690	385	1434	2945	1110	2065	955	1260	295	269	224	299												
Scaphiophryne gottlebei										980	776	270	216	465	171	377	302	191	163	171	48							
Scaphiophryne marmorata																								22	80	93		
Scaphiophryne spinosa																									170	220	20	

Comparing yearly data for the number of species traded against the number of individuals traded, there was a significant, positive, relationship (Fig. 1.; n=27, r_s = 0.76481, p=0.00). However, the number of species being traded year on year did not display any longitudinal linear increase (Fig. 2). Rather, after 1996 there was a rapid rise that peaked at 15 species in 2003/4, before then reducing to an average of approx. 9 species traded per year between 2005 to 2021 (Fig.2). Conversely, the yearly average number of individuals traded was 9677 over the 28 year period and 6668 between 2005 to 2021 with a peak of 33,313 individuals in 2001 (Fig.2).

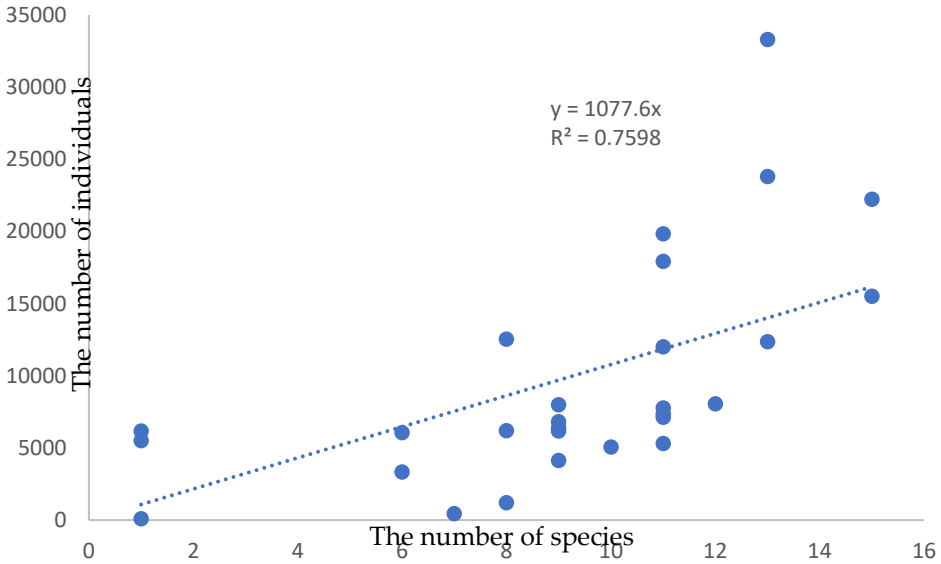

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Figure 1. The relationship between the number of species traded and the total number of individuals trade on a yearly basis from Madagascar between 1994 and 2021 (Source: UNEP/WCMC, 2023). .

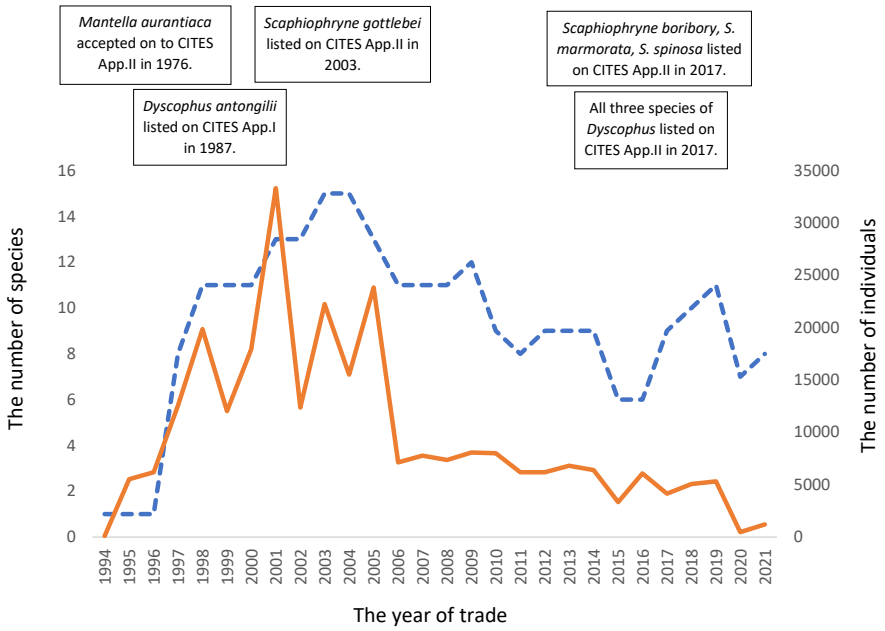

Figure 2. The non-linear increase in the number of species (blue dashed line and primary 'y' axis) exported from Madagascar each year and the total number of individuals (orange line and 2ndry 'y' axis) reportedly exported between 1994 and 2021 (Source: UNEP/WCMC, 2023).

All 20 known species traded were listed on CITES App.II, while 1 (5%) was categorised as IUCN Redlist Critically Endangered ('CR'), 6 (30%) were Endangered ('EN'), 4 (20%) were Vulnerable ('VU'), 1 (5%) was Near Threatened ('NT') and 8 (40%) were Least Concern ('LC') (Table 3). Grouping species in to their IUCN Redlist categorises recorded the greatest level of trade within the Least Concern species (8 spp; 95,902 individuals) closely followed by Endangered (6 spp; 92,634 individuals), Vulnerable (4 spp; 34,849 individuals), Near Threatened (1 spp; 21,147 individuals) and Critically Endangered (1 spp; 6,043 individuals). However, reviewing trade proportionally the category listings altered to Near Threatened (21,147 individuals per spp) species being the most traded, followed by Endangered (15,439 individuals per species), Least Concern (11,987 individuals per species), Vulnerable (8712 individuals per species) and Critically Endangered (6043 individuals per species). Furthermore, over 71% (179,763 individuals) of the trade was conducted in species with reported declining populations (Table 3).

Table 3. The Malagasy amphibian species recorded in the trade, presented in order of the total number of individuals recorded in the trade, the species status with CITES and the IUCN Red List.

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Amphibian species	Total traded	% of trade	CITES listing	IUCN Redlist population trend	IUCN Redlist status
Mantella aurantiaca	64745	23.89	II	↓	EN
Mantella betsileo	38930	14.37	II	↔	LC
Mantella baroni	29805	11.00	II	?	LC
Mantella madagascariensis	24753	9.14	II	↓	VU
Mantella pulchra	21147	7.80	II	↓	NT
Mantella spp.	20343	7.51		/	/
Mantella laevigata	15068	5.56	II	↓	LC
Mantella viridis	12056	4.45	II	↓	EN
Mantella nigricans	9842	3.63	II	↓	LC
Mantella expectata	9096	3.36	II	↓	EN
Mantella crocea	8018	2.96	II	↓	VU
Mantella milotympanum	6043	2.23	II	↓	CR
Scaphiophryne gottlebei	4130	1.52	II	↓	EN
Mantella bernhardi	1883	0.69	II	↓	VU
Mantella cowanii	1667	0.62	II	?	EN
Dyscophus guineti	1021	0.38	II	↓	LC
Mantella haraldmeieri	940	0.35	II	↓	EN
Dyscophus insularis	731	0.27	II	↓	LC
Scaphiophryne spinosa	410	0.15	II	?	LC
Scaphiophryne marmorata	195	0.07	II	↓	VU
Dyscophus antongilii	95	0.04	II	↓	LC
Dyscophus spp.	45	0.02		/	/

To manage resources, CITES utilises a quota system to limit the quantity of a particular resource. The success of quotas is that actual trade should not exceed the quota provided for that species by the exporting country. The relationship between actual trade conducted and the quota levels set have been presented for each genera in Figure 3. At the genera level, there are just two years when the number exported exceeded the CITES quota; these being for *Mantella* in 2001 (when 29567 were exported and the quota was 8000) and *Scaphiophryne* in 2010 (302 were exported and the CITES quota total was 250).

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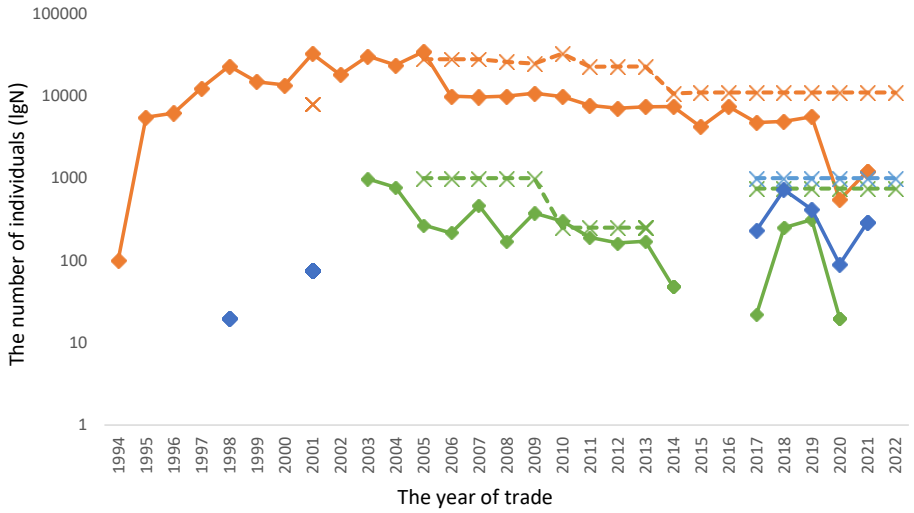

Figure 3. The relationship between the actual number of individuals exported from Madagascar for each of the three amphibian genera (*Mantella*, *Scaphiophryne* & *Dyscophus*) and the CITES quotas implemented each year as reported between 1994 and 2021 (Source: UNEP/WCMC, 2023). Brown is *Mantella*; green is *Scaphiophryne* and blue is *Dyscophus*, while solid lines with diamonds is reported export numbers and dashed line with open crosses is the CITES quota levels.

However, at the species level for each year, the reported number of amphibians exported from Madagascar exceeded the CITES quota level many more times (Fig. 4, 5). As *Mantella* accounted for nearly 98% of the reported export number total, this genus was focused on to explore the relationship between reported numbers exported and CITES quotas per species for each year comparative data existed (Fig. 4, 5). The total number of occasions when the reported export number exceeded its CITES quota within a set year was 130 times over the whole period or *Mantella* species (Fig. 4). Nearly 90% of these events were recorded leading up to 2005, with 2004 recording 16 species traded in numbers higher than their CITES quota (Fig. 4). In 2006 and 2007 there were no recorded events, while just two were recorded in 2008 with 2009 and 2010 recording 4 and 5 species exceeding quotas respectively before these events reduce to nearly zero for the remainder of the period (Fig, 4, 5). Where the reported number exported for a species equals the CITES quota, it was shown as zero on Figure 5, while numbers below zero were species traded below their CITES quota for that year and visa versa. The scale of departure from the CITES quota was highest in 1998 for *M. aurantiaca* (Fig. 5). After an initial period of a large number of above quota events, post 2005-6 trade levels rarely exceeded their CITES quota but were still highly fluctuating albeit in a negative relationship (Fig. 5). Much greater consistency in the relationships between these data sets were observed post 2014 (Fig. 5).

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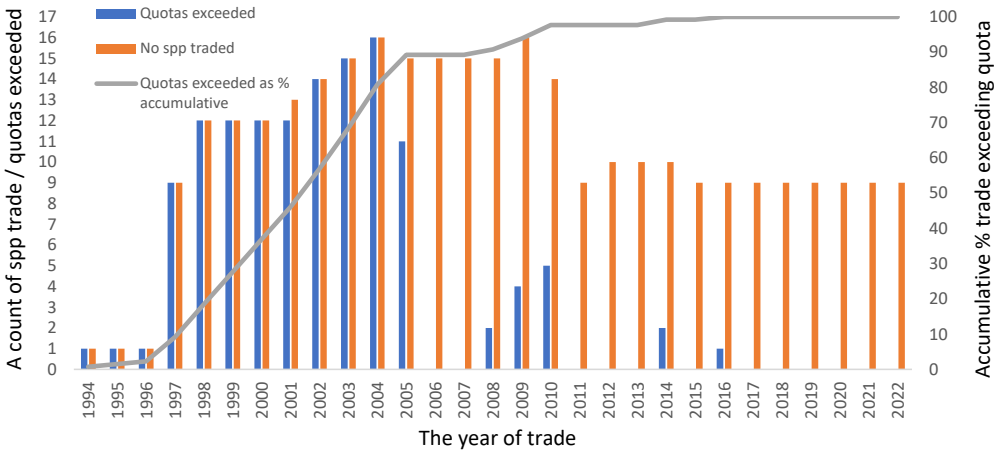

Figure 4. The events when reported trade numbers exceeded CITES quotas within a year as reported between 1994 and 2021 (Source: UNEP/WCMC, 2023).

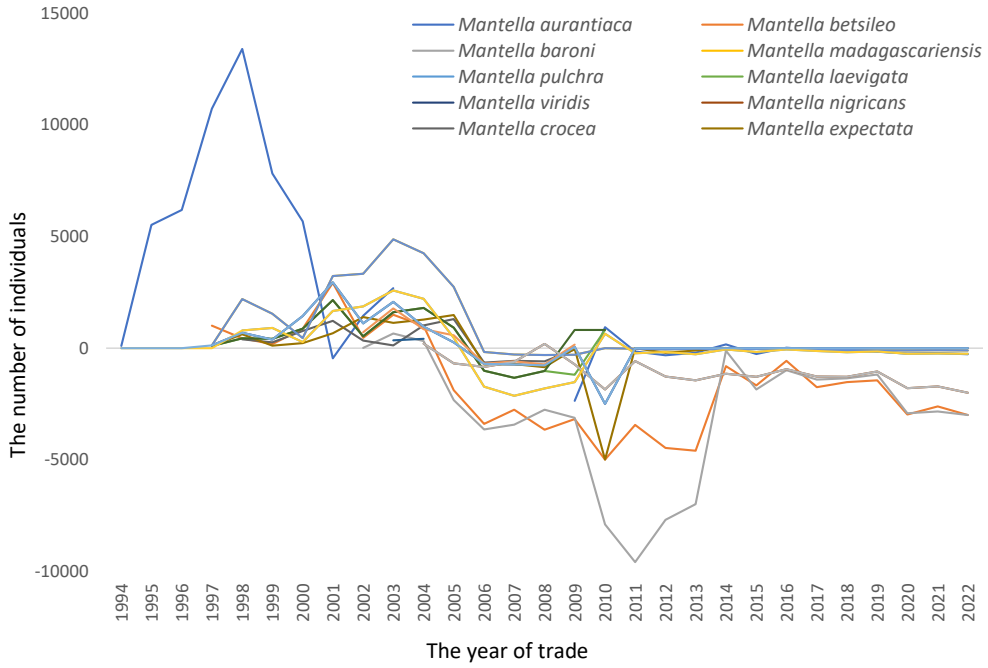

Figure 5. The graph shows when CITES quotas were exceeded (numbers presented > zero) or not meet (numbers < zero) with the zero reference line indicating when the reported number exported was equal to their CITES quota for data reported between 1994 and 2021 (Source: UNEP/WCMC, 2023). .

4. Discussion

This study has shown that the highest number of amphibians exported from Madagascar to supply the international trade demand was still dominated by Mantella species. Of the 270,963 individual amphibians exported, over 97.5% of those were Mantella species, highlighting their continued demand in the trade, followed by *Scaphiophryne* spp (1.7%) and *Dyscophus* spp. (nearly 0.7%). However, whilst an increasing number of *Mantella* species was recorded within the trade, especially post 2003,4,5 period (15, 16 & 15 species exported respectively), there was no linear increase in the yearly numbers of individuals reportedly exported (Fig. 1, 4). This suggests that the international trade in Mantella had a demand ceiling, which could be met by a few or many Mantella species. From a

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population harvesting impact perspective, this information suggests there was no longer a favourite Mantella species. Rather the harvesting impact could be spread across many Mantella species and even away from species that may have experienced high levels of exploitation or other perturbations to their populations via adaptive management processes.

A similar trading pattern was observed within the *Dyscophus* genus. Prior to 2017, *Dyscophus antongilii* was listed on CITES App.I, while *D. insularis* and *D. guineti* were not listed at all. At the CITES meeting in South Africa, in 2017, *D. antongilii* was down-listed from App.I to App.II, while both *D. insularis* and *D. guineti* were uplisted on to CITES App.II. However, post these regulatory changes, trade was reported in both *D. insularis* and *D. guineti* only. Thus indicating that the pre-2017 export trade fears that had previously listed *D. antongilii* as CITES App.I, had altered. Either this species was no longer 'fashionable' or the demand had already been satiated or the international demand window had been usurped by ex-situ, captive breeding supplying the trade. All of which highlights how extremely dynamic the wildlife trade can be in species.

Captive breeding advances in Malagasy Amphibians, such as have been reported [8], highlight the windows of native country supply are time limited, which has financial implications for conservation within those source countries. For example, in 2023, various species of captive bred Mantella could be purchased for the retail price of US $87 (GB £70; www.reptiles.swelluk.com). The average exchange rate for the last 5 years has been 1.25, producing the US $87. A reported 12,046 individuals were exported from Madagascar, equating to US $1,048,002. It has been stated that 3% of the retail value reaches local communities [17,18], resulting in a potential loss of over US $31k to local incomes on Madagascar. This also excludes the income generated for intermediaries, who are also Malagasy [17,18], in addition to the Government taxes accrued and the wider contributions to businesses and jobs along the wider supply chain, such as transport, etc..

Madagascar's management of the trade as a sustainable resource, was noticeable by its apparent lack of any control on levels of trade in amphibian species or its ability to implement CITES quotas early on (Fig. 4, 5). This led to greater international attention and scrutiny being afforded Madagascar by CITES, such as country reviews being performed, etc. [26,27]. However, trading levels exceeding CITES quotas levels appears to have almost ceased post 2010 (Fig.4), with just 14 events between 2010 to 2022 across a variety of Mantella spp.. Whether this was due to increased effectiveness in the management of the trade by Madagascar, captive breeding advances in non-native countries supplying international demands, or a combination of these and other factors requires further study. One area for future study would be the appropriateness and robustness of the data sets used to calculate CITES Non-Detrimental Findings (NDFs), provided by Madagascar's government representatives to CITES, were based on. From viewing the quota values provided, there seemed much commonality in the values despite the variable factors experienced by each species.

Furthermore, regarding management of the trade and conservation status, as indicated by the 'IUCN Red List of Threatened Species' categorisation, there appeared a lack of alignment or synchronisation between the two sectors. For example, 1 (5%) species was Critically Endangered ('CR'), 6 (30%) were Endangered ('EN'), 4 (20%) were Vulnerable ('VU') under the IUCN Red List categorisation, yet they figured appear high in trading levels (Table 3). However, at the finer scale there were variabilities, such a *Mantella milotympanum*, the IUCN Red List CR species, has not been recorded being exported since 2010. Conversely, *Mantella aurantiaca* (EN) has been recorded exported every year from Madagascar over the 28 year period, except for 2004 to 2008 when no trade was recorded. Almost all the amphibian species were stated to have declining populations under the IUCN Red List, however, CITES quotas were set at 250, 500 or 3000 apparently regardless of population trend. This highlights further research areas for the future. Such as the information synergies between CITES Non-Detrimental Findings (NDFs) and IUCN Red List categorisation, were the most up-to-date information being utilised within each working group? Also the levels of researcher collaborations taking place between the two working groups, to ensure alignments in actions taken that support one another rather than appearing independent.

Thus, this study highlights areas of improved wildlife trade practice, such as CITES management of the trade. However, the study also raises several areas for future research that could initiate further

improvements to the management of these wildlife resources. Ultimately, there needs greater alignment and much improvement in the sensitivities of these wildlife resources for their conservation benefit.

5. Conclusions

Malagasy amphibian biodiversity has increased continuously over time and continues to increase. With the addition of these new species into the trade brings into question the suitability of data that supports their inclusion. For example, the NDFs that country CITES MA's use to determine the quotas submitted to CITES needs careful investigation as to their robustness and reliability. However, CITES capacity building efforts could be, in part, the reason for the apparent improvement of the amphibian trade on Madagascar. Whilst the conservation and poverty alleviation benefits will continue to be debated, it is imperative that these areas of both species knowledge and management effectiveness are constantly being reviewed and improved. Studies such as this one allow those involved in the management of wildlife trade and conservation on Madagascar to identify areas where potential easy wins can be made with active changes.

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