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# An analysis of the live reptile and amphibian trade in the USA compared to the global trade in endangered species

Anthony Herrel[1,2] & Arie van der Meijden[3]

[1]*UMR 7179 C.N.R.S/M.N.H.N., Département d'Ecologie et de Gestion de la Biodiversité, 57 rue Cuvier, Case postale 55, 75231, Paris Cedex 5, France*

[2]*Ghent University, Evolutionary Morphology of Vertebrates, K.L. Ledeganckstraat 35, B-9000 Gent, Belgium*

[3]*CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos, Campus Agrário de Vairão, 4485-661 Vairão, Portugal*

The trade in wildlife is a globally important industry. Amphibians and reptiles are among the most commonly traded animals and this trade has raised concern because of its potential impact on natural populations, animal welfare and the spread of invasive species and emerging infectious diseases. Yet, evaluating the risks involved is difficult due to the lack of quantitative data on the trade. Here, we analyse data on the live reptile and amphibian trade in the USA and the worldwide trade in CITES-listed species over a ten year period. Our analyses show that the trade is dominated by only a few species, with ten species making up the majority of the trade. Moreover, our data show an increase of the contribution of captive bred specimens to the trade in the USA, but not worldwide. Our data do show the presence of several invasive species among those that are traded and bred most. The trade of potential invasive species is problematic and should be more strictly regulated as it may have a global impact on biodiversity and the spread of emerging infectious diseases.

*Key words:* captive breeding, CITES, export, husbandry, import, invasive species, pet trade

## INTRODUCTION

The global trade in wildlife is a billion dollar industry that is expanding rapidly (Smith et al., 2009). Moreover, a large component of the trade remains unregulated and may lead to real threats to biodiversity and act as a pathway for the spread of emerging infectious diseases (Rosen & Smith, 2010). Amphibians and reptiles ranked third and fourth in the list of the most imported animals in the United States between 2000 and 2009 (Smith et al., 2009) and are generally among the most commonly traded animals in many regions (e.g., Nijman, 2010). Although the threat to populations of reptiles and amphibians by collection for the pet trade is generally much smaller than that of habitat destruction, it can be the last straw in some cases. Small populations that have been cornered into remnants of their existing habitat are much more vulnerable to collecting than healthy populations with a large distribution area (Fahrig, 2003). Nowadays many wild populations occur in such fragmented habitats such that intensive collecting of animals may potentially become a real threat to the survival of many species (Todd, 2011; Lyons & Natusch, 2011). The exceptions are of course those species that thrive in the vicinity of humans and disturbed habitats. However, these are but a small number compared to those that require pristine habitat, and overall, reptiles and amphibians are in serious trouble through human-induced habitat destruction as well as global changes in climate (Stuart et al., 2004; Sinervo et al., 2010).

Reptiles and amphibians (Gibbons et al., 2000; Stuart et al., 2004) have taken the brunt of the effects of habitat destruction, introduced species and diseases, pollution, and over-collecting for food or the pet trade (e.g., Schlaepfer et al., 2005; Andreone et al., 2006). The trade in reptiles and amphibians has a bad reputation in general due to concerns for animal welfare, depletion of local populations, the spread of invasive species and concerns for human health (Arena et al., 2012). Since many of the widely traded species occur in unprotected and/or uncontrolled areas around the world it is hard to estimate the effects of collecting for the pet trade on the status of natural populations (Schlaepfer et al., 2005). Moreover, in countries that import exotic animals and that have an amenable climate, imported animals can become pests and a danger to the local fauna (e.g., van Wilgen et al., 2008; Westphal et al., 2008; Dove et al., 2011; Measey et al., 2012). The trade in exotic animals can also drive the spread of novel pathogens that may be detrimental for local populations (Fisher & Garner, 2007). For example, it has been proposed that the international trade in amphibians may have been responsible for the spread of the chytrid fungus, *Batrachochytrium dendrobatidis*, causing chytridiomycosis (Weldon et al., 2004). This disease has been associated with the observed global decline and extinction of amphibian species (Stuart et

*Correspondence:* Anthony Herrel (anthony.herrel@mnhn.fr)

al., 2004; Pounds et al., 2006). Finally, recent concern has been raised about the health risks imposed by exotic pets on humans through the transmission of diseases and direct injury from attacks or bites (Arena et al., 2012; Smith et al., 2012).

Given these concerns and the potential risks associated with the trade in reptiles and amphibians, lobbying groups have been formed to try to ban the trade of reptiles and amphibians in many countries. Yet, such bans may have the opposite effect and in reality stimulate the trade (legal and illegal) in rare and endangered species in some cases (Rivalan et al., 2007). Analyses of the trade in reptiles and amphibians and real, objective, assessments of the threats imposed by such trade are generally lacking due to the difficulty of obtaining quantitative data (but see Auliya, 2003; Schlaepfer et al., 2005, Prestridge et al., 2011; Todd, 2011). Moreover, potential positive aspects of the trade in amphibians and reptiles are generally ignored. The trade in wild animals can, for example, provide benefits to local communities in developing countries if based on sustainable *in situ* breeding of species in high demand on the market (Tapley et al., 2011). Whereas the economic value of species may provide an incentive to protect habitats and the species they contain, economic models have suggested that wildlife farming should be accompanied by a quota system to assure the sustainable nature of such trade (Bulte & Damania, 2005). Finally, the contact of the public with exotic wildlife may raise awareness for the intrinsic value of biodiversity and as such provide an impetus for the implication of the public in conservation at a local or global scale.

To objectively evaluate the potential risks and impacts of the amphibian and reptile trade on natural populations, objective and transparent analyses of available trade data are needed. In the present paper we analyse data on the trade in live amphibians and reptiles in the United States of America in the 2001–2009 period and focus on the diversity of species traded relative to number of animals and the proportions of captive bred animals in the trade (Tapley et al., 2011). In doing so we evaluate i) recent trends in the trade, ii) trends in the proportion of captive bred versus wild-caught animals, iii) the potential threat posed by the trade through invasive species. In addition we analyse data from the global trade in CITES-listed animals to evaluate whether USA trade records (the USA being one of the only countries for which quantitative trade data can be obtained) provide an appropriate picture of the trade in general.

## MATERIALS AND METHODS

We requested the total import and export data for live amphibians and reptiles in the USA from the Fish and Wildlife department, under the Freedom of Information Act. Unfortunately, such data is not available for the European Union (EU). We received the data for the time period of 1 January 2001 to 7 October 2009. These data were converted from excel files to CSV format and imported into a local MySQL database. The data were then available for querying. Some records did not record the animals per specimen but in some other unit (kg, or even meters for snakes). The number of such records has decreased steadily from 247 in 2001 to 54 in 2009. Of the total import-export records, 0.4% (1,025 of 260,001) was recorded in such aberrant units, and these records were

**Table 1.** The fifteen most traded amphibians and reptiles in the USA over the period 2001–2009. Results listed are the ten most commonly traded reptiles and amphibians as identified to species in the data base. *indicates species known to be invasive outside of their range. **species listed among the world's 100 worst invasive alien species (Lowe et al., 2000). The percentage that each species represents of the total trade is also indicated.

| Reptiles | | | | Amphibians | | | |
|---|---|---|---|---|---|---|---|
| | | # | % | | | # | % |
| *Trachemys* | *scripta*** | 4,843,4419 | 77.33 | *Rana* | *catesbeiana*** | 20,077,587 | 94.36 |
| *Iguana* | *iguana** | 3,194,877 | 5.10 | *Hymenochirus* | *curtipes* | 8,973,850 | 42.17 |
| *Chelydra* | *serpentina** | 2,882,664 | 4.60 | *Bombina* | *orientalis* | 3,553,738 | 16.70 |
| *Python* | *regius* | 1,336,976 | 2.13 | *Cynops* | *orientalis* | 2,332,123 | 10.96 |
| *Apalone* | *ferox* | 1,217,567 | 1.94 | *Xenopus* | *laevis** | 1,262,468 | 5.93 |
| *Graptemys* | *pseudogeographica* | 1,149,632 | 1.84 | *Hymenochirus* | *boettgeri* | 1,017,263 | 4.78 |
| *Physignathus* | *concincinus* | 812,492 | 1.30 | *Rana* | *forreri* | 831,400 | 3.91 |
| *Anolis* | *carolinensis* | 718,227 | 1.15 | *Rana* | *pipiens* | 687,374 | 3.23 |
| *Takydromus* | *sexlineatus* | 657,040 | 1.05 | *Hymenochirus* | *boulengeri* | 554,486 | 2.61 |
| *Pseudemys* | *nelsoni* | 500,837 | 0.80 | *Litoria* | *caerulea* | 504,774 | 2.37 |
| *Trionyx (Pelodiscus)* | *sinensis* | 429,846 | 0.69 | *Occidozyga* | *lima* | 358,462 | 1.68 |
| *Apalone* | *spinifera* | 421,723 | 0.67 | *Cynops* | *pyrrhogaster* | 344,100 | 1.62 |
| *Pseudemys* | *concinna* | 320,106 | 0.51 | *Rana* | *berlandieri** | 328,182 | 1.54 |
| *Eublepharis* | *macularius* | 277,295 | 0.44 | *Hyla* | *cinerea* | 280,369 | 1.32 |
| *Anolis* | *sagrei** | 277,122 | 0.44 | *Agalychnis* | *callidryas* | 249,294 | 1.17 |

**Table 2.** Proportion of the number of individuals of the ten most traded species relative to the total number of individuals traded to and from the USA. *Data from 1 January 2001 to 7 October 2009 only.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009* |
|---|---|---|---|---|---|---|---|---|---|
| Import | 7,576,197 | 8,120,657 | 7,833,713 | 7,904,643 | 7,088,779 | 6,542,832 | 6,163,580 | 5,484,764 | 3,557,200 |
| Top 10 species | 5,415,170 | 6,094,478 | 5,838,868 | 6,052,877 | 5,575,968 | 4,788,587 | 4,577,985 | 4,148,296 | 2,661,664 |
| Rest | 2,161,027 | 2,026,179 | 1,994,845 | 1,851,766 | 1,512,811 | 1,754,245 | 1,585,595 | 1,336,468 | 895,536 |
| Export | 14,308,920 | 14,423,565 | 15,162,423 | 12,379,896 | 10,040,244 | 14,576,398 | 18,835,139 | 12,603,513 | 9,886,839 |
| Top 10 species | 13,913,585 | 14,009,853 | 14,679,893 | 11,805,496 | 9,509,626 | 14,014,712 | 18,358,324 | 12,033,796 | 9,489,025 |
| Rest | 395,335 | 413,712 | 482,530 | 574,400 | 530,618 | 561,686 | 476,815 | 569,717 | 397,814 |
| % top10 of imports | 71.5 | 75.0 | 74.5 | 76.6 | 78.7 | 73.2 | 74.3 | 75.6 | 74.8 |
| % top10 of exports | 97.2 | 97.1 | 96.8 | 95.4 | 94.7 | 96.1 | 97.5 | 95.5 | 96.0 |

not used in this study. The data contained, among other things, data on species and genus name, quantity and unit, country of origin, source (wild, captive, ranched, f1, appendix 1 specimens bred in captivity) and shipping date. The data were queried to quantify the number of specimens per species, source type, country of origin and importing agency. When querying the source type, we followed Schlaepfer et al. (2005) in creating a "captive" source category that may be, however, an underestimate of the total number of captive bred animals. We considered all specimens that were not marked as captive bred (Fish and Wildlife categories C and D) as wild caught. This latter category thus included "Ranched" (R), "born in captivity" (F) and all other categories (A, I, U, P, W) and likely underestimates the true number of captive bred animals. Although species numbers were inflated slightly due to species name misspellings, such duplications were eliminated by hand-sorting the data by species epithet and joining obvious duplications. Many records did not contain species epithets but were listed as "sp.". These were not assigned to a species but rather kept as such (e.g., *Hemidactylus* sp. in Table 4). Multiple species of a single genus can be traded as "sp.", but species that are traded under their species epithet can also be traded as "sp.". In other words, we cannot say whether this will produce an under- or overestimate of the total number of animals of a given species that are traded. Customs officials appear to have opted for taxonomic stability, and we found no instance where a species name had changed during the study period.

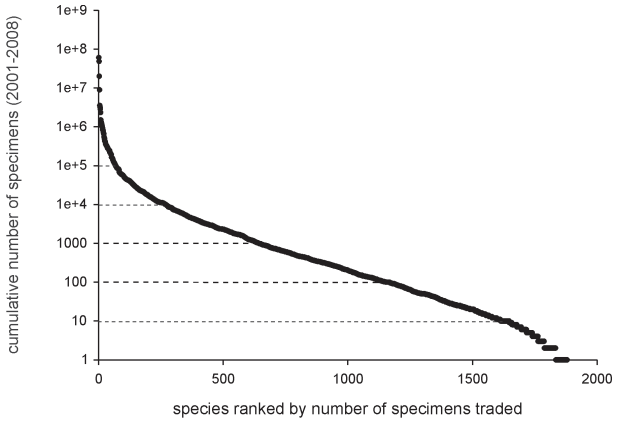


**Fig. 1.** Graph illustrating the cumulative number of specimens traded in the USA from 2001 to 2008 in descending order from the most traded (rank 1) to the least traded species. This graph shows that the top ten most traded species make up over 80% of the total trade.

In order to compare the trade data from the USA to trade in other parts of the world, we also downloaded data on the trade in live CITES listed reptiles and amphibians from 2000 to 2010 from CITES (http://www.cites.org). This dataset is more restricted, as only those species that are listed on CITES are reported. In this dataset, only 20 of 50,533 records were listed in aberrant units (19 in kg, one in "shipments"), which were not included in our analyses. As above, we used the presumably lower estimate of the "captive" source category of Schlaepfer et al. (2005). The CITES data reports numbers of specimens as being reported by the importer or the exporter, or both. However, these figures are not always in agreement. This may be due to a larger number of export permits being requested than actually used, or some of these being used in the next year. We found the total number of imported specimens to be outnumbered by the exported specimens by more than 15% over the total period of 2000–2010. Unless otherwise stated, only the reported imports were used, as we assume this was closer to the actual number of specimens traded, rather than just the number of export permits requested.

## RESULTS

### USA total trade

Over the period from 2001–2009 over 1800 species involving over 182 million specimens were traded in the USA However, our results show that most of the trade in amphibians and reptiles in the USA is dominated by only a few species (Fig. 1, Tables 1, 2). Over the nine-year period analysed, the ten most traded species take up 96.3% of all exports and 74.9% of all imports in the USA The total number of individuals traded in 2008 was only 82% of that in 2001 suggesting a decrease in the trade of amphibians and reptiles over time. This decrease is largely due to a steady decrease in the imports from 2004 to 2008 (Fig. 2A). The commercial trade took up the bulk of the trade with only 0.16 % of the total trade being for academic purposes involving only 47 species of amphibians and reptiles.

Of the 15 most commonly traded reptiles eight are turtles, six are lizards and only one is a snake. Among

**Table 3.** The ten most exported amphibians and reptiles from the USA over the period 2001–2009. Results listed are the ten most commonly exported reptiles and amphibians as identified to species in the data base. *Species known to be invasive outside of their range.

| Reptiles | | | | Amphibians | | | |
|---|---|---|---|---|---|---|---|
| | | # | % | | | # | % |
| *Trachemys* | *scripta** | 48,300,778 | 84.48 | *Hymenochirus* | *curtipes* | 300,252 | 26.6 |
| *Chelydra* | *serpentina* | 2,882,092 | 5.04 | *Hyla* | *cinerea* | 273,430 | 24.22 |
| *Apalone* | *ferox* | 1,216,989 | 2.13 | *Ceratophrys* | *cranwelli* | 159,135 | 14.1 |
| *Graptemys* | *pseudogeographica* | 1,149,076 | 2.01 | *Xenopus* | *laevis** | 120,189 | 10.65 |
| *Pseudemys* | *nelsoni* | 757,290 | 1.32 | *Notophthalmus* | *viridescens* | 84,497 | 7.48 |
| *Anolis* | *carolinensis* | 713,838 | 1.25 | *Ambystoma* | *tigrinum* | 37,379 | 3.31 |
| *Apalone* | *spinifera* | 421,682 | 0.74 | *Bombina* | *orientalis* | 34,438 | 3.05 |
| *Pseudemys* | *concinna* | 320,056 | 0.56 | *Ambystoma* | *mexicanum* | 22,899 | 2.03 |
| *Anolis* | *sagrei** | 276,250 | 0.48 | *Ceratophrys* | *ornata* | 21,110 | 1.87 |
| *Sternotherus* | *odoratus* | 266,437 | 0.47 | *Hymenochirus* | *boettgeri* | 20,812 | 1.84 |
| *Eublepharis* | *macularius* | 257,841 | 0.45 | *Rana* | *catesbeiana** | 12,004 | 1.06 |
| *Macroclemys* | *temminckii* | 219,796 | 0.25 | *Rana* | *pipiens* | 11,636 | 1.03 |
| *Pantherophis* | *guttatus** | 141,161 | 0.23 | *Lepidobatrachus* | *laevis* | 11,191 | 0.99 |
| *Chrysemys* | *picta* | 133,811 | 0.2 | *Agalychnis* | *callidryas* | 10,037 | 0.89 |
| *Apalone* | *ferox* | 115,405 | 0.17 | *Hyla* | *gratiosa* | 9,893 | 0.88 |

the amphibians, 13 are frogs and two are salamanders (Table 1). Interestingly, the top 15 amphibian species in the trade equal only 25.36% of the total trade suggesting that reptiles dominate the trade. For both reptiles and amphibians, a single species dominates the trade with 77% of the entire reptile trade being restricted to *Trachemys scripta* and 94% of the amphibian trade being restricted to *Rana (Lithobates) catesbeiana* (Table 1). Among the fifteen most traded reptiles, four are known to be invasive outside of their native range. Among amphibians three of the fifteen are known to be invasive (Table 1). Of these one reptile (*T. scripta*) and one amphibian (*R. catesbeiana*) are listed among the world's worst invasive species, yet are at the same time the most traded species among reptiles and amphibians respectively. Although some countries have limited the import of *T. scripta*, according to the IUCN website only the subspecies *T. s. elegans* is banned in the EU with the other subspecies still being imported (van Dijk et al., 2011). The top 100 of the most traded amphibians and reptiles does not contain any species that are island endemics or species with known restricted ranges such as high altitude endemics. Of most concern among the top 100 most traded species is probably one species of *Uromastyx* (*U. dispar maliensis*) which is red listed as vulnerable.

Among the ten most traded species, five have a larger contribution from captive compared to wild-caught

**Table 4.** Summary of the ten most traded species broken down by captive versus wild-caught. For species indicated in grey the majority of the specimens traded are derived from captive breeding.

| 2001–2009 | | | | | | |
|---|---|---|---|---|---|---|
| Genus | Species | Total | Captive | Wild | % Captive | % Wild |
| *Pseudemys* | sp. | 60,580,043 | 52,892,304 | 7,687,739 | 87.3 | 12.7 |
| *Trachemys* | *scripta* | 48,434,419 | 21,830,075 | 26,604,344 | 45.1 | 54.9 |
| *Rana* | *catesbeiana* | 20,077,587 | 15,091,210 | 4,986,377 | 75.2 | 24.8 |
| *Hymenochirus* | *curtipes* | 8,973,850 | 5,668,192 | 3,305,658 | 63.2 | 36.8 |
| *Bombina* | *orientalis* | 3,553,738 | 1,258,077 | 2,295,661 | 35.4 | 64.6 |
| *Iguana* | *iguana* | 3,194,877 | 2,920,223 | 274,654 | 91.4 | 8.6 |
| *Chelydra* | *serpentina* | 2,882,664 | 1,179,310 | 1,703,354 | 40.9 | 59.1 |
| *Cynops* | *orientalis* | 2,332,123 | 1,302,758 | 1,029,365 | 55.9 | 44.1 |
| *Hemidactylus* | sp. | 1,505,517 | 12,874 | 1,492,643 | 0.9 | 99.1 |
| *Python* | *regius* | 1,336,976 | 45,090 | 1,291,886 | 3.4 | 96.6 |
| Total | | | | | 66.9 | 33.1 |

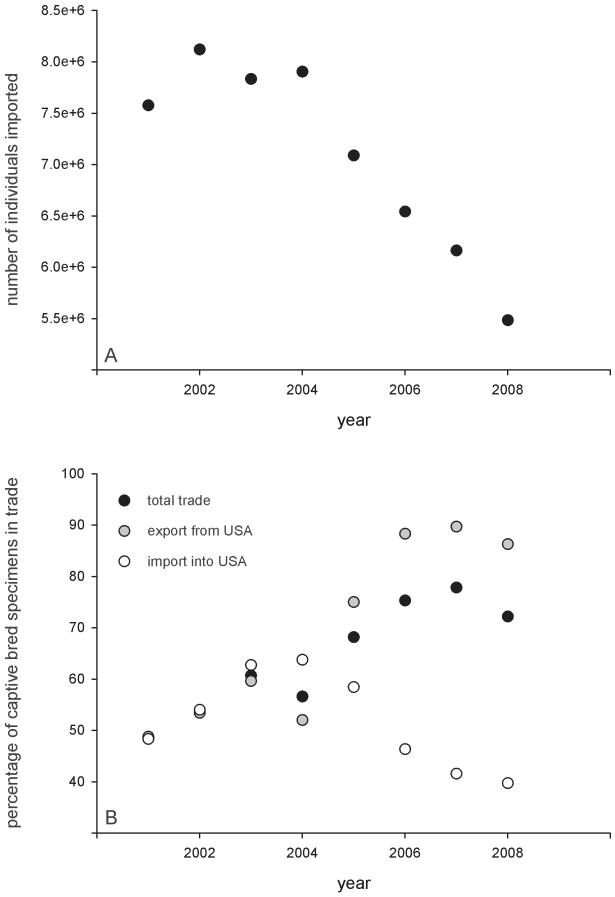


**Fig. 2.** (A) Graph illustrating the decrease in the import of amphibians and reptiles into the USA From a stable level around eight million imported in the period 2001–2004, the total number of individuals decreased to about five and a half million in 2008. (B) Graph illustrating the evolution of the trade in captive bred specimens in the USA Note the increasing trend in the overall trade from 2001 to 2008. Whereas the export of captive bred animals has steadily increased from 2001 to 2008 the imports show a slight overall decrease with about 40% of the specimens being captive bred.

specimens to the overall trade (Table 4). Numbers vary from 91.4% of all green iguanas (*I. iguana*) being captive bred to as little as 0.9% of the *Hemidactylus* species that were traded over a nine-year period. An analysis of the trends in the contribution of captive bred versus wild-caught specimens in the trade from 2001 to 2008 shows a steadily increasing number of captive bred specimens in the trade (Fig. 2B). Interestingly, this increase is largely driven by the increase in captive specimens in exports rather than imports over that period. Imports fluctuate with between 40 and 60% of the imports into the USA being from a captive bred source (Fig. 2B).

Among the 15 most exported reptile and amphibians from the USA, *T. scripta* makes up the bulk of the specimens. Exports of amphibians are much lower (less than 2% of the total number) and are dominated by the export of five principal species (Table 3). Of the 15 most exported reptiles, three are known to be invasive, and among the amphibians two are invasive. Interestingly, many of the species exported from the USA are not native to the country.

**Worldwide CITES trade**

Over the 2000–2010 period over 15 million specimens belonging to 651 species were traded within CITES. In order to ascertain whether the CITES data can be used as an indicator of the overall reptile and amphibian trade we compared it to the overall import data for the USA. When regressing the total import number of the USA for each year against those in the CITES database, a linear relationship emerges, with an $r^2$ of 0.71 (y=4.35x+4E+06). However, since a few individual species can form a large fraction of the total trade, particularly in exports, the CITES data are not a good indicator of the total exports from the USA ($r^2$=0.25).

The CITES trade data mirrors the trade data from the USA in some important aspects. The number of captive bred specimens fluctuates around 50% of the total trade (46% to 56% of the yearly trade). Although the total number of imported specimens worldwide

**Table 5.** Ten most traded species in the period 2000–2010 under CITES worldwide. The table shows the fraction of the species relative to the total trade in CITES listed species and the fraction of captive bred specimens thereof. Species indicated in grey are those for which the majority of specimens in the trade are captive bred. On average 30.9±43.7 % of the top ten species traded are captive bred. Since we only analysed the trade in live specimens it is unlikely that many of these specimens are used for other purposes such as skins although this cannot be excluded.

| Family | Taxon | Specimens | % of Total | % Captive |
|---|---|---|---|---|
| Iguanidae | *Iguana iguana* | 5,994,929 | 38.8 | 94 |
| Pythonidae | *Python regius* | 2,172,043 | 14.0 | 2.2 |
| Emydidae | *Graptemys pseudogeographica* | 619,673 | 4.0 | 1.2 |
| Testudinidae | *Testudo horsfieldii* | 619,566 | 4.0 | 5.2 |
| Geoemydidae | *Cuora amboinensis* | 500,555 | 3.2 | 1 |
| Varanidae | *Varanus exanthematicus* | 370,054 | 2.4 | 1.7 |
| Crocodylidae | *Crocodylus siamensis* | 347,989 | 2.3 | 100 |
| Boidae | *Boa constrictor* | 255,543 | 1.7 | 86.8 |
| Crocodylidae | *Crocodylus niloticus* | 236,696 | 1.5 | 16.2 |
| Varanidae | *Varanus salvator* | 207,420 | 1.3 | 0.2 |
| Total | | 11,324,468 | 73.2 | |

**Fig. 3.** Maps showing (A) the total number of imported specimens per country under CITES, (B) the total number of exported specimens under CITES, (C) the total number of imported specimens per 1,000 inhabitants, (D) the number of exported specimens per 1,000 inhabitants. Panel C does not show Hong Kong, which has the highest number of imported specimens per 1,000 inhabitants (110). Panels B and D do not show El Salvador, which has the highest number of exported specimens absolutely (5,332,056), and per 1,000 inhabitants (881).

remains relatively constant from 2001 to 2007 (around 1.5 million), there is a steady decline in the number of traded specimens from 2008 onward (from nearly 1,390,319 in 2008 to 1,184,651 in 2010). Again, a few species make up a large part of the total CITES trade with the top ten species making up 73% of the total trade. One species (*I. iguana*) is responsible for 38.8% of the total CITES trade. The top ten species consist of three lizards, two snakes, two crocodilians and two turtles (Table 5). We mapped the total number of imported and exported specimens per country (Fig. 3A, B). In order to ascertain whether these trade volumes are economically relevant to the inhabitants of these countries, we also mapped the numbers of imported and exported specimens per 1000 inhabitants (Fig. 3C, D). This analysis shows that the USA is both the biggest importer and exporter of reptiles and amphibians world-wide. When scaled to the number of inhabitants, North America and western Europe are the biggest importers in addition to Hong Kong. El Salvador has the highest number of exported specimens absolutely (5,332,056), and per 1,000 inhabitants (881).

## DISCUSSION

Our results suggest that the trade of reptiles and amphibians in the USA is a business of considerable economic importance. Interestingly, however, the trade (be it overall or in CITES listed species) is dominated by relatively few species and trade numbers of the bulk of species are rather low. For example, more than half of the total number of species traded in the USA over the nine-year period analysed are represented by less than 100 specimens (i.e. less than 10 a year). Although the comparison of the USA trade with that in other countries is difficult due to the lack of available trade data, we predict similar patterns. Moreover, the USA is both absolutely and relatively the biggest importer of live amphibians and reptiles. Due to the lack of trade records, reports and analyses for other countries are largely based on the trade in CITES listed animals (e.g., Auliya, 2003). As only three of the 15 most traded amphibians and reptiles in the USA appear on the CITES lists this renders explicit comparisons more difficult. One notable aspect, however, is that in comparison with the total CITES records the proportion of captive bred reptiles is greater in the USA trade in the period from 2001–2009 (66.9% vs. 31%; see Tables 4, 5).

Captive breeding of animals for export is becoming more and more popular in the USA with over 90% of the animals exported being derived from captive commercial breeding, something which has also been observed for the global trade in chameleons (Carpenter et al., 2004). Surprisingly, the CITES data do not show a similar trend in the increase of captive bred specimens in the trade with the total number remaining constant over the period analysed. Sustainability is of growing importance in almost any aspect of human activities and sustainable breeding of reptiles and amphibians for the trade is possible, yet lagging behind in those countries exporting most CITES-listed animals (Fig. 3). Although promoting *in situ* breeding and ranching programs in developing countries for which the trade is an important livelihood (i.e. many countries in Central and South America, South-East Asia and West-Africa, Fig. 3) may be important, its

effects on the capture of wild animals are likely contingent on the use of a quota system (Bulte & Damania, 2005). Although harvesting of ecologically versatile species with high reproductive output may be sustainable (Shine et al., 1996, 1999), many species of amphibians and reptiles are ecological specialists and have low reproductive output and thus the benefits of harvesting from the wild versus ranching or captive breeding should be evaluated carefully. Captive breeding *ex situ* is rather rare, even in countries having a long tradition in herpetoculture such as Germany or the Czech Republic (±0.07% of the total trade; Auliya, 2003). Yet, *ex situ* breeding may provide a good way to raise awareness and saturate the trade for the hobbyist with easily maintained species. By increasing the availability of easy-to-maintain species in the trade, the overall welfare of reptiles and amphibians in captivity will be improved as well. These are also the species most commonly encountered at pet shows and likely to be bought by the novice herpetoculturist (Arena et al., 2012; Prestridge et al., 2011).

Our analysis of trade data also shows that several of the most traded animals are invasive species, two of which are considered real pests (Tables 1, 4). In addition to being of real danger in the countries to which they are exported, some of these are also bred in large quantities in the USA and elsewhere, with at least one of these not being native to the USA and known to be invasive (*I. iguana*, see Tables 4, 5). Although most of the potential invasive reptiles thrive in tropical or subtropical climates, two of the most traded amphibians are known to be invasive in temperate zones as well (*R. catesbeiana* and *X. laevis*). Thus, the potential risk of the trade in reptiles and amphibians in spreading invasive species and potential novel diseases (as in the case of for example *X. laevis*; Fisher & Garner, 2007; Measey et al., 2012) is real if the trade of these species is not regulated at the international level.

Based on our analysis of the trade in reptiles and amphibians in the USA from 2001 to 2009 we conclude that the majority of the trade is confined to only a very limited number of species. Moreover, the number of captive bred specimens (excluding ranched or farmed specimens) traded appears to increase over time. This pattern is not seen in the data of CITES regulated animals worldwide despite the fact that it has been noted for some groups of reptiles such as chameleons (Carpenter et al., 2004). Figure 3D shows that the countries exporting most animals per inhabitant are in Central and South America, Southeast Asia and Africa, with the USA and Canada also being important. This suggests that the trade in reptiles and amphibians is economically important in these countries. Primary consumer countries are the USA, China (through Hong Kong) and the EU (Fig. 3B). Our analyses suggest that regulating the trade in invasive species may be of prime importance given the large numbers of those species bred and traded. Clearly, objective impact assessments of the trade can only be conducted if trade records are available and thus real efforts need to be made by the principal countries involved to make such data available for analyses.

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