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Plight of the commons: 17 years of wildlife trafficking in Cambodia

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A B S T R A C T

Southeast Asia is a hub for wildlife trafficking. Since 2001, the Wildlife Rapid Rescue Team (WRRT), a multi-agency law enforcement unit under the authority of the Cambodian Forestry Administration, has operated in Cambodia to counteract wildlife trafficking. We have analysed confiscation records from the WRRT for 2001–2018 to determine the compositional trends of trafficked species in Cambodia, and identify any detectable conservation gaps. Confiscations involved 95% native species. Over 60% of all confiscated species were either: (i) not listed in CITES; (ii) listed as Least Concern on the IUCN Red List; and/or (iii) Common under the Cambodian Forestry Law. These common, and usually less appreciated, species in trade may face greater future threats through trafficking and thus require better protection.

Birds had the most number of animals confiscated, and songbirds were particularly heavily trafficked. In terms of the number of incidents, reptiles were the most confiscated Class. A small number of specific reptile species were consistently targeted, and particularly prominent was turtle and tortoise trafficking. Conversely, birds appeared to be trafficked opportunistically. Most bird species were only confiscated in a single year, and almost two thirds of all bird species were replaced by different species each year. We show that Cambodia is contributing substantially to the bird trade and this may be an under-reported element of the Asian songbird crisis.

1. Introduction

Wildlife trafficking is a lucrative business, endangering thousands of species and millions of individual animals and plants each year (Broad et al., 2002; Wyatt, 2013). Southeast Asia is a hub for wildlife trafficking (Harrison et al., 2016; Nijman, 2010), and while most conservation and enforcement efforts have focussed on large, charismatic mammals, less is publicised about the many species of reptiles and birds, and lesser known mammals in trafficking. Yet, the songbird trade is contributing to '*silencing the forests*' of Southeast Asia (Lee et al., 2016), and is a pressing conservation issue. Similarly, reptiles are trafficked in the millions (Nijman and Shepherd, 2015), and smaller mammals, such as pangolins, are being driven to extinction (Challender et al., 2014b).

Species that are already, or may become, threatened by international trade can be listed in one of the three Appendices of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora. CITES listings do not always result in adequate protection of a species, but it is arguably the best existing tool to protect species from overexploitation for international trade (Rivalan et al., 2007). Recently, it was found that it takes an average of 10.3 years for species to be listed in CITES, from the time they are first identified by the IUCN as threatened by international trade, to the time they are listed in one of the CITES Appendices (Frank and Wilcove, 2019). This is too long for many species, especially lesser known ones, which need to be protected from trade and trafficking immediately, to prevent them from extinction (Eaton et al., 2015).

Southeast Asia is a biodiversity hotspot where wildlife trade is a major threat to many species (Sodhi et al., 2004). In all countries in the region important information gaps exists on wildlife trade dynamics (Sodhi et al., 2010). Here we present a case study for one of those countries. We investigate a unique dataset of wildlife confiscations in Cambodia, from 2001 to 2018, and analyse the compositional differences and temporal trends for key vertebrate taxa (birds, mammals and reptiles), which are heavily trafficked in the country.

Cambodia was ruled by the *Khmer Rouge* from 1975 to 1979, who left behind a devastated country. Armed conflicts can be highly detrimental for wildlife (Dudley et al., 2002; Gray and Prum, 2012; Loucks et al., 2009; McNeely, 2003). During the genocide, Cambodians increasingly relied on wildlife for subsistence, to fulfil their basic needs for food and medicine (Martin and Phipps, 1996). After the disposition of the *Khmer Rouge*, the country was heavily landmined, and weapons

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were readily available, leading to a further decline in wildlife (Loucks et al., 2009; Martin and Phipps, 1996). The (illegal) use of wildlife products was and continues to be high, increasingly so with the facilitation of trade through the opening of borders to neighbouring countries in more recent times. Recent wildlife seizures suggest that Cambodia may not only be a source, but also a transit country for different species (EIA, 2018; Gray et al., 2017a).

Traditional Medicine (TM) has always been widely used in Cambodia, and in many instances it was the only healthcare, especially for the rural poor (Ashwell and Walston, 2008); although this appears to be changing now. Endangered and rare species are considered more potent in TM, and are thus highly coveted (Ashwell and Walston, 2008). These rare and endangered species are usually priced higher than common species, and can be unaffordable for most Cambodians (Ashwell and Walston, 2008). Wealthier Cambodians commonly invest in western medicine when they get sick, but they continue to use Traditional Khmer Medicine (TKM) in conjunction. It is believed that most rare and expensive animal ingredients are destined for international markets, mostly in China, Thailand and Vietnam (Ashwell and Walston, 2008; Martin and Phipps, 1996). However, there are also threatened species that are used in TKM and which continue to be used locally, such as serow (*Capricornis* spp.) or loris (*Nycticebus* spp.) (Gray et al., 2017b; Starr et al., 2010).

Cambodia has been a Party to CITES since 1997, and is classified as a Category 1 country, meaning that the legislation in place generally meets the requirements for the implementation of CITES (CITES, 2018). Relevant laws for the trade and use of wildlife include: i) the Sub-decree on International Trade in Endangered Animals and Plant Species from 2006 (the main legislation for the implementation of CITES); ii) the Law on Fisheries from 2006; iii) the Protected Area Law from 2008; and iv) the Law on Forestry from 2002. Notably, wildlife trafficking is also a predicate crime under Cambodia's anti-money laundering laws, which is especially important, given the increasing involvement of organised criminals in wildlife trafficking (ASEAN-WEN, 2016).

There are several NGOs in Cambodia working to address and help combat wildlife crime, including Wildlife Alliance. In 2001 Wildlife Alliance partnered with the Cambodian Government to more effectively combat wildlife crime in Cambodia. The result was the Wildlife Rapid Rescue Team (WRRT), consisting of judicial police officials from the Forestry Administration and Military police from the Royale Gendarmerie. They are assisted by full-time staff from Wildlife Alliance who provides animal husbandry training, technical assistance for investigations, and logistical and financial support (see also Gray et al. (2017b)).

The study presented here is based on the confiscations made by the WRRT, i.e., the national wildlife police unit, over the last c. 17 years, and aims to provide an overview of wildlife confiscations in Cambodia, to capture conservation gaps and compositional trends of concern. A study of this magnitude and covering such a long time has never been conducted for Cambodia, or in the region, and is an important contribution to the scientific literature. We predicted that most species that were confiscated would be native, as Cambodia is predominantly known as a source country for a variety of wildlife species, both for consumption locally, as well as to meet international demand (Ashwell and Walston, 2008; Martin and Phipps, 1996). Since more attention is often paid to charismatic and iconic animals, we predicted that mammals would be the most confiscated animal Class. We also expected that species richness and diversity (but not abundance) of all three Classes would decrease through time, due to increased levels of trafficking in the country, and more targeted trafficking of specific species.

2. Methods

We analysed wildlife seizures in Cambodia from 2001 to mid-2018 conducted by the WRRT. All species names were standardised according to the 2018 Annual Checklist of the Catalogue of Life (http://www.catalogueoflife.org/annual-checklist/2018/). Data for the national protection status of species in Cambodia (species classified as either Rare, Endangered, or Common according to the Law on Forestry of 2002), were obtained from Annexes 1, 2 and 3 of Prakas No 020, PK.MAFF (Ministry of Agriculture, Forestry and Fisheries), dated 25 January 2007. Only animals classified to the species level are listed in the Prakas, with the exception of the entire bat Order *Chiroptera*. As it was unclear if this included all species of Chiroptera worldwide, or only a proportion of these, the Order listing was excluded, with the exception of single species of Chiroptera, which were listed separately in the Prakas. Data for IUCN status, as well as whether a species was native to Cambodia, were obtained from the IUCN Red List (www.iucnredlist.org), last accessed in November 2018. For reptile species not listed by the IUCN, their native status to Cambodia was obtained from the Reptile Database (www.reptile-database.org). We consolidated the IUCN categories 'critically endangered', 'endangered', and 'vulnerable' to a single category 'Threatened', while species listed as 'least concern' and 'near threatened' were consolidated into a single category 'Lower Risk'. All other species were classified as 'Not Listed'. It should be noted, that some reptile species are about to change status on the IUCN Red List (see Rhodin et al. (2018)). The current CITES listing of a species was obtained from the CITES website (checklist.cites.org). We consolidated the CITES categories into 'Listed', for species listed in Appendix I, II, or III, and 'Not Listed', for species not listed in any Appendix. All confiscated animals and their parts and derivatives were converted into 'whole estimated animals' (see Appendix S1 and Table S1 for further details).

Law enforcement operations by the WRRT (on average 379 conducted per year; increasing through time) are planned and intelligence driven. Intelligence is obtained from a 24/7 public wildlife trade hotline (which is advertised widely throughout the country), a network of confidential informants, and increasingly information provided from local government authorities. All data and information is managed by Wildlife Alliance civilian staff who works with government counterparts to plan operations and raids. Due to the small size of the team not all information can be acted upon. A number of proactive operations are also conducted in locations (e.g., markets) known, or believed, to be hotspots for wildlife trade.

On average, 19% of the number of illegal wildlife trade incidents recorded by Wildlife Alliance per year consisted of surrendered animals, i.e., where animals and their parts that had been illegally kept were handed over without resistance to Wildlife Alliance. Both wildlife that had been handed over, as well as confiscations represent instances of illegal wildlife trade, and are here collectively referred to as 'confiscations'.

We estimated trends in the number of confiscations and the number of confiscated animals through time from 2003 to 2017, accounting for the number of annual operations that were conducted by the WRRT. There were no data that could be assigned to the year 2002, and data were only partially available for the years 2001 and 2018. These 3 years, as well as any confiscations for which no year could be assigned (n = 689), were thus excluded from the analysis of trends through time. We used generalised additive models (gam), which allowed nonlinear patterns to be assessed. Models were fitted using a log link function and, as the data was over-dispersed, a negative binomial variance function. We tested for temporal autocorrelation, but did not find evidence of correlation in the residuals. We compared all possible models with the number of operations, or an offset of the number of operations (which assumes that effort, measured in number of operations, is proportional to the number of confiscations and number of confiscated animals), and the effect of time (years) as explanatory variables. Ultimately, the model, with the offset of number of operations while additionally accounting for a trend over time was the highest-ranked model for explaining both the number of confiscations, as well as total number of animals confiscated. All data were analysed in the R software environment (version 3.4.3; R Core Team (2017)). We fitted gam models

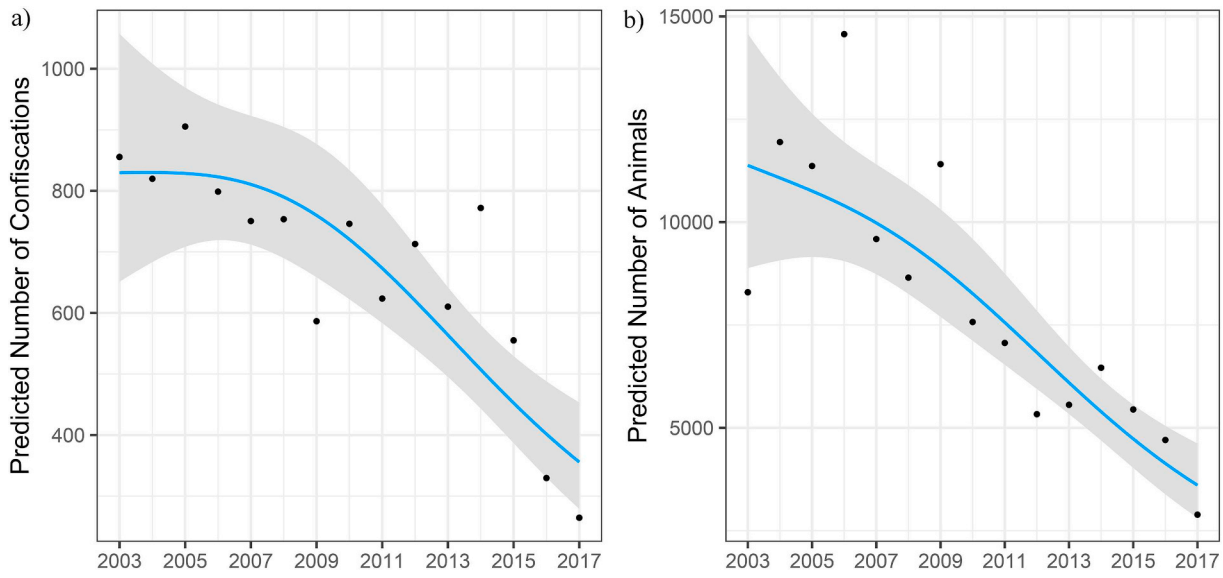

Fig. 1. The estimated number of a) confiscations, and b) animals, from 2003 to 2017. The estimated relationships (in blue) are predicted from generalised additive models, accounting for the effect of time and effort. Shaded gray areas represent 95% CI. See Fig. S2 for the raw data. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

using the 'mgcv' package (Wood, 2011), and the model ranking was done using the 'MuMIn' package (Barton, 2019).

Species richness, abundance, and diversity through time were calculated using the 'vegan' package (Oksanen et al., 2017). Species diversity, was calculated as the Shannon's Diversity Index (*H*):

$$H = -\sum_{i=1}^{R} p_i \ln(p_i)$$

where R is the number of confiscated species in a year and p_i is the proportional abundance of species *i*. Shannon's *H* was converted to the effective number of species (exp(*H*)) for analysis and visualisation (Jost, 2006).

The total turnover of species identities between years reflects the summed additions and removals relative to the total species richness across consecutive pairs of years. Additions and removals were calculated with the number of species that were added or removed in each consecutive year, relative to the total species richness across years. Species temporal turnover was calculated using the 'codyn' package (Hallett et al., 2016). Turnover in relative abundances of confiscations were calculated using measures of beta diversity (using package 'betapart' (Baselga and Orme, 2012)), and distance-based tests were used to assess differences between Orders (Anderson, 2006). We used negative binomial generalised linear mixed models (glmm) to test the effect of different categorical predictor variables on the number of animals per species that had been confiscated, with the taxonomic hierarchy of each species (Class/Order/Family) fitted as random effects (package 'glmmTMB' (Brooks et al., 2017)). We used the above described consolidated categories of IUCN and CITES listings, and categorised the Forestry Law listings further into: i) Endangered (including Endangered and Rare animals); ii) Common; and iii) Not Listed, as explanatory variables.

Bespoke permutation tests were conducted to analyse which Orders were over-represented in confiscations (following the approach described by Blackburn et al. (2017)). The permutation tests were used to test for a difference between the observed number of species per Order that were confiscated by the WRRT in Cambodia and the expected number of species per Order if the species were selected randomly. The permutation tests involved 1000 iterations, picking the number of species randomly from the species per Order listed under the Cambodian Forestry Law, and summing the number of randomly chosen species in each Order. The observed number of species in each Order was judged significantly greater than expected, if at least 95% of the randomly derived values for that Order were greater than the observed. The same procedure was followed to test for a difference between the observed number of incidents (and number of animals per species) and the expected number of incidents (and number of animals per species) if they were selected at random. In these cases, we chose the number of incidents (and number of animals) randomly, from the number of species per Order that occurred in the dataset.

3. Results

3.1. Confiscations and temporal trends

Between 2001 and mid-2018, an estimated 125,445 animals were confiscated in 10,829 incidents throughout Cambodia (Fig. S1). The animals belonged to at least 268 different species of 211 Genera in 97 Families of birds, reptiles and mammals. In 2244 incidents (26%), animals or their parts had been kept illegally in Cambodia and had been surrendered to Wildlife Alliance. Of these, 97% of incidents involved live animals (consisting of at least 12,800 live animals), while of the remaining 8585 incidents, only 38% involved live animals (consisting of at least 44,947 live animals).

When confiscation effort was taken into account, measured in number of operations through time, the estimated number of confiscations, as well as number of confiscated animals declined significantly in recent years (Fig. 1). In 2003, the estimated number of confiscations was 830 (95% CI: 651–1057), in 2010 it was still at 721 (623–834). Subsequently, the estimated number of confiscations has been reduced to 356 (279–453; Fig. 1a) in 2017. Similarly, the estimated number of confiscated animals follows the same trend. In 2003, the estimated number of animals was 11,379 (8882–14,577), in 2010 it was at 8262 (7118–9590), and in 2017 it was reduced to 3605 (2814–4619; Fig. 1b) – a third of what it was in 2003.

3.2. Differences between taxonomic classes

Of the incidents where animals were identified to at least Class (10,751 incidents; 99% of all incidents), reptiles had the highest number of incidents with a total of 4125 incidents (or 38%), while birds had the lowest number with 2970 incidents (28%). However, in terms

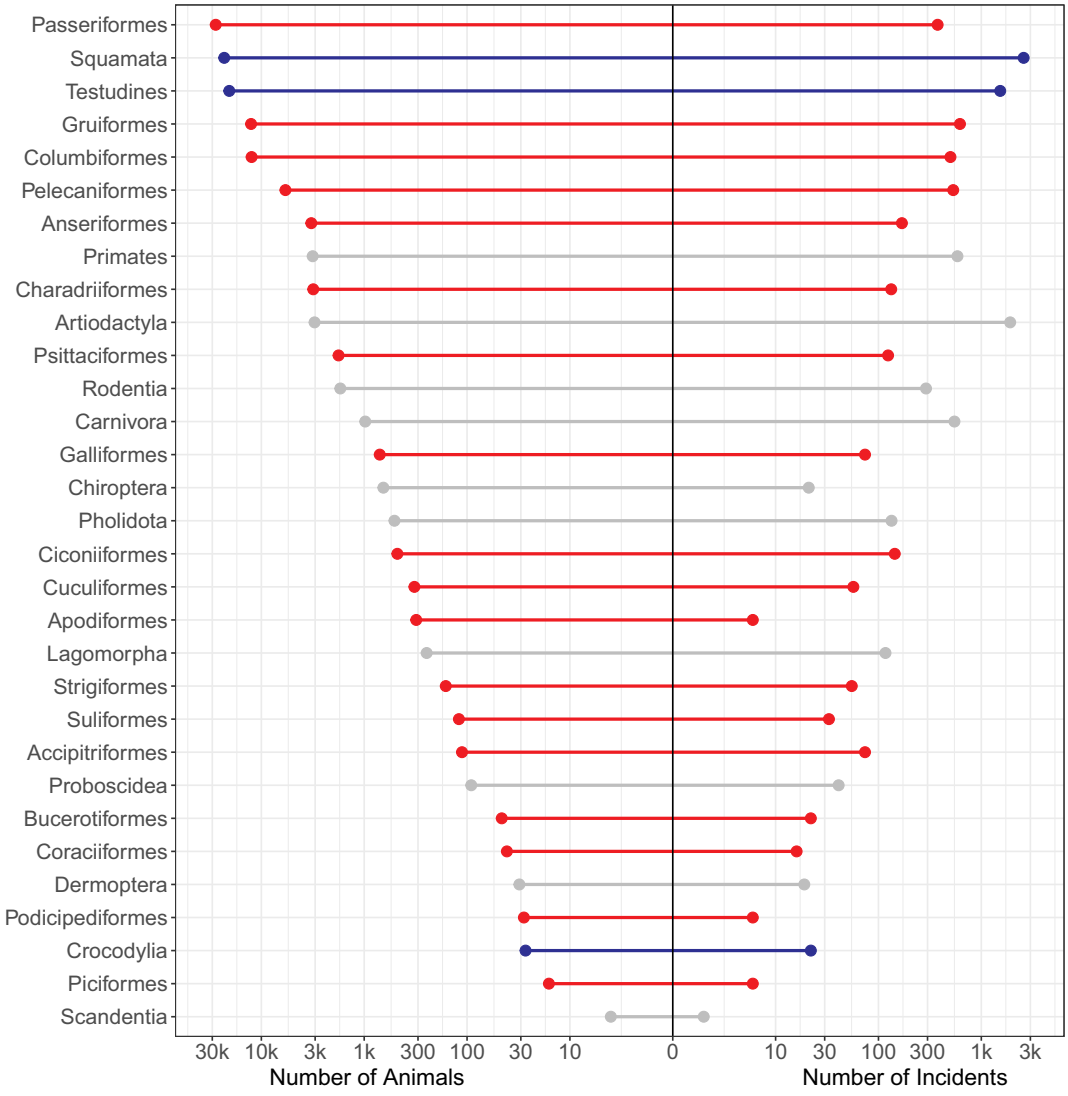

Fig. 2. The Orders of animals confiscated in Cambodia of either birds (red), mammals (gray), or reptiles (blue). Depicted are the number of animals in 'whole estimated animals' (from the middle to the left), and the number of incidents (from the middle to the right). Note that the x-axes are displayed on a logarithmic scale. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

of the number of animals confiscated, birds were the most confiscated Class, with an estimated 71,440 animals (57%), while mammals had the lowest number, with an estimated number of 10,414 animals (8%). The average number of birds per incident was significantly higher than for both reptiles (mean difference = −0.82, SE = 0.034, *p*-value < .001) and mammals (mean difference = −2.13, SE = 0.036, p-value < .001). The average number of confiscated mammals per incident was also significantly lower compared with reptiles (mean difference = 1.31, SE = 0.033, $p < .001$).

Within the three Classes, 31 different Orders were confiscated (Fig. 2). The songbirds (Passeriformes) had by far the highest overall number of animals, with almost 28,000 estimated whole animals (Fig. 2b). Snakes and lizards were the next most abundant taxa (Squamata; 23,000), followed by turtles and tortoises (Testudines; > 20,000). Testudines and Squamata were also among the three most confiscated Orders in terms of the number of incidents (Fig. 2a). The second most confiscated Order were the even-toed ungulates (Artiodactyla; Fig. 2a). It should be noted that the quantity we were unable to convert into whole estimated animals (see Appendix S1) included over 2 t of plastrons and shells of different turtles and tortoises alone, which are not reflected in this analysis. The most confiscated species are displayed in Fig. S3.

3.3. Turnover, abundance and diversity of confiscated animals

During 2003–2017, a mean number of 17.5 new species (SE = 5.6) were confiscated each year (i.e., species which had not been confiscated in any of the previous years). During these 15 years, a species lasted on average only 6.4 years in trade (SE = 0.4); from the year they had first been confiscated to the year they had last been confiscated. Of the 263 species confiscated between 2003 and 2017, there were 90 species (34%) that only occurred in a single year, whereas only 15 species (6%) were confiscated in each of the 15 years (Fig. S4). Of these 15 species, 6 were classified as threatened by the IUCN (see Fig. S3).

Species of birds showed the highest overall richness (Slope = 0.017, SE = 0.009, $p = .063$; Fig. 3a), diversity (Slope = −0.059, SE = 0.174, $p = .736$; Fig. 3b) and abundance (Slope = 0.019, SE = 0.024, $p = .442$; Fig. 3c), which were all relatively constant through time. For mammal species, their richness (Slope = −0.016, SE = 0.009, $p = .076$; Fig. 3a) and diversity (Slope = 0.176, SE = 0.174, $p = .317$; Fig. 3b) were relatively constant through time, while their abundance decreased (Slope = −0.059, SE = 0.024, $p = .019$; Fig. 3c). For reptiles, species richness increased significantly through time (Slope = 0.019, SE = 0.009, $p = .037$; Fig. 3a), while their diversity remained constant (Slope = −0.001, SE = 0.174,

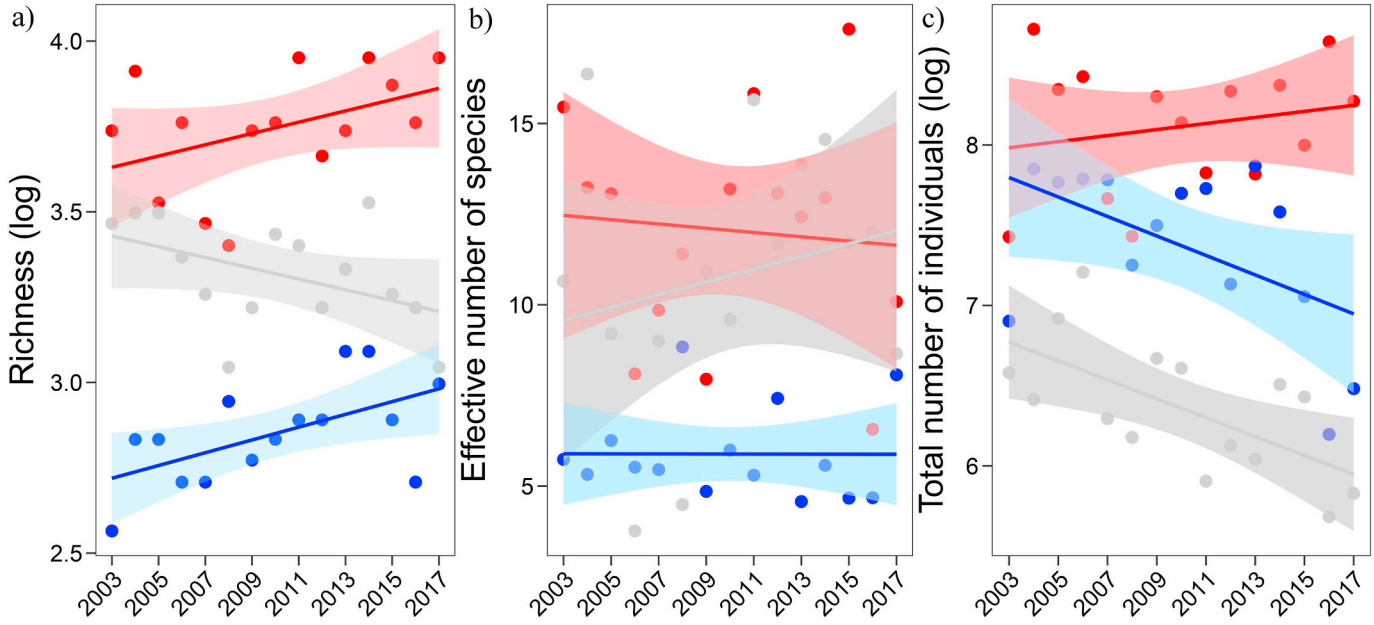

Fig. 3. Plots of the estimated temporal trends in a) log species richness, b) exponential Shannon diversity (effective number of species), and c) log total abundance for birds (red), mammals (gray), and reptiles (blue). Coloured bands represent 95% CI following the same colour scheme. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

p = .995; Fig. 3b) and their abundance declined significantly (Slope = −0.061, SE = 0.024, p = .017; Fig. 3c).

The turnover of species occurrences of all Classes remained relatively constant through time, but was lower for birds (Coefficient of variation (CV) = 12%) than for mammals (CV = 25%) and reptiles (CV = 32%). Birds showed the highest turnover rate, with almost two thirds of all confiscated bird species replaced by different bird species each year (mean turnover = 0.60, 95% CI = 0.56, 0.64; Fig. 4). The average turnover was slightly lower for mammals (0.51, 95% CI = 0.38, 0.51), and was much lower for reptiles (0.30, 95% CI = 0.25, 0.36), with only about one third of all confiscated reptile species replaced with different species each year, and thus the majority of confiscated reptile species were found consistently through time (Fig. 4). Accounting for the relative abundances of the confiscated species, there were substantial differences in the variability of temporal turnover between birds, reptiles and mammals ($F_{2, 42}$ = 6.5, p = .004), with the highest variability occurring for birds (Fig. S5).

3.4. Overrepresented orders

Of all the confiscated species, 95% were native to Cambodia and listed in either IUCN, CITES and/or under the Cambodian Forestry Law of 2002 (hereafter referred to as the 'Forestry Law'; Table 1). The species that were most confiscated, based on the number of animals, were generally less likely to be listed under the Forestry Law as endangered or rare (mean difference = −1.67, SE = 0.41, p < .001), or

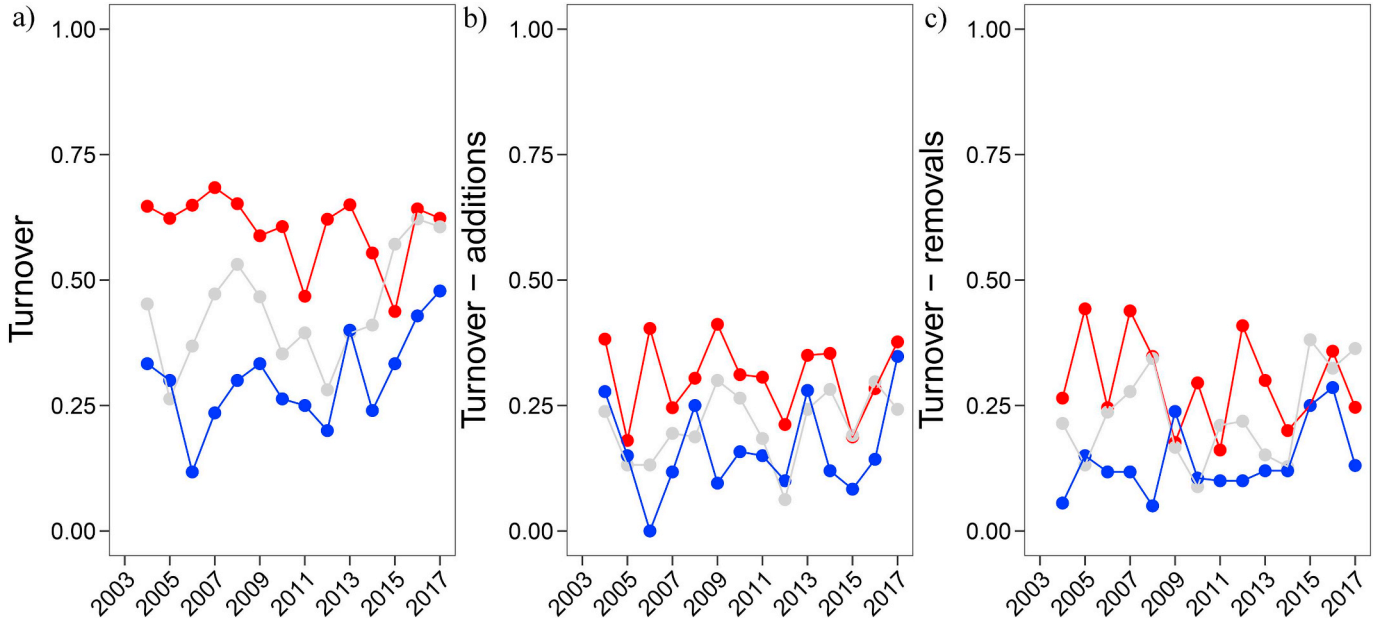

Fig. 4. Plots of the turnover in the species occurrences over time: a) total turnover, b) additions, and c) removals for bird (red), mammal (gray), and reptile (blue) species. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Percentage representation in the protection status listing categories of the 268 confiscated species in Cambodia.

Category	Listing	Species
CITES listing		
Listed	Appendix I	10%
	Appendix II	25%
	Appendix III	3%
Not listed	Not listed	62%
IUCN listing		
Threatened	Critically endangered	3%
	Endangered	8%
	Vulnerable	12%
Not Listed	Data deficient	1%
	Not listed	3%
Lower Risk	Near threatened	8%
	Least concern	65%
Forestry law listing		
Endangered	Endangered	2%
	Rare	19%
Common	Common	65%
Not listed	Not listed	14%

not to be listed at all under the Forestry Law (mean difference = −1.07, SE = 0.47, p = .024). They were also more likely to be listed in CITES (mean difference = 0.85, SE = 0.39, p = .028). The majority of the variance in the taxonomic classification of confiscated animals was explained by Family-level differences (~92%), relative to Order (~8%) and Class (< 1%) differences.

Given the number of species listed under the Forestry Law, the Orders that were overrepresented in Cambodian trafficking, i.e., the Orders which had more confiscated species than could be expected by chance, were the carnivores (Carnivora), rodents (Rodentia), primates (Primates), even-toed ungulates (Artiodactyla), cranes, rails and crakes (Gruiformes), and pangolins (Pholidota; Fig. 5a). Given the number of species confiscated, the Orders that were overrepresented, i.e., which were involved in more confiscations than could be expected by chance, were again Primates, Artiodactyla, Gruiformes, and Pholidota, and additionally the doves and pigeons (Columbiformes), hares and rabbits (Lagomorpha), as well as Squamata, and Testudines (Fig. 5b). In terms of the number of confiscated animals, i.e., the Orders that had more animals involved in the confiscations than could be expected by chance, were the Squamata, Testudines, Gruiformes, Columbiformes, and additionally the pelicans, herons, ibis etc. (Pelecaniformes), ducks, geese etc. (Anseriformes), parrots (Psittaciformes), as well as the Passeriformes (Fig. 5c).

The 65 Families within the 14 Orders that were shown to be overrepresented in either one of the three analyses are presented in Fig. S6. Notably Pythonidae and Geoemydidae were the most confiscated Families for reptiles, both in terms of the number of animals as well as number of incidents, followed by the Varanidae (in terms of number of incidents) and the Testudinidae (in terms of number of animals). For birds, the most confiscated animals belonged to the Cisticolidae, Rallidae, Columbidae and Ardeidae. For mammals, the most confiscated Families were the Cervidae, Suidae, and Cercopithecidae in terms of number of incidents, and again the Cercopithecidae, followed by the Hystricidae and Cervidae, in terms of the number of animals (Fig. S6).

4. Discussion

With over 10,000 incidents and over 125,000 estimated confiscated animals in c. 17 years the WRRT has made a substantial contribution to combatting wildlife crime in Cambodia. The analysis presented here is based on the confiscations made by the WRRT and while we presume that the rate of confiscations mirrors levels of trafficking, these results can be biased (Underwood et al., 2013). For example, with changing numbers of informants and operations conducted throughout the country, the number of confiscations may reflect these changes more

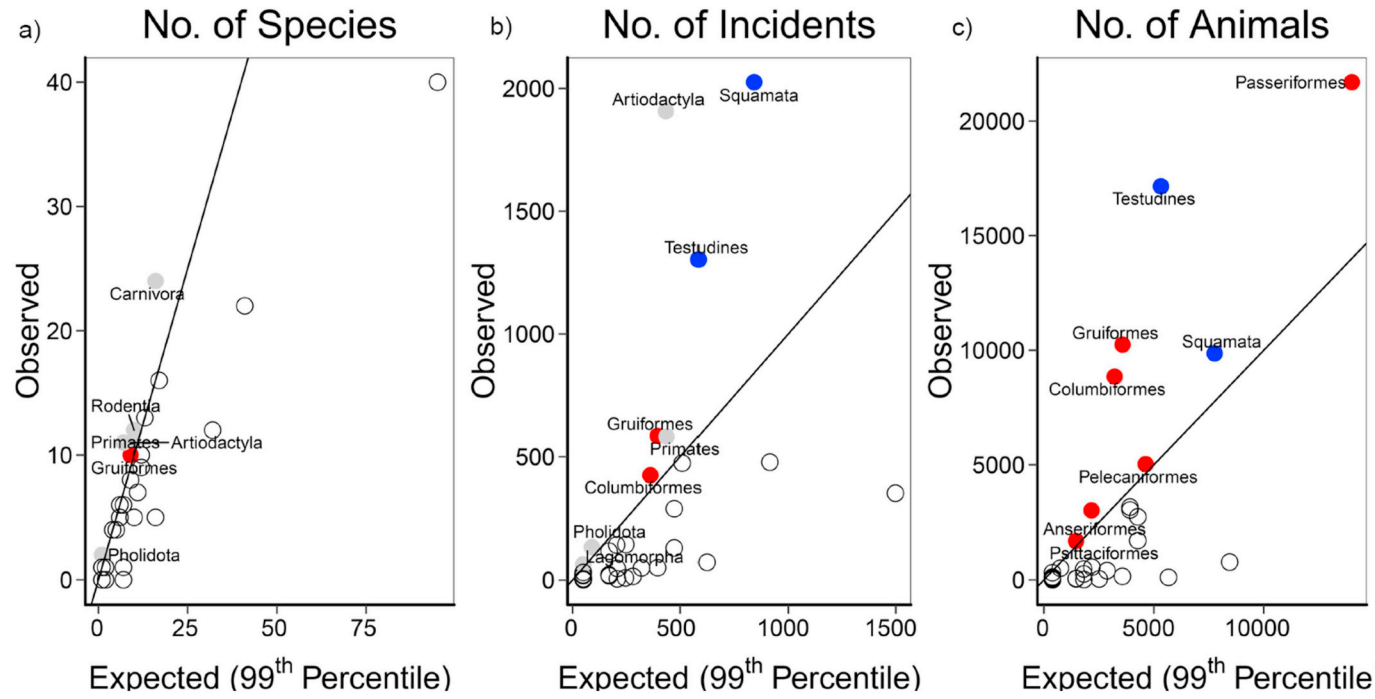

Fig. 5. Permutation tests for over-represented species in Cambodian confiscations, based on a) the number of species listed under the Forestry Law, b) the number of incidents per species, and c) the number of animals per species. The observed number of species was inferred as being significantly greater than expected if at least 95% of the randomly derived values for that Order were greater than the observed. The matching over-represented Orders are shown in colour above the line in the plots, with Orders belonging to either birds (red), mammals (gray), or reptiles (blue). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

closely than genuine trafficking levels. The locations of the confiscations are likely influenced by the population density per province, but also the proximity to Wildlife Alliance's base in Phnom Penh, resulting in a larger number of confiscations in and around the capital. Our data also did not include information on trade routes, and we cannot draw conclusions on the destination of the confiscated animals, and whether (or which) species were to be trafficked out of the country or used domestically. However, Cambodia's borders to neighbouring countries are porous and cross-border trade is likely considerable.

Our results show a significant decline in wildlife confiscations through time, both in terms of the estimated number of confiscations, as well as the estimated number (and identity) of confiscated animals. These results are taking into account the number of operations per year, which have increased through time, but are resulting in relatively fewer confiscations and fewer confiscated animals. The worst-case scenario is that this is an indication of reduced availability of wildlife, caused by population declines throughout the country. However, it is also possible that it is a reflection of reduced levels of wildlife trafficking, e.g., due to increased awareness among people regarding the existing laws and the illegality of their activities. The traffickers may have also become more adept at avoiding capture. Another plausible explanation is that the way the operations are conducted by the WRRT has changed through time. Prior to the establishment of the WRRT open physical markets selling a wide variety of wildlife products were widespread in Cambodia (e.g. Martin and Phipps (1996)). In early years of WRRT operations, these were often the targets of raids and resulted in high numbers of confiscations. The disruption and closure of these large multi-species physical wildlife markets is likely a driver of the subsequent decline in the volume of wildlife seized by the WRRT, despite increasing efforts.

Further limitations of this study include that certain species may have been missed in this dataset, not because they are not trafficked, but because they were not confiscated (or identified), while others may be comparatively overrepresented. Reptiles were the Class with the most unidentified species (i.e., 59% of incidents containing animals or their parts that were unidentified to the species level; $n = 1313$), and we were unable to convert over 4.5 t of reptile commodities into estimated whole animals. The number of animals in the analysed data is also certainly much lower than the actual number of animals trafficked in Cambodia. For example, Gilbert et al. (2012) estimated an annual turnover of c. 690,000 birds, for merit release purposes, and only in Phnom Penh. Brooks et al. (2007) estimated that c. 6.9 million water snakes were annually extracted just from the Tonle Sap Lake. These studies dwarf the estimated 72,000 confiscated birds and 44,000 reptiles in a 17 year period, from confiscations across the entire country. Furthermore, there are other wildlife teams in different parts of the country that are not part of the WRRT and whose confiscations are not reflected in the current analysis. While every precaution in identifying animals to the species level was taken, misidentifications and data entry errors can happen, even with highly knowledgeable and trained staff, and while curating these kind of data. Nevertheless, our dataset provides a unique insight into the trafficking of wildlife in an important country for wildlife trafficking in Southeast Asia. The dataset comes from a single source with consistent reporting practices over a long period of time and encompasses an enormous breadth of taxonomic groups.

Much of the taxonomic breadth of the confiscated species can be explained by the rapid turnover of species, especially birds. Each year two thirds of all bird species were replaced by different ones, which is a strong indication that most birds are not targeted for specific species, but poached opportunistically. Snares, nets, and sticks covered in glue, among other methods, are often used to trap birds illegally (Brochet et al., 2016; Gray et al., 2018; MaMing et al., 2012). These methods are non-selective, easy, and cheap to replace, and removal alone is largely ineffective (Gray et al., 2018). While we found at least 19 different Orders of birds involved in Cambodia's wildlife trafficking, the songbirds (Passeriformes) were by far the most confiscated animals. The Asian songbird crisis is threatening an increasing list of species, and depleting populations across Asia (Chng et al., 2015; Lee et al., 2016). However, the songbird trade in Cambodia seems to be an under-reported element of this crisis and here we reveal that large-scale songbird trafficking occurs across the country. Songbirds are harvested around the world, for religious reasons (i.e., prayer releases), food, as well as for the pet and cagebird trade, and for songbird competitions (Bhattacharya, 2016; Brochet et al., 2016; Gilbert et al., 2012; Regueira and Bernard, 2012; Su et al., 2014). Many species involved in this trade are currently lacking adequate protection from overexploitation (Chng et al., 2015; Lee et al., 2016; Regueira and Bernard, 2012; Shepherd et al., 2013), and this might also be the case for Cambodian species. Further research is required to determine specifically why the different species of songbirds are trafficked in Cambodia, and what impact the trafficking has on their populations.

While bird trafficking appears to be largely opportunistic, some reptile species were heavily targeted, and the same species were repeatedly confiscated every year. This places considerable pressure on a few highly desired species. There are a number of scenarios that could explain the decline in reptile abundance through time; the worst being that their numbers in the wild are declining. However, it is uncertain if this is the case, or if this decrease was caused by other factors, such as reduced demand, or a shift in focus by the WRRT. Reptiles had the highest number of species that were confiscated in each of the 15 years, while birds had the highest number of species in just a single year of trade. Snakes, such as pythons, as well as turtles and tortoises (testudines), were confiscated in particularly high numbers.

While arguably many of the species presented in Fig. S3 may be of conservation concern in Cambodia two species stand out: The Burmese Python (*Python bivittatus*) and the Mekong Snail-eating Turtle (*Malayemys subtrijuga*), which were among the species that were confiscated in 15 consecutive years, and were additionally among the most confiscated animals, both in terms of number of confiscations, and number of animals. The Burmese Python is listed in CITES Appendix II, as part of the Family listing of the Pythonidae spp., and is listed as Vulnerable on the IUCN Red List (Stuart et al., 2012). Prized for their use in traditional medicines, for food, luxury items, as well as pets, they are believed to be declining in the wild. As there are no official python farms in Cambodia (Natusch and Lyons, 2014; Thomson, 2008) we believe that the estimated 4283 confiscated *P. bivittatus* across 1129 incidents are most likely to have come from the wild. The Mekong Snail-eating Turtle (or 'rice field turtle' as it is termed in Cambodia) is also listed in CITES Appendix II and as Vulnerable in the IUCN Red List. Its status needs urgent updating, with the last assessment having been conducted almost 20 years ago (Asian Turtle Trade Working Group, 2000). Recently, however, the IUCN Tortoise and Freshwater Turtle Specialist Group classified them as Near Threatened in a 2018 provisional assessment (Rhodin et al., 2018). Emmett (2009) reports this species to be decreasing in Cambodia, due to over collection for food and loss of habitat. It is also reported they are hard to breed, and younger individuals are often released, as in most cases they cannot easily be reared to food market size (Emmett, 2009). However, due to religious reasons ('merit release'), the juveniles are often sold to be released back into the wild (Emmett, 2009). *M. subtrijuga* was also one of the most frequently encountered turtle species for sale in Vietnam (Stuart, 2004) and Lao PDR (Schweikhard et al., 2019). We found almost 9000 *M. subtrijuga* confiscated across 499 incidents, giving reason for conservation concern of this species.

Many species that are now perceived as 'common' may not remain common in the future if current levels of exploitation continue. Species that were once abundant and did not receive sufficient attention in the past are now critically endangered due to high levels of trade and trafficking; e.g., pangolins (Challender et al., 2014a; Newton et al., 2008). There are many other species that are currently falling under the radar, but which are trafficked frequently and in such high numbers

that they urgently need better protection. One of these species is the Malayan porcupine (*Hystrix brachyura*). The Malayan porcupine is classified as Least Concern in the IUCN Red List (Lunde et al., 2016) and not listed under CITES, despite the use and international trade of this species dating back centuries (Duffin, 2013; Yew et al., 2018). Farming of porcupines does not currently occur in Cambodia, although there are several farms in Vietnam (Thomson, 2008). However, investigations into the conservation impact of porcupine farming in Vietnam indicate that the majority of porcupine farms use wild caught animals to restock, and restaurants still prefer wild porcupine meat, and it is unlikely that these farms have a positive impact on porcupine conservation (Brooks et al., 2010). Farm owners also indicated that they believed demand for porcupines was increasing (Brooks et al., 2010). *H. brachyura* is heavily trafficked for its meat, inner organs and bezoar, as well as other body parts, and we found the Malayan porcupine to be among the most confiscated animals in Cambodia. It is likely that persisting demand and overexploitation will extend to all eight Asian species of Hystricidae, and future demand may put increasing pressure on the three African species, similar to what has been observed for African pangolins after the decline in Asian pangolin species (Heinrich et al., 2016). Like many other lesser known or less appreciated species, trade in at least the Malayan porcupine needs to be regulated in range countries, as well as internationally through CITES. Currently, conservation approaches are very reactive and usually species are only protected (at least on paper) if they are already threatened and declining. However, to adequately protect species we need to foresee these changes and it may be warranted to apply more cautious and proactive conservation approaches in the future. Species should ideally be protected before they disappear from the wild and this includes protecting species that may be perceived as common, but for which trade, both legal and illegal, is likely to have negative impacts on populations, should current levels of trade continue.

Over 60% of all species confiscated in Cambodia were not listed in CITES, however, the majority of confiscated animals belonged to species that were CITES listed. While not all species trafficked locally in Cambodia necessarily need to be protected by CITES, many species are being trafficked without trade being recognised as a threat to them (see also Frank and Wilcove (2019)). This is also evidenced by > 60% of all confiscated species in Cambodia being listed as 'Common' under the Forestry Law, as well as Least Concern in the IUCN Red List. More research is required to estimate the level of threat to these species, and whether or not they are also traded internationally and if they should be included in CITES, re-assessed in the IUCN Red List, or simply better protected locally in Cambodia. The latter is likely necessary for an array of species, and it is critical that the existing laws in Cambodia are implemented and enforced in order to conserve species in the wild.

As our analysis has demonstrated, the majority of confiscations by the WRRT concern species listed as 'Common' under the Cambodian Forestry Law. A major challenge is the often obsolete classification of species, as 'Endangered', 'Rare', and 'Common'. Until 2018 (when all species of elephant, pangolin, and rhinoceros were added to the Forestry Law) no non-native species were protected. The 13 mammal species receiving the highest level of protection ('Endangered') include one mythical (khting vor "*Pseudonovibos spiralis*"), one globally extinct (kouprey *Bos sauveli*), and two extirpated species from Cambodia (Javan Rhinoceros *Rhinoceros sondaicus* and tiger). Of the 47 IUCN Threatened or Near-Threatened mammal species occurring in Cambodia 13, including fishing cat *Prionailurus viverrinus*, binturong and sambar, are classified as 'Common', with their trade and consumption involving minimum penalties. An additional challenge is that the Fisheries Law, which covers the trade in all species which 'breed in water' (including aquatic reptiles such as the Critically Endangered Siamese crocodile and southern river terrapin *Batagur affinis*) provides limited mandate to forcefully seize and prosecute based solely on the possession, transport and trade of live animals. Furthermore, confiscation is only legally required on an individual's second offence, but animals are sometimes voluntarily handed over by first-time offenders. Further, the existing laws are often not respected nor implemented, and courts are often reluctant to prosecute offenders. Both may be facilitated by corruption, but also by a lack of concern and prioritisation of wildlife crime.

Snaring of wildlife is posing a major threat to all vertebrates in Southeast Asia and is a likely cause of the capture of many of the mammals confiscated by the WRRT. The use and possession of snares may need to be addressed through changes in legislation, as suggested by Gray et al. (2018). Wildlife Alliance is removing hundreds of thousands of nets and snares each year, which are threatening all animal species in the region (Gray et al., 2018). However, Gray et al. (2018) also found that simply removing the traps, which are quickly and easily replaced by hunters, is not effective, and suggested that Cambodian legislations may need to be amended, for example, by penalising the possession of snares (including electric wires), and material used to build them, in or near protected areas. They also suggested that law enforcement efforts need to be increased, and long term demand reduction activities implemented to address the consumption of wildlife products in Southeast Asia. We strongly support these recommendations. If strong legislation concerning snares and dedicated efforts to remove them could be implemented, the trade could be reduced substantially.

In conclusion, we found most species that were confiscated are not well protected internationally nor domestically. Many perceived common species were found in Cambodian trafficking, which urgently require better protection. Birds were the most confiscated Class in terms of the number of animals that had been confiscated, and songbirds were particularly heavily trafficked. The songbird trade in Cambodia may be an under-reported element of the Asian songbird crisis. In terms of the number of incidents, reptiles were the most confiscated Class. A relatively small number of specific reptile species were targeted, and particularly prominent was the turtle and tortoise trafficking. Increased law enforcement efforts in and around protected areas, strong legislation to limit the use of snares, and improved implementation of existing laws are key to protecting all species in trade.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2019.108379.

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