THE UNIVERSITY of ADELAIDE

The Global Trade in Pangolin Species from Asia and Africa

Sarah Heinrich

A dissertation submitted for the degree of

Doctor of Philosophy

School of Biological Sciences

Department of Ecology and Environmental Sciences

The University of Adelaide

December 2019

~ Dedicated to the remaining pangolins of this world.

May you forgive our crimes against your kind ~

Contents

i) Publication list

Chapter 2: Heinrich, S., Wittmann, T.A., Prowse, T.A., Ross, J.V., Delean, S., Shepherd, C.R. and Cassey, P. (2016). Where did all the pangolins go? International CITES trade in pangolin species. *Global Ecology and Conservation* **8**:241–253.

Chapter 3: Heinrich, S., Wittmann, T.A., Ross, J.V., Shepherd, C.R., Challender, D.W.S., and Cassey, P. (2017). The Global Trafficking of Pangolins: A comprehensive summary of seizures and trafficking routes from 2010 –2015. TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

Chapter 4: Heinrich, S., Ross, J.V., Cassey, P. (2019). Of cowboys, fish, and pangolins: US trade in exotic leather. *Conservation Science and Practice* **1**:e75.

Chapter 5: Heinrich, S., Koehnke, A., Shepherd, C.R. (2019). The role of Germany in the illegal global pangolin trade. *Global Ecology and Conservation* **20**:e00736.

Chapter 6: Heinrich, S., Ross, J.V., Gray, T.N.E., Delean, S., Marx, N. and Cassey, P. (2020). Plight of the Commons: 17 Years of Wildlife Trafficking in Cambodia. *Biological Conservation* **241**:108379.

Chapter 7: Heinrich, S., Ross, J.V., Cassey, P. (2019). Pangolins in Trouble. *Frontiers for Young Minds* **7**:107

Appendix 1: Gomez, L., Leupen, B.T.C., Heinrich, S. (2016). Observations of the illegal pangolin trade in Lao PDR. TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

Appendix 2: Gomez, L., Leupen, B.T.C., Krishnasamy, K., and Heinrich, S. (2017). Scaly Nexus: Mapping Indonesian pangolin seizures (2010–2015) TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

ii) Abstract

Global pangolin trafficking is a major conservation concern, threatening the eight extant pangolin species (Order: *Pholidota*, Family: *Manidae*). Most demand for pangolins is coming from Asian countries and in particular from China and Vietnam. The scales are used in traditional medicines and the meat is consumed as a luxury dish. Historically, the skins have also been used in a lucrative leather industry.

Persisting demand, especially for the scales and meat, and unsustainable harvesting across Asia have led to a decline and local population extinctions among the Asian species. The trade has since shifted to include the four African species, which are increasingly trafficked to Asian countries to meet demand.

In this thesis, I have analysed pangolin trade patterns and quantitatively assessed the dynamics pertaining to this trade to fill important gaps that were missing in the literature. I have analysed the patterns of the historical (legal) trade in pangolins from 1975 – 2015 reported to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Chapter 2). I found more than an estimated half a million pangolins were traded within that timeframe and confirmed that since the establishment of a zero export quota in the year 2000, for wild-caught Asian pangolin species traded for primarily commercial purposes, the trade in African pangolins has increased significantly. I also highlighted the role of non-range countries in the trade, which had previously not received much attention in the scientific and conservation community.

Following the analysis of CITES trade, I focussed my attention on pangolin trafficking dynamics from 2010 – 2015 (Chapter 3). After collating an extensive seizure dataset, I conducted the first global pangolin trafficking analysis. I found more than 1200 seizure incidents globally, involving at least 67 countries. Most of the seizures still occurred within Asia, but European countries were identified as important transit hubs for African pangolins being trafficked to Asia. Of these European countries, Germany especially stood out in terms of the number of trafficking incidents it was involved in. Persistent trafficking links were also identified from Asia to the United States of America (US).

The US was historically the dominating market for pangolin leather products. I analysed the pangolin leather trade in the US from 2000 – 2018, using data obtained from eBay and the US Fish and Wildlife Service Law Enforcement Management Information System

(LEMIS) (Chapter 4). I found that pangolin leather trade has been decreasing since 2000, and medicinals are nowadays the most traded pangolin commodity in the US. Yet, pangolin leather products continued to be sold in the US, for example on e-commerce platforms, such as eBay. I found that demand for the conspicuous skin pattern persists in the US and the declining trade in pangolin leather products is potentially being replaced by leather products from the skins of a giant freshwater fish: the arapaima (Order: *Osteoglossiformes*, Family: *Arapaimidae*). I provided a key example of wildlife substitution and the complexity of wildlife trade. The implications of this potential substitution will need to be assessed further, as arapaimas are also threatened in the wild.

I further analysed the role of Germany in international pangolin trafficking, using seizure data from 2010 – 2018 (Chapter 5). Germany had previously been identified as one of the prominent European countries acting as a transit hub for pangolin products being trafficked from Africa to Asia. Germany was being used as a transit point predominantly for shipments of scales coming from Nigeria and on their way to China/Hong Kong. Most of the shipments were transported via postal services. Another important finding was the large discrepancy between government and media reporting, which may have implications for the use and interpretation of wildlife seizure data in the future.

Pangolin trafficking is especially prominent in Asia. While it is widely agreed that China is driving most of the global pangolin trafficking, pangolins are usually sourced outside of China. Apart from African countries, which are an increasing source of pangolins found in illegal trade, several Asian countries still serve as important countries of origin. I therefore contributed to characterising pangolin trafficking dynamics in Lao PDR (Appendix 1) and Indonesia (Appendix 2), and I further analysed wildlife trafficking dynamics in Cambodia (Chapter 6). While I did not specifically focus on pangolin trafficking, but rather on general wildlife trafficking dynamics in Cambodia, I did find pangolins to be overrepresented in Cambodian wildlife trafficking. I further assessed the threat many other animal species face in Cambodia through wildlife trafficking, focussing mainly on the differences between birds, mammals, and reptiles.

This thesis has contributed to a much deeper understanding of pangolin trade and trafficking patterns. Within the individual chapters, I have highlighted and discussed country specific issues, with the aim to support conservation and law enforcement efforts. Finally, I present an overview of areas that need to be strengthened to ensure the survival of all pangolin species.

iii) Statement

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I acknowledge that copyright of published works contained within this thesis resides with the copyright holder(s) of those works.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

_____

Signature Date

iv) Acknowledgements

This work would not have been possible without the continued support from Phill Cassey. He gave me this opportunity and his efforts and commitment throughout my time in Adelaide were exemplary. I could not have wished for a better supervisor and I will be forever grateful. I would also like to thank my two co-supervisors, Josh Ross and Chris Shepherd. Both have gone above and beyond to help me and have always been there with much needed advice. I cannot thank them enough.

I would also like to acknowledge the University of Adelaide for giving me the opportunity to study here and providing me with a generous scholarship – without it I would not have been able to undertake this journey.

Thank you also to our lab group, the most wonderful, supporting bunch of people, who have made every regular day a good one to come into the office, have a coffee, and keep on working. Especially because of Talia Wittmann – best office mate and friend. Extended gratitude also to Steve Delean and Thomas Prowse who have helped me with many issues and with whom I have always enjoyed a beer or two. And of course Jack Tatler, my emotional-support-human; and Adam Toomes for supporting me so much during this last bit of my PhD.

I would also like to recognise my beloved danger-noodles Kaya and Arlo, as well as Moritz and Barcadi for always making me smile and keeping me sane. I am also grateful to the Team at SDT, especially Graham Kuerschner, who have brought Krav Maga into my life and who have helped me in dealing with general PhD stress and keeping a good work-life-balance.

And lastly, my sincerest gratitude to Thomas Kirch, for starting all this by making me move to the other side of the world, and standing by me through any mood. Philipp Heinrich for constantly encouraging me; and Barbara Finke-Heinrich and Bernd Heinrich, for giving me the wings to fly and the strength to go my own way.

Chapter 1

Introduction

Chapter 1. Introduction

Humans have always relied on wildlife for food, medicine, clothing, and companionship (Roth and Merz 1997). The domesticated species with which we are familiar with today were once wild animals and plants, which humans have shaped in their appearance and behaviour to best suit human needs. Wildlife use and trade can be sustainable, and it has been argued that under the right circumstances it can even be beneficial for certain species (MacGregor 2006; Roe 2008). Globally, people rely heavily on wildlife use and trade and it is an important component of people's livelihood (Cooney, et al. 2015).

To ensure that trade in plant and animal species does not threaten their survival, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was established and entered into force in 1975. It has since become a global agreement between currently 183 'Parties' (i.e., member countries). CITES is a voluntary agreement, which regulates the international trade in wild animals and plants. The regulations that are agreed upon by CITES need to be implemented by each Party in their national legislation. Currently, the legislation of only 55.2% of all Parties meet the requirements to fully implement CITES, and are thus classified as 'Category 1' countries (https://cites.org/legislation).

Roughly 5800 species of animals and 30 000 species of plants are listed in one of the three CITES appendices. Appendix I listed species are those threatened with extinction, and trade is only permitted under exceptional circumstances. Appendix II listed species may become threatened with extinction if current trade levels are not controlled, and Appendix III listed species are protected in at least one country which has asked CITES Parties for assistance in controlling the further international trade (https://www.cites.org/eng/app/index.php).

Excessive wildlife trade can quickly become unsustainable. This is often the case when wildlife is either overexploited, and the threat this poses to a species is not quickly detected and recognised, or when wildlife species are illegally traded (hereafter also referred to as wildlife trafficking). Wildlife trafficking is a driver of global biodiversity loss, having major implications for a diverse range of species (Broad, et al. 2002; Wyatt 2013; Phelps and Webb 2015; Maxwell, et al. 2016). It is estimated to be among the most lucrative organised criminal activities, alongside the trafficking of humans, drugs, and weapons (Wyatt 2013; Nellemann, et al. 2016). Wildlife trafficking involves millions of individuals

of thousands of species each year and threatens the continued existence of an ever-growing list of species and thereby the livelihoods of many people (Broad, et al. 2002; Wyatt 2013).

Among the animals threatened by wildlife trafficking are the pangolins (Order: *Pholidota*, Family: *Manidae*), which have been described as 'the most heavily trafficked wild mammals' (Challender, et al. 2014a). Pangolins are solitary, shy ant eaters, covered in keratinous scales. A pangolins' various body parts, especially their scales, but also their fetuses, blood, bones and claws are used in traditional medicines (Bräutigam, et al. 1994; Sodeinde and Adedipe 1994; Katuwal, et al. 2013; Boakye, et al. 2014; Mohapatra, et al. 2015; Soewu and Sodeinde 2015). Their skins are made into leather products (CITES 1992), and their meat is considered a delicacy in Asian restaurants, where its consumption is also a symbol of status (Challender, et al. 2015b; Shairp, et al. 2016). All eight pangolin species are consumed as a local source of protein (Bräutigam, et al. 1994; Mohapatra, et al. 2015), although it has been suggested that this local use is in decline, due to high prices paid, and ongoing demand from China (Newton, et al. 2008; Conniff 2013).

Prices for pangolin scales in China increased tenfold from 2000 to 2013 (Challender, et al. 2015b), and the demand from China is driving much of the global trade (Pantel and Chin 2009; Challender 2011; Harrison, et al. 2015; Nijman, et al. 2016). A survey conducted in China's major Mederia Medica markets in the mid-1990s revealed an incredible 80 – 100 tons of pangolin scales estimated to be traded annually (Zhang 2009), not accounting for all other parts of the pangolin being traded. A substantial proportion of the scales were believed to be derived from pangolins not sourced from China (Zhang 2009), already indicating that local harvest was insufficient to meet the Chinese demand. As a result of ongoing trade, these once widespread mammals have been driven to the edge of extinction in Asia, and both the Sunda (*Manis javanica*) and the Chinese pangolin (*M. pentadactyla*) are now listed as Critically Endangered by the International Union for Conservation of Nature (IUCN) (Challender, et al. 2014b; Challender, et al. 2014c). The remaining two Asian species, the Indian (*M. crassicaudata*) and the Philippine pangolin (*M. culionensis*) are listed as Endangered (Baillie, et al. 2014; Lagrada, et al. 2014). The four African species[1] – the white-bellied pangolin (*Manis* (*Phataginus) tricuspis)*, the Giant pangolin (*Manis (Smutsia) gigantea)*, Temmincks Ground pangolin (*M. (S.) temminckii)* and the

[1] Note that the nomenclature used in this thesis follows Wilson and Reeder (2005), aligning with the nomenclature used in CITES and the Catalogue of Life. It is acknowledged that the IUCN Red List and other sources follow Gaudin et al. (2009), placing the species in three genera (*Smutsia*, *Phataginus*, and *Manis*).

black-bellied pangolin (*M. (P.) tetradactyla)* – are listed as Vulnerable (Pietersen, et al. 2014a; Waterman, et al. 2014c; Waterman, et al. 2014b; Waterman, et al. 2014a). The primary threat all eight species face is poaching for the illegal wildlife trade (Challender, et al. 2014a), but additional pressures include ongoing habitat destruction and local persecution (Pietersen, et al. 2014b; Thapa 2014). The current distribution of the eight pangolin species is displayed in **Figure 1.1**.

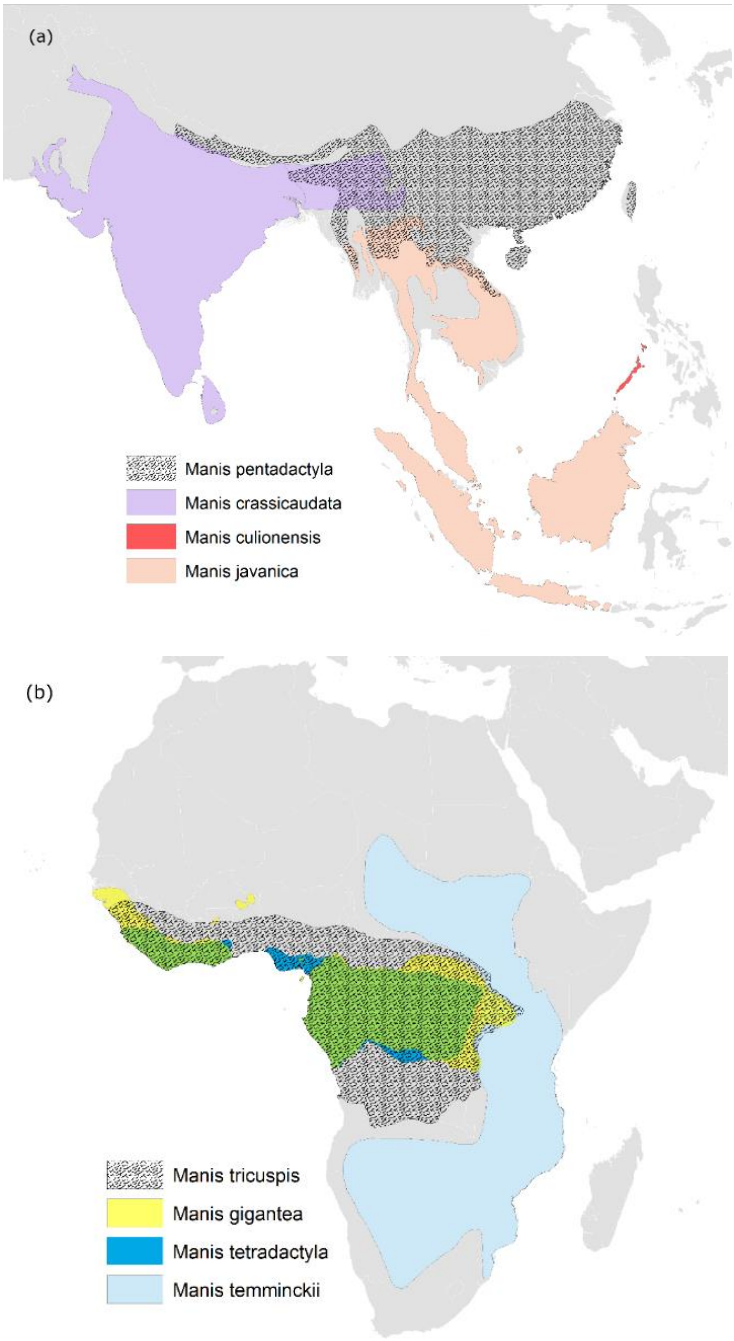

Figure 1.1: Species distribution maps of the eight extant pangolin species showing a) the Asian species, and b) the African species. A mix of colours within the maps indicates an overlap in the different species' distributions. The species' ranges are based on the IUCN Red List assessments (IUCN 2014).

All pangolins are particularly vulnerable to high poaching rates and overexploitation as they have a very slow reproductive rate, with female pangolins usually only bearing one offspring per year (Yang, et al. 2007; Lim and Ng 2008; Van Thai, et al. 2014; Hua, et al. 2015). Furthermore, pangolins cannot easily be kept, let alone bred, in captivity (Hua, et al. 2015; Challender, et al. 2019b). They are prone to stress related conditions and have a highly specialised diet, feeding on ants and termites, which makes it particularly difficult to provide them with a correct and high quality diet in captivity (Van Thai, et al. 2014; Hua, et al. 2015).

Pangolins have been listed in varying CITES Appendices since its inception in 1975 (UNEP-WCMC 2014). In 1995 all species (only seven were recognised at the time) were listed in Appendix II (UNEP-WCMC 2014). It was documented early that trade levels, especially of Asian pangolins, may not be sustainable (Challender, et al. 2019a). In 1987, the US, being the main destination for pangolin skins that were used in the leather industry, prohibited the import of pangolin skins from Indonesia and Thailand (CITES 1992). In the year 2000, a proposal to up-list the Asian pangolins to CITES Appendix I was denied, but instead a zero export quota for wild-caught Asian pangolin species, traded for primarily commercial purposes, was established (CITES 2000a; UNEP-WCMC 2014). As Asian pangolin populations were declining, and the supply was no longer able to meet the demand, it was suggested that there would be a proportional market shift to the four African species, to supply the Asian market (Challender 2011; Challender and Hywood 2012). Prior to 2008 there were no known records of pangolins being illegally shipped from Africa to Asia (Challender and Hywood 2012). Since then, increasing numbers of illegal shipments originating from Africa have been intercepted on their way to Asia (Challender and Hywood 2012; Gomez, et al. 2016b). Apart from the decline in Asian pangolin populations (Wu, et al. 2004; Baillie, et al. 2014; Challender, et al. 2014b; Challender, et al. 2014c), one major reason believed to have facilitated the shift from Asian to African species were the growing economic ties between the two continents (Challender and Hywood 2012; Baker 2014; Challender, et al. 2016). As a response to the continued trade and trafficking of pangolins, all eight species were transferred from Appendix II to Appendix I in January 2017. This finally guaranteed all pangolin species the highest protection status through CITES, essentially prohibiting international trade in wild-caught pangolins for commercial purposes globally.

In this thesis, I have analysed pangolin trade patterns and quantitatively assessed the dynamics pertaining to this trade to fill important gaps that were missing in the literature. The individual chapters are reproduced here from their peer-reviewed published versions, but have been amended slightly to reduce redundancy throughout the thesis and to ensure consistent formatting across all of the chapters.

Firstly, I conducted an analysis of the trade patterns of the historical (legal) CITES trade in pangolins from 1975 – 2015 and found more than an estimated half a million pangolins to be traded within that timeframe (Chapter 2). I confirmed that since the establishment of a zero export quota of wild-caught Asian species in the year 2000, the trade in African pangolins has increased significantly. Following the analysis of CITES trade, I focussed my attention on pangolin trafficking dynamics from 2010 – 2015 (Chapter 3). After collating an extensive seizure dataset, I conducted the first global pangolin trafficking analysis. I found more than 1200 seizure incidents globally, involving at least 67 countries. The US was historically the dominating market for pangolin leather products (CITES 1999; Chapter 2; Chapter 3). In Chapter 4, I analysed the pangolin leather trade in the US and found that it has been decreasing since 2000, while medicinals are nowadays the most traded pangolin commodity in the US.

I further analysed the role of Germany in international pangolin trafficking (Chapter 5). Germany had previously been identified as one of the prominent European countries acting as a transit hub for pangolin products being trafficked from Africa to Asia. Germany was being used as a transit point predominantly for shipments of scales coming from Nigeria and on their way to China/Hong Kong. Most of the shipments were transported via postal services.

Pangolin trafficking is especially prominent in Asia. While it is widely agreed upon that China is driving most of the global pangolin trafficking (Pantel and Chin 2009; Challender, et al. 2015b; Nijman, et al. 2016), pangolins are now usually sourced outside of China, as pangolin populations in China are considered ‘commercially extinct’ (CITES 2016a). Apart from African countries, which are an increasing source of pangolins found in illegal trade, several Asian countries still serve as important countries of origin. I therefore contributed to characterising pangolin trafficking dynamics in Lao PDR (Appendix 1) and Indonesia (Appendix 2), and I further analysed wildlife trafficking dynamics in Cambodia (Chapter 6). I further assessed the threat many other (mostly native) animal species face in Cambodia

through wildlife trafficking, focussing mainly on the differences between birds, mammals, and reptiles.

Lastly, I wrote a translation of the conservation story of the pangolins, combining the results of three years of research (Chapter 7). The published article was aimed at a younger audience, aged 8 – 15. I believe it is extremely important, not only to conduct robust science, but also to make research findings accessible to the general public, and especially the next generation, who will eventually become the guardians of our wildlife.

Chapter 2

Where did all the Pangolins go? International CITES Trade in Pangolin Species

Statement of Authorship

Title of Paper	Where did all the pangolins go? International CITES trade in pangolin species.
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Heinrich, S., Wittmann, T. A., Prowse, T. A., Ross, J. V., Delean, S., Shepherd, C. R. and Cassey, P. (2016). Where did all the pangolins go? International CITES trade in pangolin species. *Global Ecology and Conservation* **8**:241–253.

Principal Author

Name of Principal Author (Candidate)	Sarah Heinrich		
Contribution to the Paper	Curated and interpreted the data, wrote manuscript and acted as corresponding author		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	14.12.2019

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Talia A. Wittmann		
Contribution to the Paper	Assisted with curating the data, data visualisation and editing the manuscript		
Signature		Date	

Name of Co-Author	Thomas A. Prowse		
Contribution to the Paper	Assisted with data analysis and editing the manuscript		
Signature		Date	

Name of Co-Author	Joshua V. Ross		
Contribution to the Paper	Assisted with the development of the work and manuscript editing		
Signature		Date	

Name of Co-Author	Steven Delean		
Contribution to the Paper	Assisted with data analysis and interpretation		
Signature		Date	

Name of Co-Author	Chris R. Shepherd		
Contribution to the Paper	Assisted with the development of the work and manuscript editing		
Signature		Date	

Name of Co-Author	Phillip Cassey		
Contribution to the Paper	Supervised the development of the work, assisted with data analysis and interpretation, as well as manuscript editing		
Signature		Date	

Chapter 2. Where did all the Pangolins go? International CITES Trade in Pangolin Species

This chapter has been amended slightly from its original published version to reduce redundancy and ensure consistent formatting throughout the thesis. The original publication can be found online with the following citation:

Heinrich, S., Wittmann, T.A., Prowse, T.A., Ross, J.V., Delean, S., Shepherd, C.R. and Cassey, P. (2016). Where did all the pangolins go? International CITES trade in pangolin species. *Global Ecology and Conservation* **8**:241–253.

2.1 Abstract

The pangolin is greatly sought after for its various body parts, largely driven by demand from China. The mammal has been driven to the edge of extinction in Asia, with two Asian species listed as Critically Endangered in the International Union for Conservation of Nature Red List. With declining Asian pangolin populations, a shift in trade from Asian to African pangolin species has been suggested. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Trade Database provides a unique opportunity to investigate global trends in pangolin trade at the species level, across a broad temporal scale (1977 – 2014). We found that CITES trade in Asian pangolin species decreased through time, whilst trade in African species increased post 2000. The total number of incidents involving Asian species declined since 2000, yet they were still being traded in large volumes (more than 17 500 estimated whole Asian pangolins were traded from 2001 to 2014) despite a zero export quota for all wild sourced Asian species, traded for primarily commercial purposes. In 2014 all eight pangolin species were recorded in the CITES trade for the first time. An increasingly complex international network was identified through time, with the United States of America (US) being the dominant player in the global pangolin trade that was reported to CITES. The US was the most frequent trade country throughout the entire period and was the greatest importer of pangolins, and their products; measured both in volume as well as frequency. We hope that identifying these global trade network characteristics, and pangolin trade dynamics will help to inform pangolin conservation efforts, and guide enforcement and legislative changes in the future.

2.2 Introduction

Wildlife trade is a key threat to biodiversity conservation, with billions of specimens being traded globally every year (Broad, et al. 2002; Smith, et al. 2009; Rosen and Smith 2010; Nijman and Shepherd 2011). To ensure sustainability of wildlife trade, especially in threatened species, an international agreement between governments entered into force in 1975 (www.cites.org). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Each country ('Party') is a voluntary member to the Convention, and all imports, exports and re-exports of CITES listed species are regulated, by each Parties designated Management Authority, through a licensing system.

The Management Authorities of each Party authorise trade by issuing permits for shipments. The issuance of permits is dependent on the status of the traded species, its CITES Appendix listing, and are sometimes subject to additional individual quotas. Parties are required to report their annual trade to the CITES Secretariat and the data is then centrally stored in the CITES trade database (accessible at http://trade.cites.org). Historically, the annual reports have only contained legally permitted transactions (but see the Discussion). However, Parties were additionally requested to report on illegal trade for some species, such as elephants (Resolution 10.10: CITES (1997)) and pangolins (Decisions 16.41/16.42: CITES (2013b)). From October 2017, all illegal trade detected by the Parties must also be included in the new illegal annual reporting system (see Notification 2016/007: CITES (2016e)).

Illegal wildlife trade (hereafter referred to as 'trafficking') is often reported in the media, through research and non-Government organisations (e.g., www.healthmap.org; www.traffic.org), or via enforcement agencies and government reports (e.g., UNODC (2016)). The distinction between the regulated trade in wildlife (i.e., CITES permitted trade) and wildlife trafficking is often blurred (Wyatt 2013). Whilst reports on wildlife seizures provide a unique opportunity to estimate trade flows (Shepherd, et al. 2016), reported seizures may only represent a fraction of the actual trafficking amounts, and it is difficult to reliably estimate the volumes being traded, or the impact that trafficking is having on specific populations. Due to the illicit nature of wildlife trafficking, seizure records can be difficult to acquire and curate, particularly when information is sensitive and

different enforcement agencies (i.e., countries) provide variable levels of reporting. The trade recorded in the CITES trade database (hereafter referred to as 'CITES trade') is the primary source of international wildlife trade data at the species level, which provides a consistent mechanism for estimating legal trade dynamics through time, and allows investigation of variability in trade around specific changes in international trade regulations. Whilst we acknowledge the inherent biases associated with the CITES trade data (see the Discussion), there is no comparable data available at this scale.

Since the Convention entered into force in 1975, pangolin species have been variously listed in all three CITES Appendices. Since 1995 all species have been listed in Appendix II, and a zero export quota for all wild-caught Asian species, traded for primarily commercial purposes was established in 2000 (CITES 2000b). This quota does not apply to African species, which are still allowed to be legally traded under the provisions of Appendix II species (see Article IV of the Convention). More recently, pangolin listings are under further pressure to change. At the Seventeenth Conference of Parties (CoP17; Johannesburg, South Africa: September 24th until October 5th 2016), 19 countries have submitted proposals for the up-listing of all eight pangolin species from Appendix II to Appendix I (Proposals 8, 9, 10, 11 and 12: CITES (2016d))[2].

To our knowledge, no studies have investigated the global pangolin trade network reported to CITES for all eight pangolin species, nor investigated the relative proportions of African to Asian species involved in CITES reported trade in relation to these trade networks, especially following the zero export quota in 2000. To address this, we have analysed global pangolin trade as reported by CITES Parties. We have quantitatively compared the temporal dynamics of this international trade, among all Asian and African pangolin species. In addition, we have documented the key trading partnerships and characteristics of the global pangolin CITES trade network. We hope that quantifying these trade dynamics and identifying key trading partners will inform better decision making around existing (and future) CITES regulations, national legislation, and pangolin conservation measures.

[2] Note that since the time of writing, all eight pangolin species were transferred to Appendix I at the CoP17, effective as of January 2017 (CITES 2016b)

2.3 Methods

The CITES Trade Database (www.trade.cites.org; downloaded on the 20th of May 2016) was queried for trade data of all pangolin species (*Manis* spp.) between the years 1975 and 2014 for all 'Sources', 'Purposes', 'Trade Terms', 'Importing Countries', and 'Exporting Countries' as a comparative tabulation report. The resulting data included 1485 trade incidents; noting that incidents in comparative tabulations are summed by CITES when the trade details in a particular year are identical across all of the variables listed above, and are not necessarily reported on a shipment-by-shipment basis (CITES 2013a).

All identified species were assigned to their respective home continent; being either 'Africa' (*M. tricuspis, M. gigantea, M. temminckii, M. tetradactyla*) or 'Asia' (*M. crassicaudata, M. javanica, M. culionensis, M. pentadactyla*). Unidentified species, which were reported to originate from an Asian or African native range country (see **Table S2.1**) in the 'origin country' field, were assigned their respective home continent, or otherwise flagged as 'unknown'.

CITES trade terms were consolidated into six groups for analysis: i) whole animals (live and bodies); ii) specimens/medicine (medicine, powder and specimens); iii) scales; iv) body parts (trophies, feet, claws, tails, skulls, skeletons); v) leather/skins (leather, leather items, leather products large and small, shoes, skins, skin pieces, skin scraps, and garments); and vi) miscellaneous (derivatives, carvings, bone pieces, meat, and unspecified). Trade sources were grouped into five categories: i) captive (captive and ranched); ii) wild; iii) seized; iv) pre-convention; and v) unknown. Finally, trade purpose was grouped into five categories: i) scientific (biomedical research, scientific); ii) miscellaneous (circus, zoo, educational, law enforcement, captive breeding); iii) commercial; iv) personal (personal, hunting trophy); and v) unknown.

We assigned units to all incidents where the unit for the trade term was blank, following the ´preferred unit´ according to the *Guidelines for the preparation and submission of CITES annual reports (February 2011)*. Where the units were provided, they were standardised from centimetres to metres, grams to kilograms, millilitres to litres, boxes and flasks to cartons, and pairs and pieces to number of specimens. Where both the importer and the exporter reported a quantity, the larger of the two quantities was used in all cases; the correlation between importer and exporter reported ($\log_{10}$) quantities was extremely high (Pearson's r = 0.94, 95% CI = 0.90, 0.96), and the slope of the linear regression

between exporter quantities and importer quantities was not significantly different from one (slope = 0.94, 95% CI = 0.87, 1.02).

All traded quantities were then converted into an estimated minimum and maximum number of whole pangolins. Where the unit was defined as the 'number' of specimens, the minimum and maximum quantity of whole pangolins was assumed equal to the traded quantity provided, with the exception of small leather products and leather items where the maximum number of whole pangolins required to make the product was instead assumed to be double the quantity provided. For large leather products, it was assumed that at least two whole animals were required to construct each product, and a maximum of four. Up to eight claws were estimated to belong to at least one pangolin and a maximum of eight pangolins. Up to four feet were assumed equal to a minimum of one whole pangolin, or a maximum of four. Shoes were reported in pairs (UNEP-WCMC *Guide to using the CITES Trade Database Version 8, October 2013)* and it was assumed that a minimum of two or a maximum of four pangolins were needed for a pair of shoes. Meat, reported in kilograms, was converted to whole pangolins according to the average weight of each pangolin species (Gaubert 2011). Weight for scales and skins were converted to whole pangolins using known body mass ratios and actual scale weights (Heath 1992a; Heath 1992b; Zhou, et al. 2012; Mohapatra, et al. 2015). Skins reported in metres were converted by using length measurements for each species (Heath 1992b; Heath 1992a; Gaubert 2011). As data was only available for *M. javanica, M. pentadactyla, M. crassicaudata* and *M. temminckii*, it was assumed that *M. tricuspis* and *M. culionensis* would be similar to *M. javanica* and *M. pentadactyla* as they have a similar average weight (Gaubert 2011). It was also assumed that *M. gigantea* had similar proportions as *M. temminckii*. If the species was not identified, the numbers for conversion from the largest pangolin species were used to calculate the minimum number of whole pangolins and the maximum number was assumed to be that of the smallest pangolin species. Derivatives, bone pieces, carvings, garments, medicine, powder, specimens, unspecified shipments, as well as all shipments that were reported in cartons, boxes, flasks or other non-standard units were omitted from the calculation of whole pangolins (18.72% of total incidents), as it was impossible to unambiguously convert them into an estimated number of whole pangolins.

A comparison between CITES and LEMIS (Law Enforcement Management Information System) data was conducted post-hoc after it became apparent that a large number of CITES trade incidents were being reported by the United States of America (US) as source

'seized'. Given that the CITES metadata (CITES 2013a; pg. 12) states that the source column relates to the "original source of the species being traded", we interpreted a 'seized' source as a species that is re-exported from a previous seizure event (i.e., legally redistributed). However, the large number of US seizure events led us to investigate whether the source column was being misused. CITES and LEMIS data were compared for seized shipments imported into the US from 1999 to 2013. LEMIS is a database administered by the US Fish and Wildlife Service (USFWS), reporting on all shipments being imported to or exported from the US. Furthermore, LEMIS provides detailed information about the recorded shipments, including if they were seized or not. The source column in CITES trade data was filtered to 'seized' and the Disposition Code column (indicating the final action that was taken by US Authorities) in LEMIS was filtered to 'I' (seized), 'R' (refused) and 'A' (abandoned). As a rule, exact matches were required in the quantity, exporter, year and species columns. Varying matches were allowed for the wildlife description ('term' in CITES), the 'purpose', 'origin country' and 'unit' columns. The number of matches between the two datasets, for seized shipments imported into the US, were then compared.

2.3.1 Analytical methods

Generalised linear models were fitted to test for a change (e.g., increase) in the number of CITES reported incidents through time (Poisson variance and log link function), and the proportion of incidents identified to species level (Binomial variance and logit link function) through time. Multinomial logit regression models were used to model the categorical response of the CITES nominal outcome variables (i.e., 'purpose' and 'term') through time (using R package 'nnet'; (Venables and Ripley 2002)). We used low-order natural splines (degrees of freedom = 2) to capture non-linearity in the temporal trends in the relative number of occurrences in each category of the multinomial responses. Bootstrapped predictions (B = 1000) of temporal trends were calculated for each response category and were used to calculate 95% Confidence Intervals for the predictions (based on temporal block bootstrap resampling; block length = 3 years). We also estimated the average linear trends in the relative number of incidents for each response category within the pre and post 2000 time periods based on the first derivatives of the bootstrap spline predictions (with 95% Confidence Intervals). The relative proportional trade in the eight

pangolin species through time, including segmented fitted regression lines (breakpoint = 1995), was calculated using Shannon's Diversity Index (*H*):

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

where R is the number of pangolin species in a year and p_i is the proportional abundance of species *i*. Contingency-type frequency tests were used to visualise and assess the independence of categorical variables (using the R package 'vcd'; (Zeileis, et al. 2007; Meyer, et al. 2017)). The homogeneity of frequencies was evaluated with Wald Chi-square tests for independence ($\alpha = 0.05$). When assessing the independence of CITES categorical variables, body parts were omitted from the CITES trade 'term' category, and the unknown and miscellaneous categories were omitted from the CITES trade 'purpose' category as they made up less than 5% and 10% of the total (n = 422) incidents since 2000, respectively.

To visualise the network of pangolin trade, and how this has changed over time, we constructed network diagrams representing the flow of pangolin products between countries which we classified as: 1) within the native range of Asian pangolin species; 2) within the native range of African species; or 3) outside the native range of any pangolin species (using the R package 'igraph'; (Csardi and Nepusz 2006)). We constructed circle networks to illustrate the annual number of trade incidents between exporting and importing countries for: 1) all pangolin species over the entire period (1977 – 2014); and 2) African pangolin species before and after the year 2000. A web application (https://taaprowse.shinyapps.io/pangolins/) was developed to facilitate visualisation of these trade networks for different data subsets and different time periods (using the R package 'shiny'; (Chang, et al. 2016)). All data analyses were conducted in the R-software environment (version 3.2.2) for statistical and graphical computing (R Core Team 2017).

2.4 Results

Trade in pangolin species is globally widespread (**Figure 2.1**). We found a total of 1485 trade incidents reported to CITES and an estimated 809 723 pangolins (not accounting for 18.72% of 'inconvertible' incidents) to be involved in the trade for the entire period between 1977 and 2014. Trade has been conducted across all major inhabited ice-free continents, and between 74 countries (**Figure 2.1**).

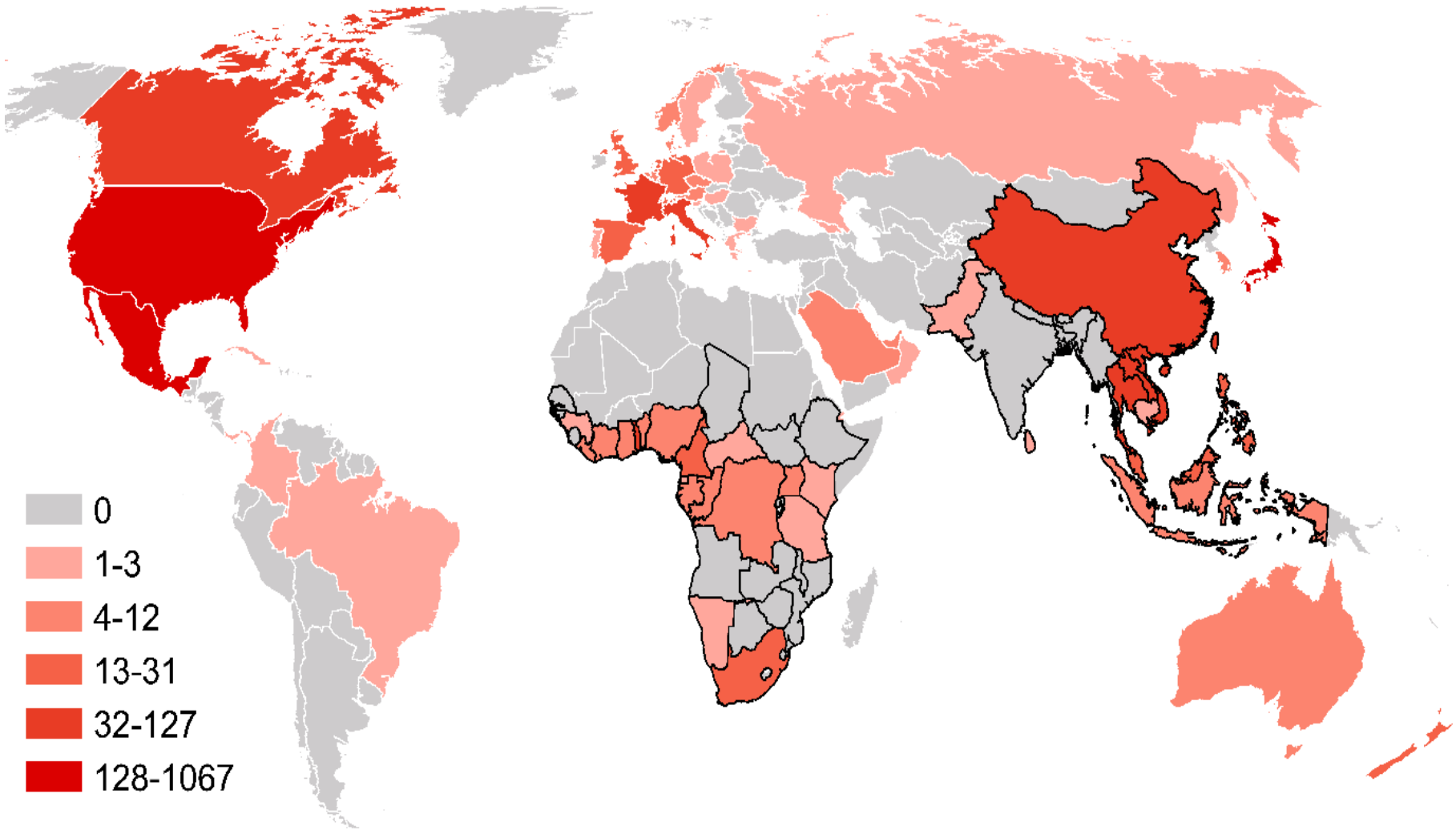

Figure 2.1. Pangolin (*Manis* sp.) trade has been reported by CITES (number of import plus export incidents on $\log_{10}$ coloured scale) between 74 countries from 1977 – 2014, of which over half of the countries (58.11%) are outside the native range of all eight species (depicted by thick black country borders).

Among these countries, 218 unique trade partnerships were identified (**Figure 2.2**), and the number of new partnerships formed per year (mean = 5.7, Standard Error (SE) = 0.52) has not decreased (nor increased) significantly through time (slope ± SE = -0.02 ± 0.05, t-value = -0.54).

The top 5 trading countries contributed to 63% of the import-export trade links, with the US being the most connected country in the network (61 links/44 trading partners); followed by China (28/23), Japan (25/19), Italy (22/18) and Singapore (19/15). Of these five countries, only the US was primarily an importer of pangolin products, with 78% of pangolin trade incidents recorded as imported goods (**Figure 2.2**).

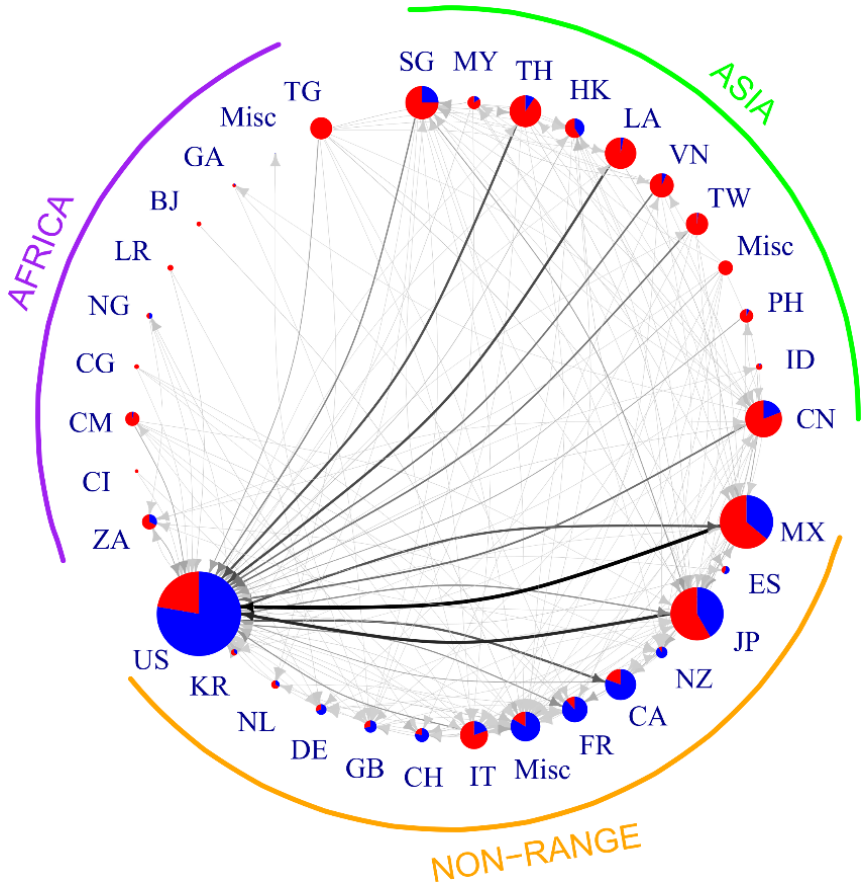

Figure 2.2. All CITES trade incidents from 1977 – 2014. Countries are classified by whether (or not) they are African, Asian, or non-range countries. Refer to **Table S2.1** for corresponding country names associated with each country code. The size of the nodes (and the coloured pies), and the directional trade arrows (Export [red pie] to Import [blue pie]), are natural-log transformed by the number of incidents represented.

The trade network in African pangolin species has radiated substantially over time, with 24 trade-network links operating between 1977 and 2000 compared to 54 network links post 2000 (**Figure 2.3**). The US was the dominant importer of African pangolin products over

both periods, while export growth for these species has been driven largely by Togo, South Africa and Cameroon, for which the annually-averaged number of export incidents were 620%, 514% and 171% higher post 2000 (**Figure 2.3**).

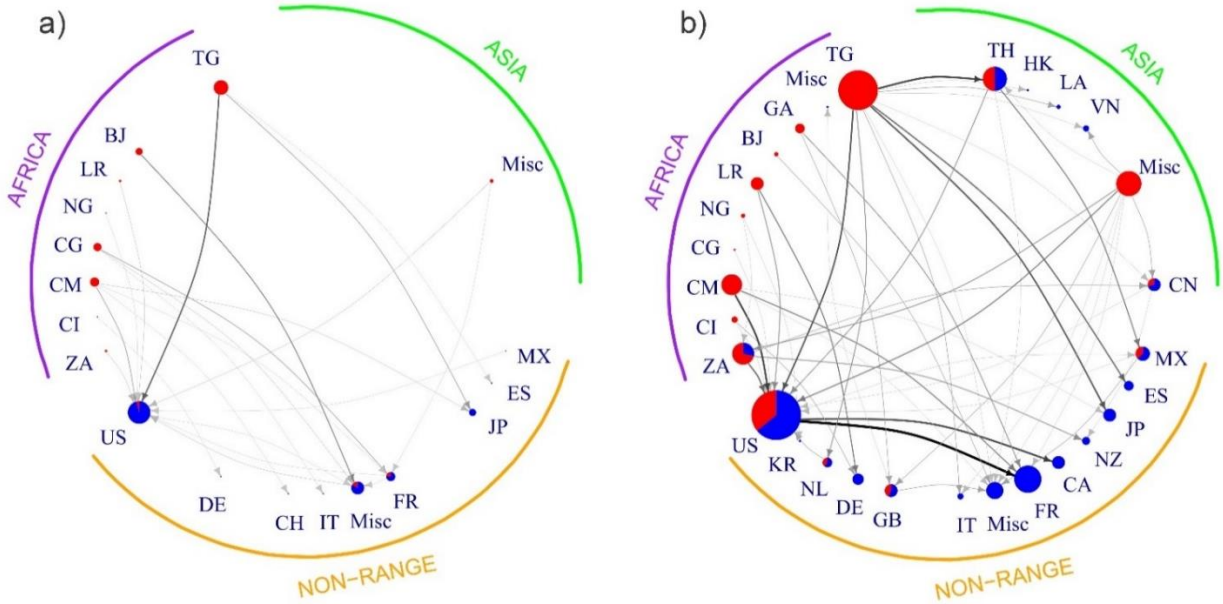

Figure 2.3. African species incidents a) prior to 2001, and b) post 2000. Countries are classified by whether (or not) they are African, Asian, or non-range countries. Refer to **Table S2.1** for corresponding country names associated with each country code. The size of the nodes (and the coloured pies), and the directional trade arrows (Export [red pie] to Import [blue pie]), are natural-log transformed by the number of incidents represented.

The greatest number of incidents (98 incidents; 6.6%) was in 1983, whereas the largest (estimated) number of whole pangolins traded was in 2000 (min = 109 399, max = 118 298; average percentage of total (estimated) whole pangolins = 12%; **Figure 2.4**).

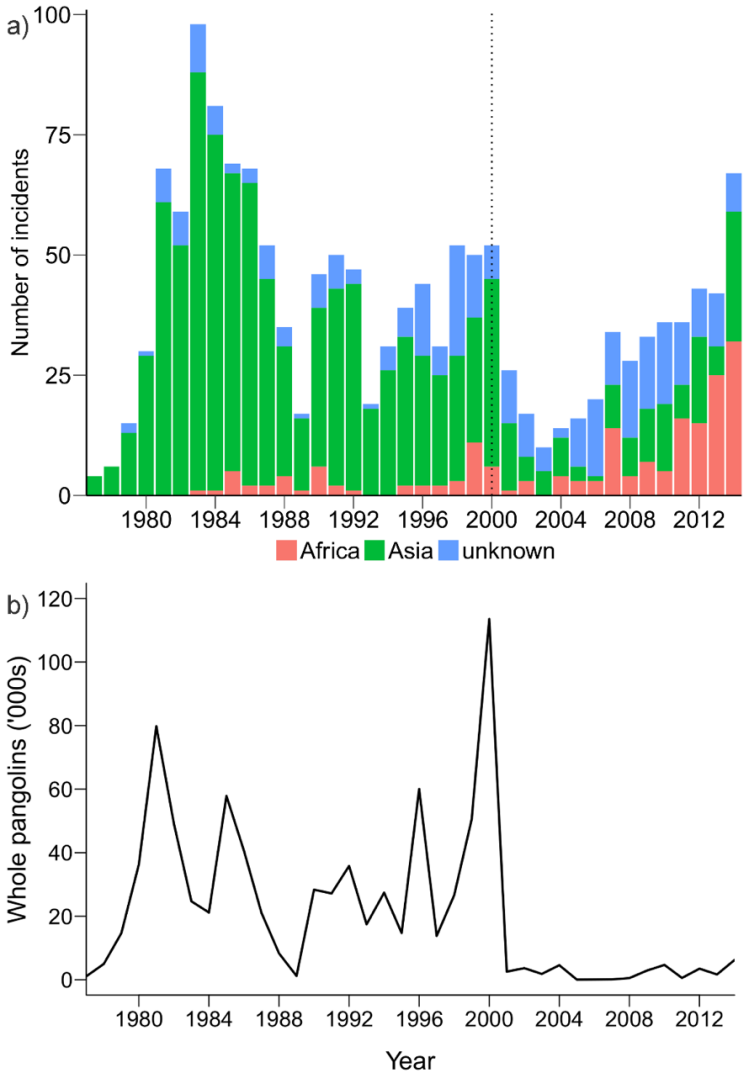

Figure 2.4. a) Total number of incidents for African, Asian and unknown pangolin species through time, and b) the estimated number of (mean) whole pangolins for all eight species traded through time (n = 82.3% incidents; see main text for more details).

Species diversity decreased prior to 1995 (Estimated break-point(s) = 1995, SE = 1.9; slope ± SE = -0.024 ± 0.011, t-value = -2.13), and has increased thereafter (slope ± SE = 0.086 ± 0.014, t-value = 5.83); reaching a maximum in 2014; the first year in which all eight pangolin species were recorded in the trade (**Figure 2.5a**). Prior to 1995, the average number of pangolin species recorded ($year^{-1}$) in trade was 3.2 (SE = 0.2). More than 93% of incidents over this period consisted of just two Asian species; *M. javanica* (63.5%) and *M. pentadactyla* (30.2%) (**Figure S2.1**). The relative contributions of these species to the overall trade declined substantially post 2000 (*M. javanica* slope = -0.03, 95% CI = -0.05, -0.02; *M. pentadactyla* slope = -0.01, 95% CI = -0.02, -0.01). Since 2001, the number (**Figure 2.5b**; slope ± SE = 0.25 ± 0.03, t-value = 8.74) and proportion (**Figure 2.5c**; slope ± SE = 0.19 ± 0.03, t-value = 5.69) of African species incidents have significantly increased.

Since 2001, approximately two-thirds (67%) of the incidents involving whole animals (alive and dead), has been African species.

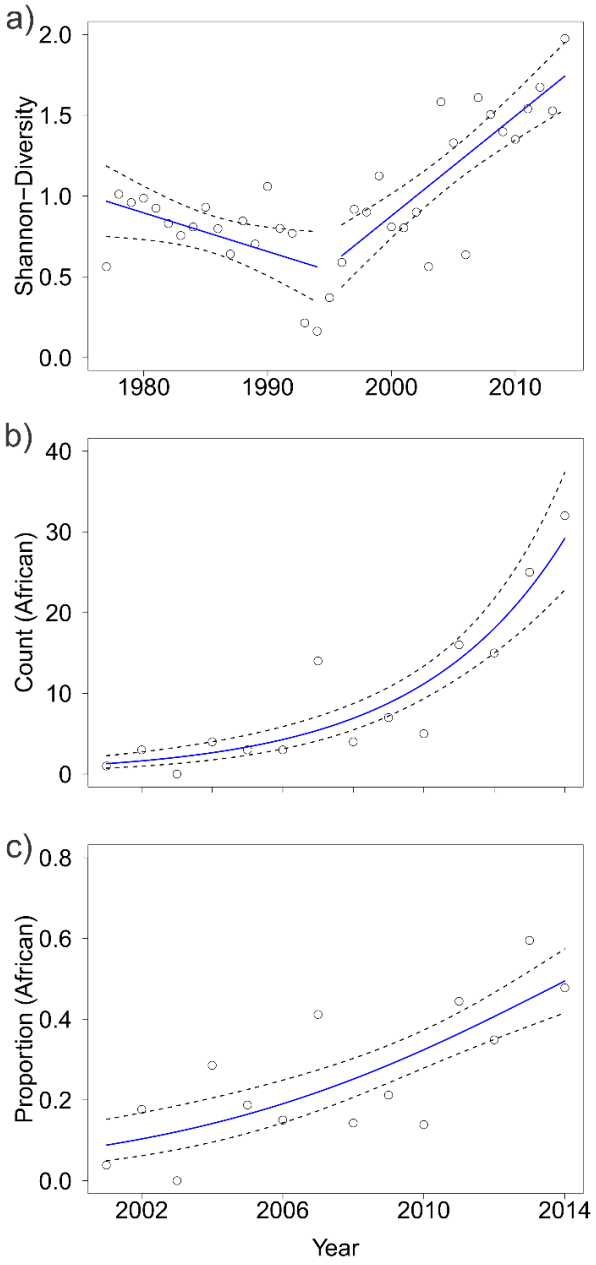

Figure 2.5. a) Shannon (H) species diversity index (Spellerberg, 1991) for the relative proportional trade in the eight pangolin species through time; including segmented fitted regression lines (breakpoint = 1995); b) the sum (Poisson regression with log link-function); and c) proportion (binomial regression with logit link-function) of CITES trade incidents involving African pangolin species since 2001. Dashed lines (in all three panels) are 95% Confidence Intervals.

Prior to 2001, the vast majority of trade (year^{-1}) was for commercial purposes (72.5% year^{-1}, SE = 3.05%), although the purpose of much of the remaining trade was unknown. The average proportion of trade for commercial purposes declined through time (pre 2000: slope = -0.01, 95% CI = -0.02, -0.00; post 2000: slope = -0.03, 95% CI = -0.04, -0.01), whilst

trade for personal purposes (slope = 0.02, 95% CI = -0.01, 0.05) and scientific purposes (slope = 0.02, 95% CI = -0.01, 0.04) increased post 2000. The average trend in leather products traded significantly declined through time (pre 2000: slope = -0.02, 95% CI = -0.03, -0.01; post 2000: slope = -0.02, 95% CI = -0.04, -0.01). Approximately two-thirds of all reported trade in pangolins has been leather/skins (922 out of 1485 incidents) and over 90% of this trade occurred prior to 2001 (**Figure 2.6**). This trade has included 625 211 skins, and 31 396 kilograms (kg) plus 4103 metres (m) of leather.

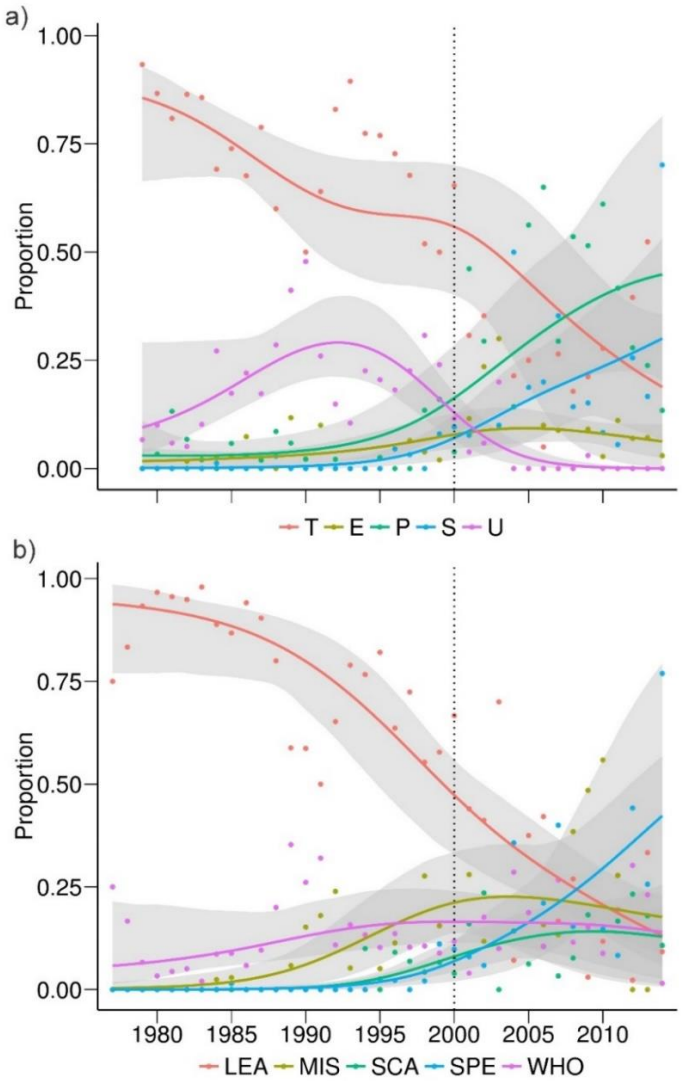

Figure 2.6. Estimated proportional abundances of: a) purpose (T = Commercial, E = Miscellaneous, P = Personal, S = Scientific, U = Unknown); and b) trade commodity term (LEA = leather/skins, MIS = miscellaneous, SCA = scales, SPE = specimens/medicine, WHO = whole animal) through time (average slope estimate ± 95% CI) from bootstrapped multinominal logit models. Body parts were omitted from this analysis as they made up 2% of the total incidents.

Since 2010, the majority of the trade (85.7%) has been in African species (**Figure 2.7**; 979 skins). Approximately 5% (71 out of 1485) of the total number of incidents were related to the export/import of pangolin scales (average incident^{-1} ± SE = 505.4 ± 159.43 kg). Prior to 2010 there was no recorded trade in African pangolin scales. Post 2010, over 4500 kg of African scales have been reported, 79% of the total recorded trade for that period (5744 kg).

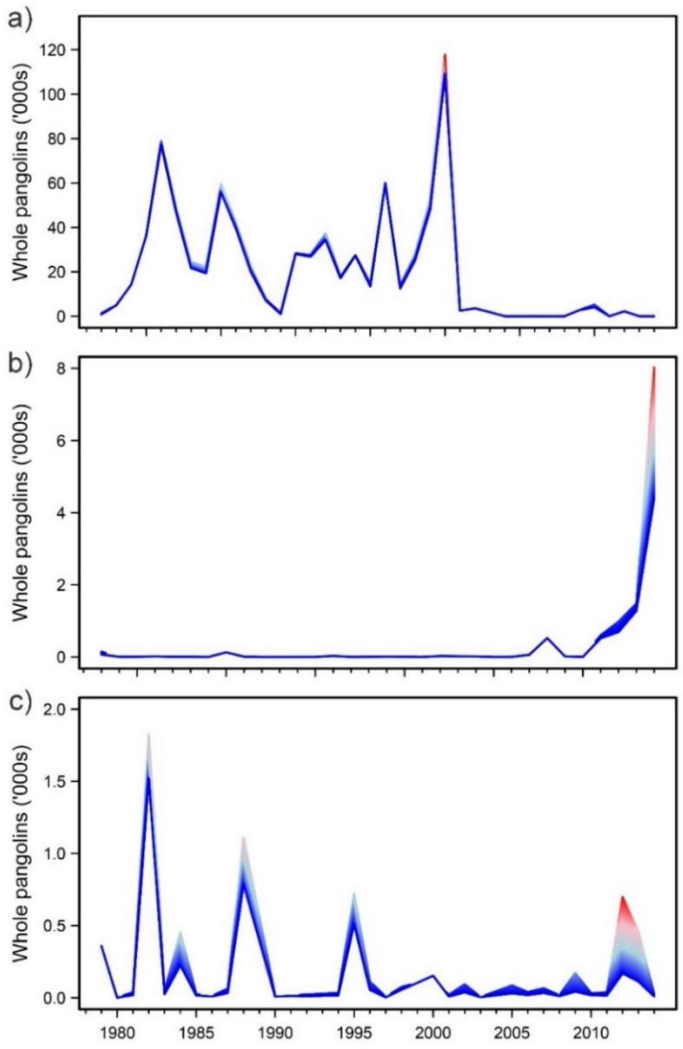

Figure 2.7. Total whole pangolins by a) Asian species, b) African species, and c) unknown species through time. Minimum and maximum estimates are provided, and the colour scale (blue to red) is relative to the maximum absolute difference over the time series. If the absolute difference (maximum - minimum), for a given year, is half the maximum difference then the colour scale will go half the way to red.

Compared with other (Asian and unknown) species, African species were significantly more likely to be traded as whole animals and for commercial purposes, and significantly

less likely to be miscellaneous items and traded for personal purposes (**Figure 2.8**). Alternately, compared with other (African and unknown) species, Asian species were significantly more likely to be traded as specimens/medicine for scientific purposes, and significantly less likely to be traded as whole animals (**Figure 2.8**). Unknown species, compared with African and Asian (identified) species, were significantly more likely to be miscellaneous items, traded for personal purposes, and significantly less likely to be specimens/medicine and traded for scientific or commercial purposes (**Figure 2.8**).

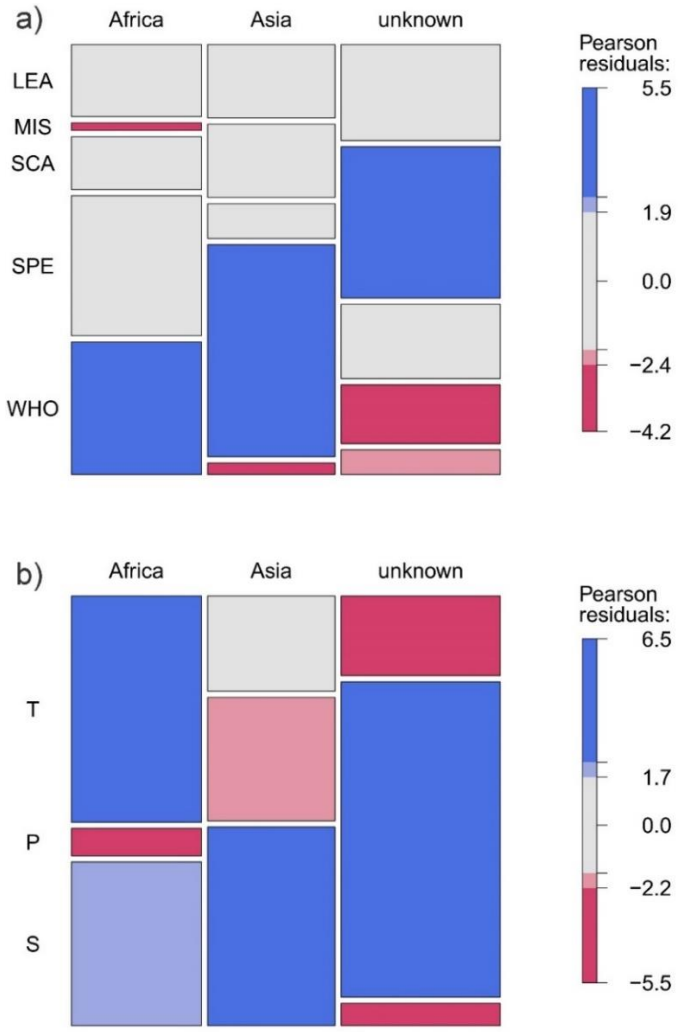

Figure 2.8. Mosaic plots of the deviation in conditional independence between pangolin species (African, Asian, unknown) and CITES trade categories: a) term (LEA = leather/skins, MIS = miscellaneous, SCA = scales, SPE = specimens/medicine, WHO = whole animals); and b) purpose (T = commercial, P = personal, S = scientific) for all CITES trade incidents since 2000 (n = 422). The plot is constructed so that the size of each cell (rectangle) is proportional to the observed cell frequency for each trait. The residual-based shading follows Zeileis et al. (2007), and reflects the cell contribution to the Chi-square statistic: shades of blue, when the observed frequency is substantially greater than the expected frequency under independence; shades of red, when the observed frequency is substantially less, as shown in the legend.

The proportion of incidents from African range countries, which were identified to species level, has not changed significantly through time (**Figure 2.9a**; slope ± SE = 0.01 ± 0.02, t-value = 0.39). However, the proportion of incidents, for which species were identified, from both Asian (**Figure 2.9b**) and non-range countries (**Figure 2.9c**), have significantly declined through time (Asian: slope ± SE = -0.08 ± 0.00, t-value = -8.05; non-range: slope ± SE = -0.07 ± 0.01, t-value = -6.87).

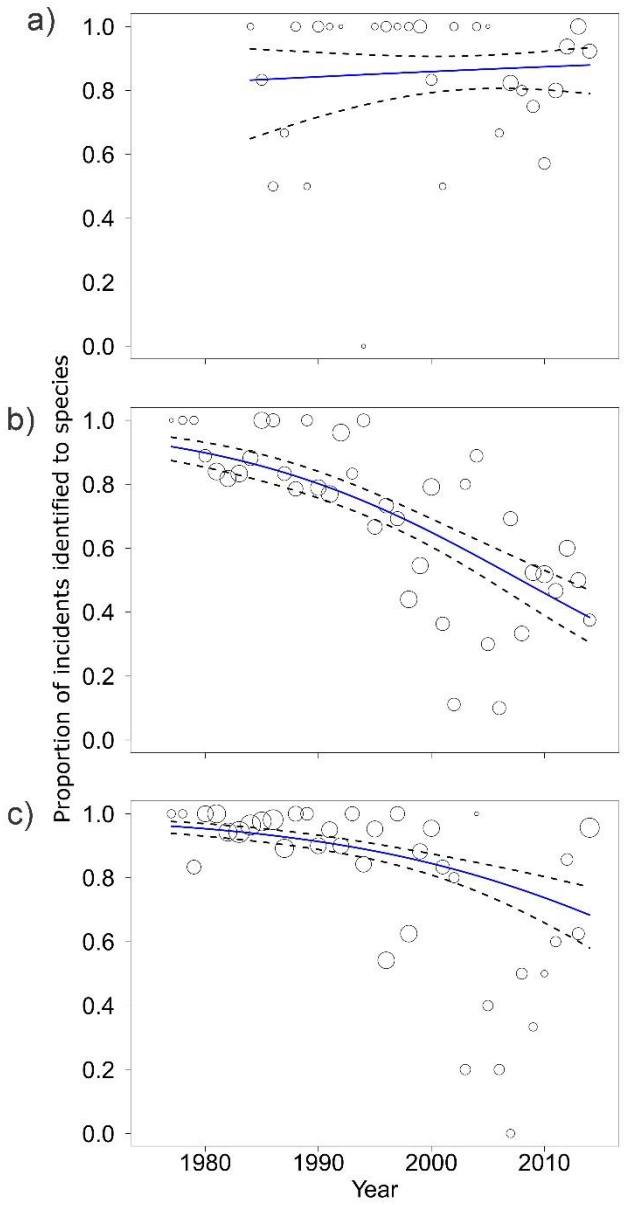

Figure 2.9. Proportion of incidents identified to species level from export countries that are either: a) African range countries b) Asian range countries, or c) non-range countries. Fitted binomial regression lines, and 95% Confidence Intervals, are also shown. The size of the data points are weighted by the logarithm of the number of incidents.

2.5 Discussion

CITES trade data revealed a significant shift in pangolin trade from Asian to African species, pre and post 2000, despite Asian species still being traded in large numbers; from 2001 to 2014 more than c. 17 500 whole Asian pangolins were traded. Trends in the global trade in pangolin species revealed that whilst the trade in Asian species has decreased, the trade in African species has increased significantly since 2001. Prior to 2000, Asian pangolins constituted the majority of trade, and there was almost no trade in any of the African species. It is possible, that African specimens may have been misidentified during this period (e.g., see Bräutigam, et al. (1994)), yet, since 1995 *M. tricuspis* has become increasingly common in the trade. Since 2000, *M. tricuspis* and *M. gigantea* were the most frequently encountered of the African species, and in 2014 all eight pangolin species were recorded in the trade for the first time. Non-implementation of CITES provisions for Appendix III species may also have accounted for trade in African species not being consistently reported to CITES prior to 1995 (Bräutigam, et al. 1994).

Prior to 2000, the CITES trade consisted almost exclusively of two species (*M. javanica* and *M. pentadactyla*), both of which were traded in enormous numbers, and are currently listed as Critically Endangered by the IUCN Red List (Challender, et al. 2014b; Challender, et al. 2014c). In addition, very large shipments of trafficked pangolins have undoubtedly further contributed to their endangerment and IUCN listing (Challender 2011; TRAFFIC 2014; Challender, et al. 2015b; Andersen 2016). Nevertheless, Asian pangolins were still 'legally' traded in substantial numbers, after 2000, despite the zero export quota. It is particularly noteworthy that the largest number of whole pangolins traded was in the year 2000, which aligns with the establishment of the zero export quota for Asian species. It has been previously found that trade in a species can increase (i.e., is 'stimulated') when legislation is changed to make it more difficult to trade a particular specimen in the future (Rivalan, et al. 2007).

Prior to 2000 the dominant trade partnerships were between the US and Mexico, and the US and Japan, but also between the US and Asian range countries, including Lao PDR, Thailand, Taiwan and Singapore. Notably, China did not contribute to the top 10 partnerships, with regards to frequency in CITES trade, prior to 2000. However, after 2000 China became a major exporter of pangolins to the US. The US remained the key trader, mostly importing pangolins from the same trading partners as before, with the addition of

African range countries, particularly Togo. The US most frequently traded pangolins throughout the entire period (pre and post 2000) and was the greatest importer of pangolins and their products, measured both in volumes, as well as in frequency. Since 2001, almost half of the CITES trade in pangolins (46.0%) has been reported as 'seized' (SE per year = 4.4%) and the majority of this trade has been seized by the US (82.5%). Although it remains unclear why so many pangolins and their parts are imported to the US, it is striking that globally many of the major contributors to the trade are actually non-range countries, both prior to and after 2000. A potential bias of the data is that non-range countries may appear to be very prominent in the trade, because they largely rely on imports from source countries, whereas native range countries can rely on exploiting their native pangolin populations, while they are still extant. Clearly, this depends on the population status and availability of the native pangolin species within their range country and we could not account for this in the present analysis.

It is our belief that no captive bred pangolins exist in the wildlife trade. Instead, all supposedly 'captive bred' pangolins are suspected to be derived from the wild (Shepherd 2009). To date, only Uganda, China, India, Singapore and Vietnam have reported breeding activities, though not in commercial quantities (CITES 2015; D. Challender, pers. comm. (2016)), and captive breeding programmes, or even captive care for pangolins, have so far been highly unsuccessful (Yang, et al. 2007). Surprisingly, we found that a number of incidents were declared as captive bred (18 incidents), or ranched (four incidents). Captive bred specimens were reportedly sourced from Vietnam, Lao PDR, the Philippines, Hong Kong, Thailand, China and India (as origin states) and from the US, Taiwan, Lao PDR, South Africa, Thailand, Malaysia and Mexico (as exporter states). Togo and Lao PDR were the only countries that reported ranched pangolins in the trade (both as an exporter and origin country). There are no known reported breeding facilities in the Philippines, Hong Kong, Thailand, nor Lao PDR; therefore, the shipments with captive sourced pangolins reported to CITES, are highly questionable. China reported that they are at the stage of a population breeding development, but no sale has yet occurred (Yu, et al. 2015; D. Challender, pers. comm. (2016)). In India, pangolins are only allowed to be bred by recognised zoos for conservation purposes. Vietnam has a rescue centre for pangolins seized from trafficking incidents, and sometimes pangolins give birth in these rescue centres (*M. javanica* was bred in Vietnam at least once). In some zoos (e.g., in the Singapore and Taipei Zoo) pangolins give birth in captivity, though at great expense and effort, and in very small numbers and not for commercial sale. This does not explain the high numbers

of pangolins traded, sometimes for commercial purposes. For example, the US reported the import of 198 skins of captive bred *M. javanica* in 1990 and 1991, being exported from Taiwan and with an origin in Vietnam. It is highly unlikely that these animals where bred in rescue centres or other breeding facilities, and it is unknown (yet very unlikely) that the reported rescue centres for pangolins even existed at that time. Furthermore, it is known that keeping pangolins in captivity is extremely difficult (Heath and Vanderlip 1988; Wilson 1994; Yang, et al. 2007; Mohapatra and Panda 2014; Hua, et al. 2015) and few institutions have had success at keeping pangolins, let alone breeding them. It can only be concluded that the reports of captive bred specimens in the trade are misleading.

The increasing numbers of ranched specimens in the trade in recent years, most of them coming from Togo, are particularly concerning. In contrast to captive bred specimens, ranched animals, by CITES definition (CITES 2010), can be taken from the wild as a juvenile and need not necessarily be born in captivity. To date, 10 skins of *M. gigantea*, supposedly ranched in Togo (where they do not even occur), have been reported in 2011 (and were possibly re-exported in 2013 from Thailand). A further 500 live pangolins of ranched *M. tricuspis* were imported to Italy from Togo in 2008. Lao PDR reported the export of 1000 skins of ranched *M. pentadactyla* in 2010. Given the difficulties in keeping pangolins alive in captivity for a prolonged length of time (Heath and Vanderlip 1988; Wilson 1994; Yang, et al. 2007; Mohapatra and Panda 2014; Hua, et al. 2015), it is highly unlikely that ranching occurs and these claims are probably misleading. It is critical that further research is conducted to identify if this clause is providing traders with a harvest and conservation loophole.

African species have mostly been traded as whole animals, for commercial purposes, which might further indicate their increasing supplementary role for Asian species. Asian species prior to 2000 were mostly traded for the commercial trade in leather and skins (see also Challender (2011), Challender, et al. (2015b)). The commercial trade decreased after 2000, which could be due to the fact that Parties only needed to summarise re-exports of manufactured goods since January 1994 for species in Appendix II and III (see Notification to the Parties No. 788: CITES, 1994). The commodities most frequently traded were leather and skins, and this is also in contrast to the commodities most frequently encountered in pangolin trafficking, which are scales, whole animals (dead and alive), and meat (Challender 2011; TRAFFIC 2014; Challender, et al. 2015b; Zhang, et al. 2015). In the CITES trade, scales only constituted 4.8% of the whole trade, and the trade in meat, bodies

and live animals only constituted 0.6%, 5.4%, and 6.6% of total incidents, respectively. We recognise, therefore, that there are clear differences in the drivers between legal trade and trafficking, and these differences deserve urgent research attention in order to understand future pressures, particularly from trafficking.

It is interesting to observe that the proportion of incidents identified to species level, for shipments coming from both Asian and non-range countries, have significantly declined through time. We propose that it is highly likely that unidentified species coming from Asian range countries are also Asian species, which leads to the question, why they are being declared as 'unknown'. One possible explanation could be that, following the establishment of stricter international trade regulation for Asian species, more specimens are being disingenuously categorised as 'unknown', presumably to circumvent the zero export quota. This possible illegal activity requires immediate attention, and further investigation.

Although legal trade in wild sourced Asian species (traded for primarily commercial purposes) decreased after the zero export quota in 2000, there were still questionable exceptions. We found 15 recorded incidents, all involving wild caught Asian species (all but one were *M. javanica*) being traded for commercial purposes in the period 2001 – 2012. Notably, all but one of these incidents originated in Malaysia. In sum, the trade included 3300 kg scales, 17 small leather products, 1 large leather product, and 7909 skins. Even if these incidents were re-exported, from shipments before the zero export quota, (for example, there were exports from Malaysia to Singapore including 11 430 kg of scales prior to 2000, and 3300 kg originating from Malaysia and being exported from Singapore to China after 2000), it remains unclear to us why a permit for the trade in these specimens was allowed to be issued.

A number of limitations have been previously reported with CITES trade data. Parties regularly fail to reliably report wildlife to species level (Gerson, et al. 2008; Phelps, et al. 2010), and Blundell and Mascia (2005) found significant discrepancies in CITES and Customs reporting in the US. The reported units and quantities are also often missing in the CITES database (Foster, et al. 2016), and Parties sometimes report by permits that have been issued rather than permits that have been used (CITES 2013a). Not all countries, including some pangolin range countries, have been a Party to CITES since its' inception, and trade from years before they became members will be under reported. Vietnam for example, a range country for the Chinese and the Sunda pangolin, and believed to be a

major consumer country for pangolin products, only became a Party to CITES in April 1994. In addition, Angola, a range country of all four African pangolin species, only became a Party to the Convention in December 2013. Furthermore, 17 pangolin range countries do not appear at all in the reported CITES data, 14 of which are in Africa, further indicating a possible lack of reporting.

The CITES trade database should only contain legal trade data, reported via granted permits and certificates (as specified in Article VIII of the Convention, Paragraph 6 and 7), however, Parties are recently required to report pangolin seizures, as was requested through Decision 16.41 in 2013 (CITES 2013b). Therefore, another limitation of the data, which will cause confusion, is that not all Parties are consistently reporting their seizures. The US is one of the few countries reporting trafficking incidents, and it seems to be doing this by reporting the seized code 'I' in the source column. To our understanding, and as also indicated in the 'guide to using the CITES Trade Database' (CITES 2013a), and confirmed by CITES Authorities (P. Cassey, Pers. Comm., 2016), the source column in the CITES database is used to describe the actual origin of a specimen (e.g., wild caught, captive bred, etc.). This means that the Code 'I' in the source column should only be used if a specimen was seized at some point and is then legally distributed under a CITES permit. To find supporting evidence of suspected misuse of the source column we compared incidents from the CITES and the LEMIS database, of which the latter provides more reliable details of whether or not a shipment was for example cleared or actually seized. We were able to match CITES 'seized' incidents with the LEMIS database, and found that 98.16% of incidents were in fact seized by US authorities, therefore indicating incorrect use of the 'source' data reporting column in CITES. However, it remains unclear which, if any, other Parties are doing the same. This provides further evidence of the unreliability of CITES data and the obvious confusion about CITES reporting requirements by some Parties. It should be noted, that unreported trafficking of pangolins is taking place in a variety of countries, and those seizures are in most cases not reported to CITES. Most notably in Asian countries, huge seizures of pangolins have been reported in the media, as for example, the seizure of 11.5 tonnes of pangolins that were seized in China's Guangdong Province (Anon. 2015c). China is implicated in many incidents reported in the media, as either a seizure or destination country (Challender, et al. 2015b), and is likely to be the most dominant player in the global pangolin trade, if accounting for both the illegal and CITES reported trade. Here however, we focussed on CITES reported trade only, and even when reported 'seized' shipments are omitted, the US still remains the dominant player (see

https://taaprowse.shinyapps.io/pangolins/); acknowledging all of the aforementioned limitations around CITES data when interpreting our results.

The total number of CITES recorded pangolins traded between 1977 and 2014 is enormous, with an estimated 809 723 whole pangolins; which does not account for 18.72% of recorded incidents (including: 7239 cartons of derivatives and skin pieces; 68 flasks of specimens; 568.19 kg of derivatives, medicines, specimens, and unspecified shipments; and, 60 307 specimens, derivatives, garments, medicines, carvings and bone pieces with an undefined unit). While we acknowledge that the numbers of whole pangolins will overestimate the trade, because we did not account for potential re-exports, the conversion process worked with fairly conservative numbers, and as noted before, it does not include all incidents. In addition, the previously discussed limitations to CITES data indicate that the trade is more likely to be underestimated than overestimated. Finally, the illicit global trafficking contributes enormously to the decline in pangolin species, and the contributions and trade partnerships of this illegal network go largely unstudied, and unquantified.

In conclusion, no previous study, has analysed CITES trade data for both African and Asian pangolins (but see Challender, et al. (2015b) for Asian pangolin species). Here, we found a massive increase in trade of African species after 2000, while Asian species trade has decreased. Again, it should be emphasised that these results do not reflect trafficking in pangolins, but only trade reported to CITES. There has been a dramatic switch from Asian to African species, and as Asian populations have declined (Wu, et al. 2004; Baillie, et al. 2014; Challender, et al. 2014b; Challender, et al. 2014c), we predict the same to happen in African populations. We therefore recommend that all trade, legal and illegal, should be monitored closely and enforcement efforts should be enhanced considerably. The establishment of the new mandatory annual illegal trade report, with the first report due in October 2017 (CITES 2016e), is also a step in the right direction. It should be emphasised, however, that the reports on trafficking and seizures should be kept separate to the legal trade data to avoid confusion, and in order to unmistakably distinguish between them. Generally, improved CITES reporting is necessary, and we strongly encourage Parties to reliably report all of the trade in a standardised manner, especially with regards to future reporting of trafficking.

Further research into the demand, the drivers, and the impact of pangolin trade and trafficking in all range countries, but also in non-range countries (e.g., the US and certain European countries), should be conducted to better understand trade characteristics and underlying networks. These findings can then be used to guide the strengthening of law enforcement and conservation efforts, and to raise awareness, change consumer behaviour, and finally, reduce the demand for pangolins.

Chapter 3

The Global Trafficking of Pangolins:

A Comprehensive Summary of Seizures and Trafficking Routes from 2010 – 2015

Statement of Authorship

Title of Paper	The Global Trafficking of Pangolins: A Comprehensive Summary of Seizures and Trafficking Routes from 2010 – 2015.
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Heinrich, S., T. A. Wittmann, J. V. Ross, C. Shepherd, D. W. S. Challender, and P. Cassey. 2017. The Global Trafficking of Pangolins: A Comprehensive Summary of seizures and Trafficking Routes from 2010 –2015. TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

Principal Author

Name of Principal Author (Candidate)	Sarah Heinrich		
Contribution to the Paper	Collated, curated, analysed and interpreted the data, wrote manuscript and acted as corresponding author		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	14.12.2019

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate to include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Talia A. Wittmann		
Contribution to the Paper	Assisted with data visualisation and manuscript editing		
Signature		Date	

Name of Co-Author	Joshua V. Ross		
Contribution to the Paper	Assisted with the development of the work and manuscript editing		
Signature		Date	

Name of Co-Author	Chris R. Shepherd		
Contribution to the Paper	Assisted with development of the work and manuscript editing		
Signature		Date	

Name of Co-Author	Daniel W.S. Challender		
Contribution to the Paper	Assisted with manuscript editing		
Signature		Date	

Name of Co-Author	Phillip Cassey		
Contribution to the Paper	Supervised the development of the work, assisted with data analysis and interpretation, as well as manuscript editing		
Signature		Date	

Chapter 3. The Global Trafficking of Pangolins: A Comprehensive Summary of Seizures and Trafficking Routes from 2010–2015

This chapter has been amended slightly from its original published version to reduce redundancy and ensure consistent formatting throughout the thesis. The original publication can be found online with the following citation:

Heinrich, S., Wittmann, T.A., Ross, J.V., Shepherd, C.R., Challender, D.W.S., and Cassey, P. (2017). The Global Trafficking of Pangolins: A comprehensive summary of seizures and trafficking routes from 2010 –2015. TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

3.1 Abstract

Pangolins are considered the most heavily trafficked wild mammals in the world. Their meat is considered a delicacy and their scales are used in traditional medicines. All eight species are listed as threatened on The IUCN Red List of Threatened Species™. An estimated one million pangolins have been trafficked in the period 2000 – 2013, however, there is currently little understanding of the trafficking routes used to transport pangolins globally. Here, we investigated the illegal pangolin trade from 2010 – 2015, focussing on global trade routes used to traffic pangolins and their derivatives. We collated 1270 seizure incidents for the study period, which included at least 20 749 kg and an additional 7154 individual pangolin body parts, 55 251 kg and an additional 5613 individual pangolin scales, and 44 475 kg and an additional 46 760 individual whole pangolins. We used a subset of the data (excluding domestic trade) to study international trafficking routes and identified an average of 27 new trade routes each year, highlighting that wildlife trafficking occurs through a highly mobile trade network with constantly shifting trade routes.

We identified China and the United States of America as the most frequent destinations, and Europe as an important transit hub, mostly for African pangolins and their derivatives being transported to Asia. The most frequently used trafficking routes were all within Asia, with the exception of direct routes from China to the United States of America, and China to the Netherlands. The seizure incidents involved 67 countries and territories across six continents, demonstrating the global nature of pangolin trafficking, which is not limited to Asian and African range countries.

3.2 Introduction

Pangolins are often cited as the most heavily trafficked wild mammals worldwide, with estimates of over one million animals taken from the wild between 2000–2013 (Challender, et al. 2014a; Challender, et al. 2015b). It is widely believed that pangolin trade is primarily driven by demand in Asian countries, especially China and Vietnam (Pantel and Chin 2009; Challender 2011; Challender, et al. 2014a; Nijman, et al. 2016), although it has also been shown that demand exists in non-range countries, such as the United States of America (US), European countries, and Japan (see e.g., Chapter 2). With declines in populations of Asian pangolins, there is now evidence of fast-developing intercontinental trafficking of African pangolins to Asian markets, facilitated by increasing economic ties between East Asia and many African nations (Challender and Hywood 2012; Challender, et al. 2016; Gomez, et al. 2016b). Research has also shown an increase in regulated (legal) pangolin trade activity reported to CITES after the year 2000, particularly in African pangolin species, which coincided with the establishment of a zero export quota for commercial trade in wild-caught Asian pangolins (Chapter 2).

All pangolins were recently transferred from CITES Appendix II to Appendix I (CITES 2016c). This important step provides pangolins with the highest protection status through CITES, and prohibits international trade in wild-caught pangolins for commercial purposes globally.

Pangolin seizure data were collected from a variety of sources. Seizures are an indirect measure of actual trafficking levels and, across countries, seizure data are likely to be biased by a large number of complex factors (see also Underwood, et al. (2013), and Utermohlen and Baine (2017)). These factors will influence both the "level of enforcement" (i.e., corruption, environmental crime, lack of awareness) and "level of reporting" (i.e., non-English media, non-compliant enforcement, variation in the in-country activity of non-governmental organisation (NGO) agencies). In addition, law enforcement authorities intercept an unknown percentage of all contraband. Consequently, the seizure incidents reported here are only a proportion of the total number of trafficking incidents worldwide. This is an inherent bias of all seizure data.

The purpose of this Chapter is to determine trafficking routes for the illegal transnational pangolin trade and enhance knowledge of where pangolins are sourced from. This information can be used to understand better where demand exists, which is critically

important to inform conservation action, species management, and law enforcement efforts. Despite increasing attention on pangolins globally, a detailed understanding of international trafficking routes used in the illegal pangolin trade is largely lacking in the existing literature. Some studies have partially described illegal pangolin trade dynamics, but they have always focussed on specific regions or countries, and mostly Asia (Challender, et al. 2015b; Gomez, et al. 2016a; Nijman, et al. 2016; Cheng, et al. 2017; Zhang, et al. 2017). This is the first study to describe the international trafficking routes for pangolins on a global scale.

3.3 Methods

Pangolin seizure data were collated for the period 2010 – 2015 from a variety of sources, including online media reports, openly accessible data from CITES documents from the CITES website (it should be noted that legal pangolin trade reported to CITES has been previously analysed in Chapter 2; whereas only illegal incidents were used for this study, hence the legal CITES trade database was *not* queried), and from NGO publications, including Education for Nature Vietnam (ENV), the *TRAFFIC Bulletin*, and Last Great Ape Organization (LAGA) annual reports. Additional data were received from the African Pangolin Working Group (APWG; Namibia only) and the EAGLE Network. Datasets previously collated by Dan Challender (data from 2010–2013), and TRAFFIC (2010–2015) were also included. In addition, data were received from Healthmap (www.healthmap.org; 2011–2015) and the Environmental Investigation Agency (EIA; 2010–2015). Data from the European Union Trade in Wildlife Information Exchange (EU-TWIX) database (for data from Europe; 2010–2015) were included, as well as data from the Law Enforcement Management Information System (LEMIS; 2010–2014) for the US.

Seizure data were requested from 179 CITES Management Authorities (CITES MAs). Data requests to the CITES MAs were sent via email in September 2016 and, where no initial response was received, a follow up request was sent in October 2016 (with the exception of Syria). Four MAs were not contacted: the European Union was not contacted as all member countries were contacted individually; Panama and Tonga could not be contacted with the details provided on the CITES webpage, nor through the relevant national departmental webpages; and Liechtenstein was not contacted as it shares a Customs union with Switzerland. New Zealand provided data (from 2010–2016, 67 seizure incidents), but

were unable to assign any of the incidents to specific years, and were excluded from further analysis. Furthermore, while Hong Kong Special Administrative Region (SAR) is a territory of China, data are provided separately through their respective CITES MAs, and therefore data from each source has been kept separate for the purpose of this study. Reference to China in the Results and Discussion sections of this study is to mainland China only and does not include data from Hong Kong SAR, Macao SAR, nor Taiwan.

All available seizure data were collated into a bespoke SQL database (Microsoft Access). The data were collected based on seizure events pertaining to a particular seizure location, hereafter referred to as an "incident". Information collected for each incident included, but was not limited to: i) location and date of seizure; ii) species, commodities and quantities seized; iii) transport mode; and iv) trade route information (i.e., links between origin, transit and destination countries), where available. In some cases an incident consisted of more than one trade route (e.g., when more than one origin or destination location were reported, such as a shipment of pangolins was seized in an Asian country, but the commodities that made up the shipment originated from two different African countries). When curating the trade route information for each incident, an "origin country" was defined as the first known point, and a "destination country" as the last known point in any trade route. All reported countries in-between were designated as transit countries. The country of seizure could occur at any point along the trade route, and could be an origin, transit or destination country.

All data were subset to include only: i) *verified incidents* (i.e., those that were either provided by restricted access sources or where open access sources could be independently verified online); and ii) *international incidents* (i.e., trade routes crossing at least one international border, and excluding all domestic trade links). It is acknowledged that this potentially precludes incidents that were supposed to be exported but were intercepted before reportedly crossing an international border.

Commodities were grouped into three categories, namely: i) "Scales" (including only scales); ii) "Whole Animals" (including whole animals that were either live, dead, or whole but uncertain of their condition); and iii) "Body Parts" (including all other commodities and medicinals, i.e., legs, claws, skins, and undefined raw or processed products). Three rules were constructed in order to assign a home continent (Africa or Asia) to the pangolins traded. First, if the pangolin species was reported in the incident, it was assigned its respective native home continent; secondly, if the commodity source country was reported

(this being the actual source country where the trafficked pangolins originated) it was assigned to the home continent of that source country; and thirdly, the trade flow between continents was used to assign a home continent. If the home continent differed from the destination continent (intercontinental trade) the origin was assumed to be the home continent of the pangolins being traded. A conservative approach was adopted and a home continent was not assigned where only intracontinental trade occurred. The modes of transport were grouped into: i) "Air" for transport by plane; ii) "Sea" for transport by boat; iii) "Land", including transport by car, bus, and similar vehicles, or by train and foot; and iv) "Unknown", where none of the above transport modes was reported.

As part of the data collection, the reported quantities of pangolins trafficked, or their parts/derivatives, per incident was also recorded. Quantities of seized commodities, where this information was reported, were provided either in count or weight. The reported weight was reported in grams, kilograms (kg) or tonnes, and was converted into kg during the data curation process. The quantities reported in counts were provided in various units, e.g., cups, individual number of specimens, bags, packages, boxes, vials and pills, and were maintained as reported. It is important to note that quantitative information was not available for every incident, and non-quantitative information, including qualitative information (e.g., "hundreds of animals", "bags of scales" etc.), was not included in further analysis. For the *international incidents* subset of the dataset, scales with a known weight quantity were reported in 244 records (86.9% of records), whole animals with a count were reported in 177 records (86.4%), and body parts with a count were reported in 149 records (87.9%).

All data analyses were conducted in the R environment (R Studio, version 3.3.2) for statistical and graphical computing (R Core Team 2017). The visualisation of the maps was conducted in ArcGIS (ArcMap, version 10.3.1).

A circle network diagram was constructed representing the frequency of trade flow between the countries involved in illegal pangolin trade from 2010 – 2015; including the direct links (edges) between two countries (nodes) in a trade route using the R package 'igraph' (Csardi and Nepusz 2006). The directional trade arrows (edges) were weighted by the natural logarithm of the total number of links between exporter and importer, while the size of the pie charts (nodes) were weighted by the natural logarithm of the total number of incidents the country was involved in. The displayed countries were classified as: i) within the native

range of Asian pangolin species; ii) within the native range of African pangolin species; or iii) outside the native range of any pangolin species (non-range countries).

To visualise the most commonly used trade routes, trade routes that occurred in five incidents or more were identified. The directional trade arrows were weighted by the normalised number of incidents that a particular trade route was used in. The intercontinental trade flow map was constructed in a similar way, by summing the trade route edges between continents. For each of the commodity categories, the quantity was summed per trade route and a "large-quantity shipment" was defined to consist of 1000 kg or more for scales, at least 100 body parts, and 500 whole animals or more. The top trade routes for each commodity category were visualised in a similar manner to the top commonly used trade routes, although the size of the directional trade arrows was unweighted.

A generalised linear model (glm) was used to test for a change in the number of incidents, and in the number of countries involved in the international pangolin trafficking through time, as well as large-quantity shipments for the three different commodity categories. A glm was also used to test for a change in the weight and number of incidents of large-quantity shipments of scales. Contingency-type frequency tests were used to assess and visualise the independence of categorical variables (commodity, transport mode, and home continent) (Zeileis, et al. 2007; Meyer, et al. 2017). Wald Chi-square tests for independence were used to evaluate the homogeneity of frequencies. The relative proportion of occurrences of each category within the variables, commodity type and home continent, were calculated through time.

3.4 Results

3.4.1 Seizure summary

A total of 1270 seizure incidents were recorded from the period 2010 – 2015. Seizure incidents have been reported consistently through time, with an average of 212 incidents per year (Estimate = -3.2, Standard Error (SE) = 6.125; t = -0.522, p = 0.629; **Figure 3.2**). The illegal trade involved 67 countries across all continents, except Antarctica (**Figure 3.3**).

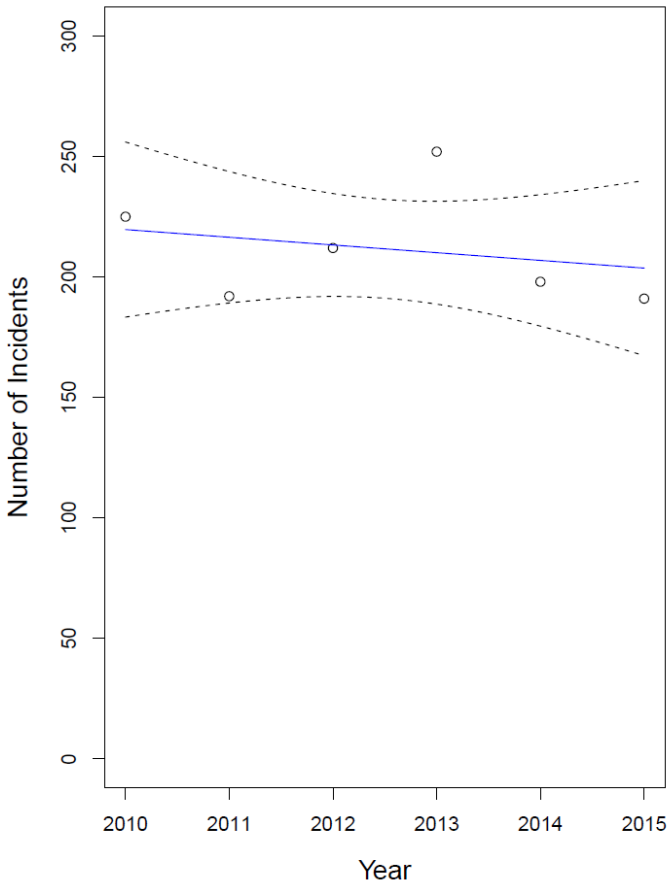

Figure 3.2: Total number of pangolin (*Manis* spp.) seizure incidents through time from 2010 – 2015, based on all available data (n = 1270 incidents). The number of incidents was used in a generalised linear model to create the fitted estimates (in blue) and 95% CI displayed in the dotted lines.

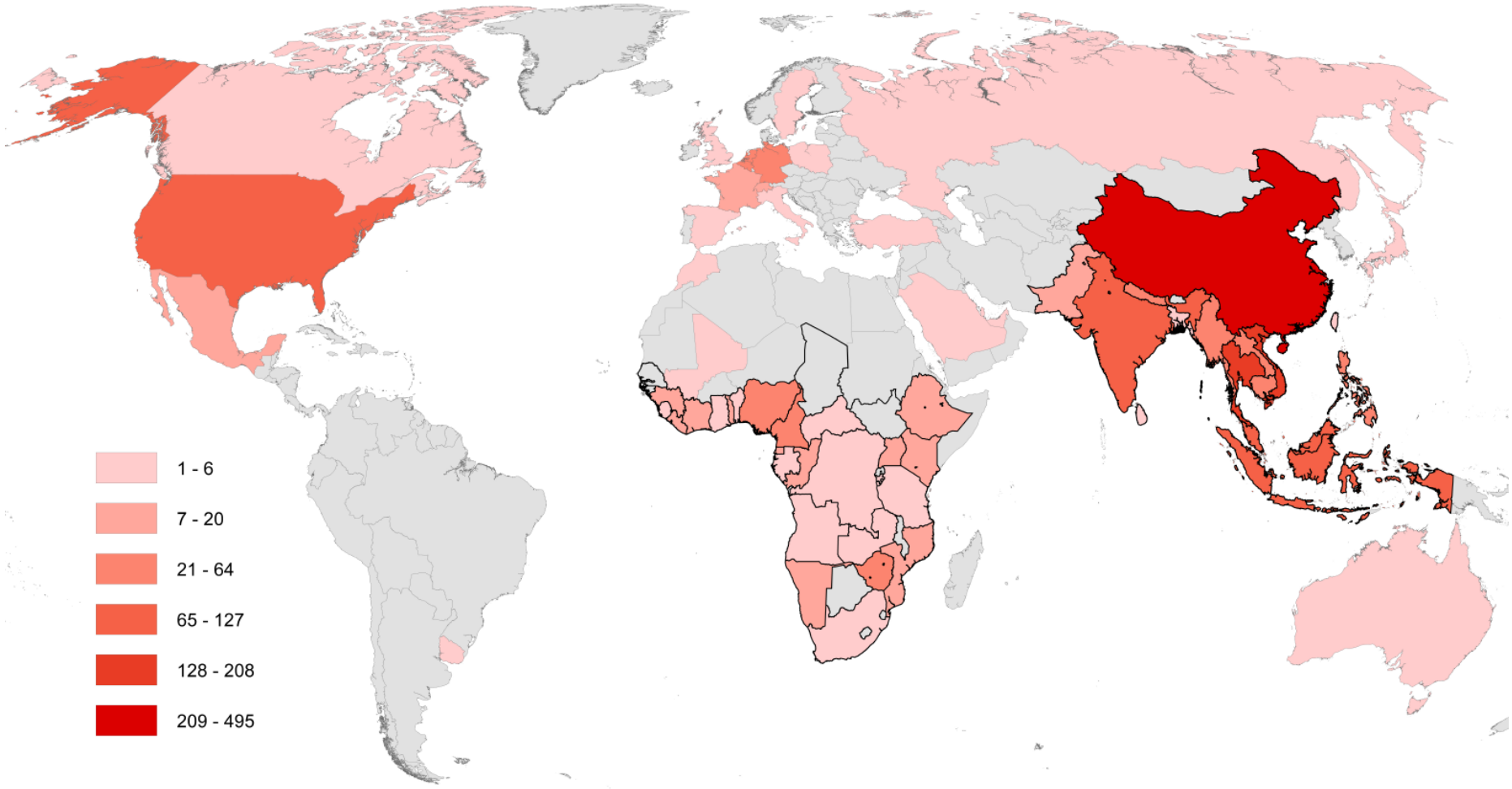

Figure 3.3: Countries implicated in pangolin (*Manis* spp.) trafficking incidents between 2010 – 2015, regardless of their role in trade routes (i.e., transit, origin or destination location), based on all of the available data (n = 1270 incidents). African and Asian pangolin range countries are depicted by thick, black country borders. The darker the colour, the more trafficking incidents occurred per country, with the number of trafficking incidents per country displayed in the legend.

Of the 1270 seizure incidents, 117 included multiple commodities (e.g., when scales and live animals were seized in the same incident), and the quantity of each commodity was recorded separately (hereafter referred to as a "record"). In total there were 1387 records, of which 105 did not contain quantitative information (7.6%). The quantities of the remaining records are provided in **Table 3.1**.

Table 3.1: Seized quantities of pangolin (*Manis* spp.) commodities, excluding records with no or only qualitative information on quantities (n = 1282).[3]

Commodity	Quantities		Number of records + (missing quantitative information %)
	Count (number of items)	Weight (kg)	
Body parts	7154	20 749.11	209 (16.27)
Scales	5613	55 251.09	432 (10.4)
Whole	46760	44 474.60	746 (3.5)

Prominent examples of "whole" animals included the seizure of 8.5 tonnes of dead pangolins along with 350 kg of pangolin scales in Jakarta (Indonesia) in November 2012; or the seizure of 2764 pangolin carcasses hidden in cooling boxes and weighing a total of 11.5 tonnes in September 2015 in China's Guangdong Province. The seizure of an estimated 10 tonnes of dead pangolins from a boat, which ran aground on a protected coral reef in Palawan (Philippines) in April 2013, marks one of the biggest confiscations of seized whole animals during the study period. Additionally, the seizures of 7.45 tonnes of pangolin meat along with 64.6 kg of scales in Indonesia on its way to Vietnam, and the seizure of 3000 undefined 'medicinals' in the US, which were imported from Vietnam, are among the biggest seizures for "Body parts". Prominent seizures involving pangolin scales may be an indicator that quantities of trafficked pangolins and their parts and derivatives are increasing through time. There were 22 medium-large incidents, each involving over 500 kg of scales (and each equating to approximately 1000 or more individuals). Of these

[3] Commodity quantities were not always reported in the same measure, hence the sum of the quantities per commodity for each measure is presented in weight (kg) and count (number of items of individuals, scales or body parts). The two measures are independent, i.e., each record only contains one measure, being either count or weight.

22 incidents, eight took place in 2015 alone. Three of these originated in Nigeria and were intercepted on their way to Asia; involving a total of 4587 kg of scales. Two incidents involved 2029 kg of scales from Uganda that were seized on their way to the Netherlands, and 970 kg of scales from Africa that were intercepted in China. A further three of the eight incidents from 2015 occurred in Asia, including 4000 kg of scales being trafficked from Malaysia to Vietnam, and 10000 kg and 505 kg of scales that were discovered in India and China respectively, with unknown further trade route information.

3.4.2 International trafficking

The top 10 countries involved in illegal international pangolin trade, based on the number of incidents they were involved in, and regardless of their role in the trade route (i.e., origin, transit, or destination), are provided in **Table 3.2** and **Figure 3.4**, along with the traded quantities associated with the most commonly implicated countries. Commodities were reported in weight (kg) or count (individual number of items per commodity). The number of items represent the number of scales, body parts or whole animals; e.g., the count would represent the number of individual scales that were seized, or the number of individual body parts.

Table 3.2: Top 10 countries ranked by the total number of international trafficking incidents of pangolin (*Manis* spp.) in which they were involved, regardless of their role in the trade route (i.e., origin, transit, destination, or seizure country).[4]

Rank	**Country**	**Number of incidents**	**Commodity Quantities**					
			Scales		***Body parts***		***Whole***	
			Weight (kg)	Count (number of items)	Weight (kg)	Count (number of items)	Weight (kg)	Count (number of items)
1	China	342	16 291	474	2290.4	1444	6407.5	15 764
2	US	127	1.4	417	5.1	6662	-	15
3	Vietnam	90	7487	-	2119.1	5828	19 125.3	10 490
4	Malaysia	60	10 534.3	-	-	-	5061	8460
5	Hong Kong SAR	57	7147.6	10	-	2	600	157
6	Thailand	56	1222.2	7	-	103	61	3608
7	Lao PDR	44	1914	16	-	48	61	2565
8	Nigeria	41	6372.7	71	26.2	-	10.4	-
9	Indonesia	40	4103.4	-	-	1	45 140.3	8070
10	Germany	38	666.5	71	26.2	11	-	1

Relative to the other countries, mainland China was by far the most heavily involved in terms of number of incidents, followed by the US. However, the overall quantities traded were far less in the US compared to China or countries involved in fewer trafficking incidents, such as Indonesia, or Nigeria (see **Table 3.2** and **Figure 3.4**). The same applies for other countries that are not listed in **Table 3.2**. Additional countries that were involved

[4] The countries have been ranked, where the highest ranked country (rank = 1) is the country that was involved in the most international incidents relative to other countries in the available data (n = 539 incidents). The trafficked commodities and their corresponding quantities per country are also shown. Commodity quantities were not always reported in the same measure, hence the sum of the quantities per commodity for each measure is presented in weight (kg) and count (number of items of individuals, scales or body parts). The two measures are independent, i.e., each record only contains one measure, being either count or weight.

in high quantities of trafficked pangolins and their parts and derivatives were Uganda, Cameroon, Myanmar, India, the Philippines, Singapore, Pakistan, and the Netherlands (see also **Figure 3.10**).

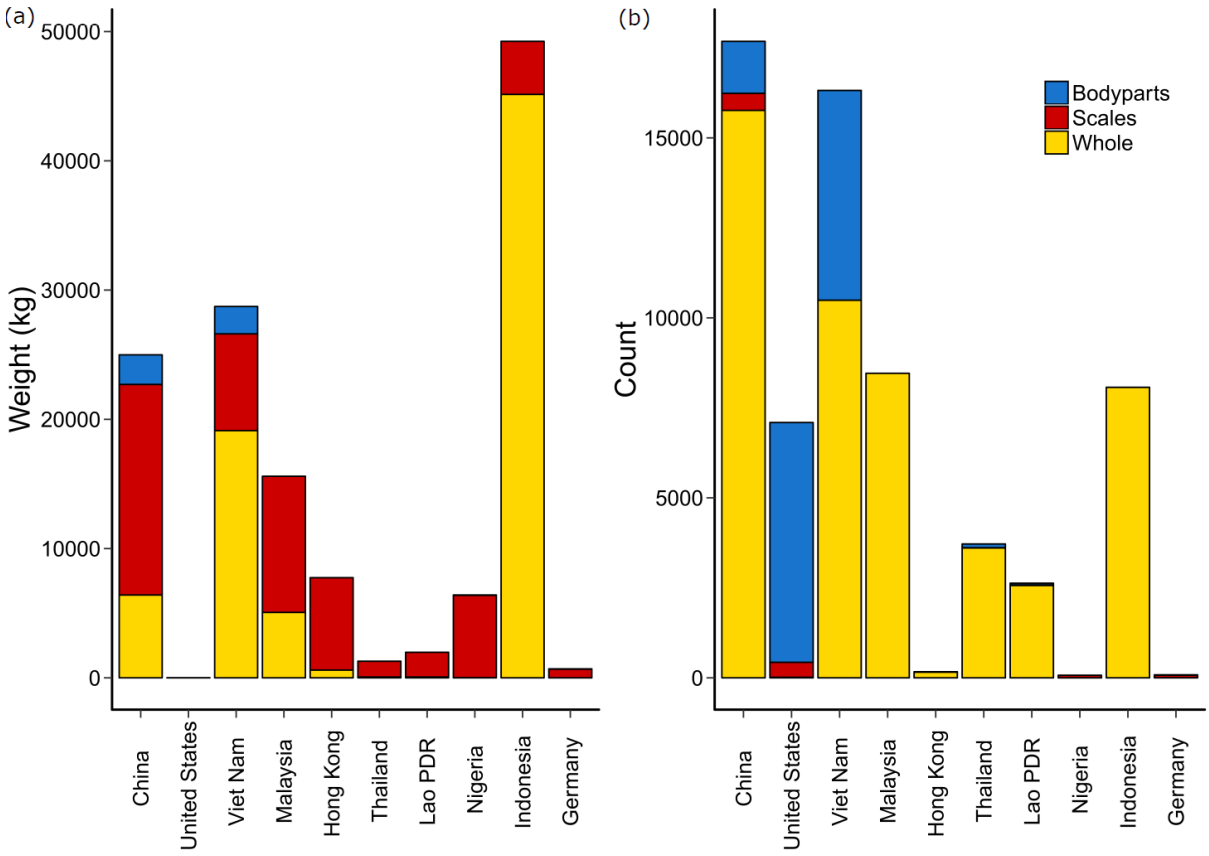

Figure 3.4: Trafficked quantities of pangolins (*Manis* spp.) and their products showing: a) the weight in kg; and b) the count (number of items of individuals, scales or body parts). The quantities are shown for the top ten countries involved in the most incidents of pangolin trafficking. Countries are ordered by their involvement in trafficking, starting on the left-hand side with the country most involved. Note that the two quantity measures are independent, i.e., each record only contains one measure, being either count or weight.

Notably, Nigeria, Lao People's Democratic Republic (Lao PDR), and Hong Kong SAR were ranked in the top 10 countries involved in the most pangolin trafficking incidents, they were not, however, ranked within the top 10 countries where seizures occurred **(Figure 3.5**, and **Table S3.1**). Other countries with a high discrepancy between the number of incidents they were involved in (≥ 5) in pangolin trafficking and the number of seizures (≤ 3) that occurred in these countries were Lao PDR, Nigeria, Myanmar, Cameroon, Guinea, Mexico, the Philippines, Pakistan, Liberia, Equatorial Guinea, Côte d'Ivoire, Ethiopia, Kenya, Singapore, Mozambique, Uganda, and Togo.

In terms of the number of incidents a country was involved in, African countries mostly served as origin countries, most notably Nigeria, Cameroon, Guinea, Liberia, Equatorial Guinea, Côte d'Ivoire, Kenya, Ethiopia, Mozambique, Uganda, and Togo (in descending order), as they were all involved in five or more incidents. Of the Asian range countries involved, China, Vietnam, Indonesia, Hong Kong SAR, Malaysia, India, Thailand, and Myanmar were origin countries in 20 or more incidents. The major destination countries in Asia were China, Vietnam, Malaysia, and Thailand, with 15 or more incidents, and Lao PDR, Thailand, Vietnam, and Myanmar served as the major inner Asian transit countries, with nine incidents or more. In Africa, several countries were involved in five or more incidents, but no seizures were recorded to have occurred, for example in Nigeria, Equatorial Guinea, Liberia, Guinea, Côte d'Ivoire, and Ethiopia (**Figure 3.5**, and **Table S3.1**).

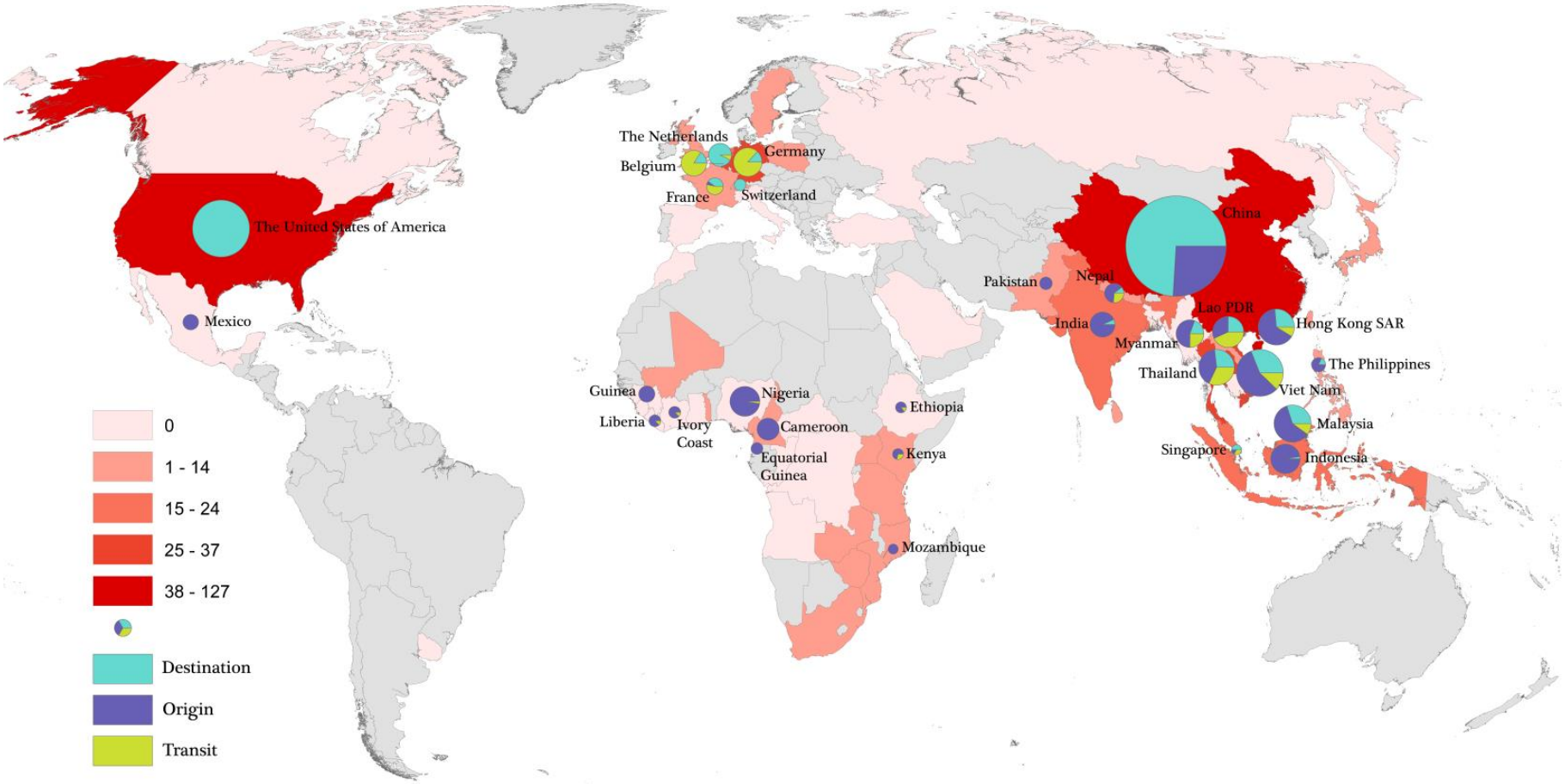

Figure 3.5: Countries involved in pangolin (*Manis* spp.) trafficking incidents between 2010 and 2015, based on the available data of verified international incidents (n = 539). The shading of the countries (light to dark) reflects the number of seizures that took place in these locations. The country of seizure could occur at any point along the trade chain, and could be an origin, transit or destination country. For all countries involved in more than five incidents (regardless of the location role), the pie chart indicates the relative proportion of the number of incidents a country was involved in for each role. The size of the pie charts is weighted by the total number of incidents a country was involved in (across all location roles).

For international incidents, 539 records (out of 570) contained quantitative information. Of these, 55% contained count information (number), and 45% contained weight information. Of all records involving scales, 10 records involved large-quantity shipments of scales (i.e., ≥1000 kg). The sum of the scale weights across these 10 records constituted 60% of the weight across all records involving scales. The proportion of large-quantity shipments containing scales has increased significantly through time (**Figure 3.6a**: estimate = 0.65, SE = 0.27, z = 2.43, p = 0.015). This proportional increase cannot simply be explained by the number of very small shipments (less than 1 kg) decreasing through time (**Figure 3.6b**: estimate = 0.56, SE = 0.27, z = 2.08, p = 0.038).

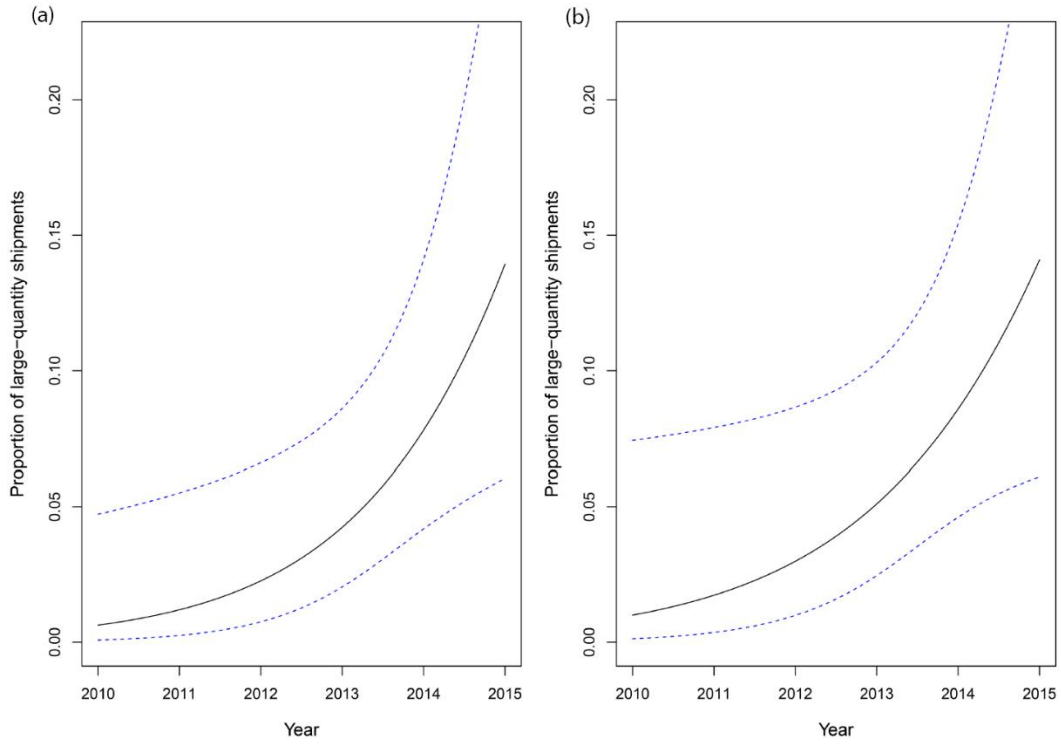

Figure 3.6: Proportional increase of large-quantity shipments of scales (i.e., ≥1000 kg): a) with all seizures of scales, and b) without "small" seizures of scales involving less than 1 kg. The number of incidents was used in generalised linear models to create the fitted estimates and 95% CI are displayed in the dotted lines. It is important to note that the significant increase in the proportion of large-quantity shipments through time is not simply due to a change in the frequency of "small" seizures of scales.

However, the proportion of large-quantity shipments of body parts measured as a count (i.e., ≥100 body parts; estimate = -0.62, SE = 0.41, z = -1.52, p = 0.13), and the proportion of large-quantity shipments for whole animals measured in count (i.e., ≥500 animals; estimate = -2.9, SE = 0.23, z = -1.25, p = 0.21) has not increased significantly through time. The eight large-quantity shipments of body parts (≥100 body parts) and the eight large-

quantity shipments of whole animals (≥500 animals), made up 85% and 69% of the quantity of all shipments of body parts and whole animals respectively (both measured in count).

There was, however, a highly significant increase in the size of the shipments of scales (measured in kg) through time (**Figure 3.7a**: estimate = 0.24, SE = 0.04, t = 5.41, p <0.001). This result was partly affected by "small" seizures of scales declining through time, but the positive trend was still statistically significant (**Figure 7.3b**: estimate = 0.1, SE = 0.04, t = 2.85, p = 0.005).

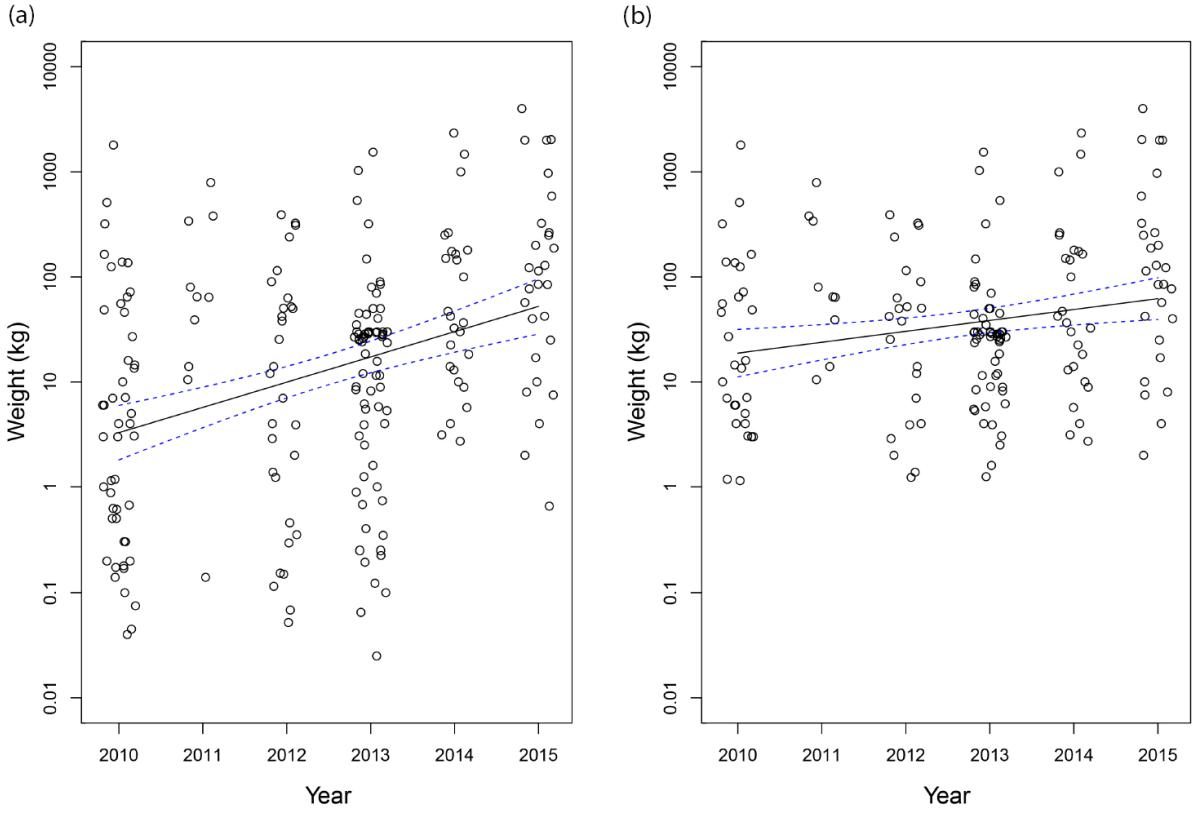

Figure 3.7: Weight of pangolin scale seizures (kg) through time from 2010 - 2015: a) Scale weight of all available records; b) Scale weight excluding "small" records (i.e., less than 1 kg). The number of incidents was used in generalised linear models to create the fitted estimates and 95% CI are displayed in the dotted lines.

3.4.3 Trafficking routes

A total of 159 unique international trade routes were identified (recognising that it is difficult to be certain that *complete* trade routes have been documented) and it was found that 29 of these have been used at least five times during the study period (**Figure 3.8**).

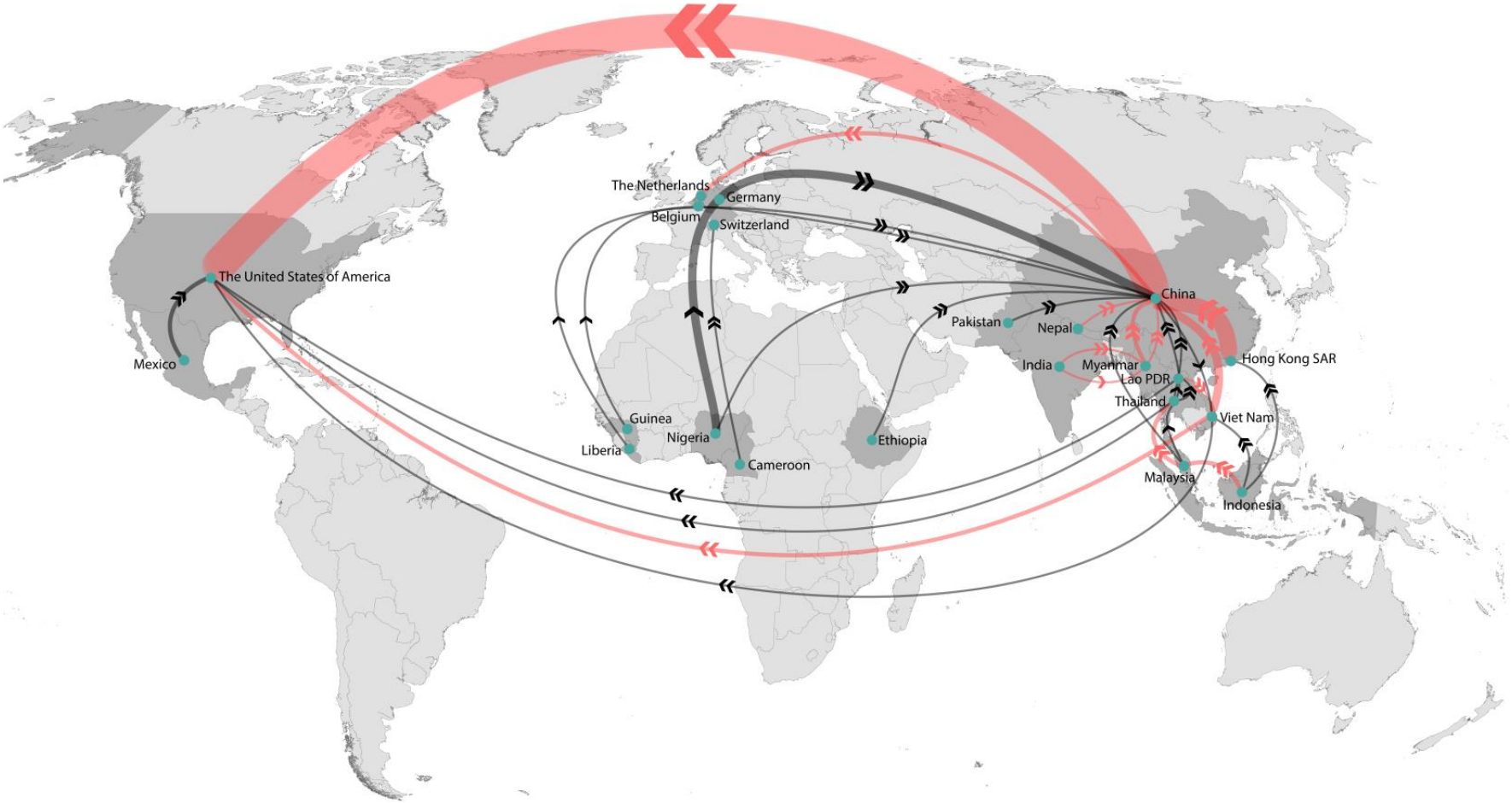

Figure 3.8: The top 29 trade routes that have been used five times or more in international pangolin (*Manis* spp.) trafficking incidents between 2010 and 2015 (n = 539). The directional arrows (edges) are weighted by the normalised total number of incidents occurring along each unique trade route. The 12 trade routes that have also been used in five or six consecutive years are displayed in red. Single arrow heads (>) indicate a transit edge in a trade route, and double arrow heads (>>) indicate the last edge in the trade route. Note that the start and end points of a trade route have been approximately centralised per country and do not indicate a specific location within a country.

Based on the most commonly used unique trade routes (**Figure 3.8**), and the overall involvement of the different countries (number of trafficking incidents, not quantities traded) (**Table 3.2**), the top two destination countries were China and the US. The US was a major destination country, receiving shipments almost exclusively from Asian countries (54 times directly from China, and six times from China via Vietnam). Mexico was the only non-Asian country (within the top trade routes) exporting directly to the US, a trade route that has been detected 13 times. The US was never an exporting or transit country, but always a destination (see **Figure 3.8**).

China was the major destination of pangolin products, relative to other countries. Based on the 29 trade routes relating to China, the most commonly used direct trade route was between Hong Kong SAR and China, which was used 36 times. China was also a destination for pangolins from other Asian countries, most notably Vietnam (28 times) and Myanmar (28 times; 10 of these seizures originating from India), but also directly from African countries, e.g., Nigeria (five times) and Ethiopia (six times), or indirectly from African countries via Europe (44 times; see **Figure 3.8**).

Of all European countries involved in the top 29 trade routes, only the Netherlands and Switzerland were destinations for pangolins and their products. The Netherlands was a destination for 18 shipments from China, whereas five shipments from Cameroon were destined for Switzerland. The other European countries, Germany and Belgium, were transit countries (**Figure 3.8**).

The trade routes that were used in at least five years of the study period were mostly within Asia, but also from China and Vietnam to the US, as well as from China to the Netherlands (**Figure 3.8**). It also appears that some trade routes, which were used in a large number of incidents, such as the trade route Nigeria → Germany → China, have not been used consistently though time, but only for short periods; i.e., less than five years (**Figure 3.8**). On average, 27 new unique trade routes were formed each year (SE = 3.19), i.e., trade routes that had not occurred or been reported in any of the previous years (**Figure 3.9**).

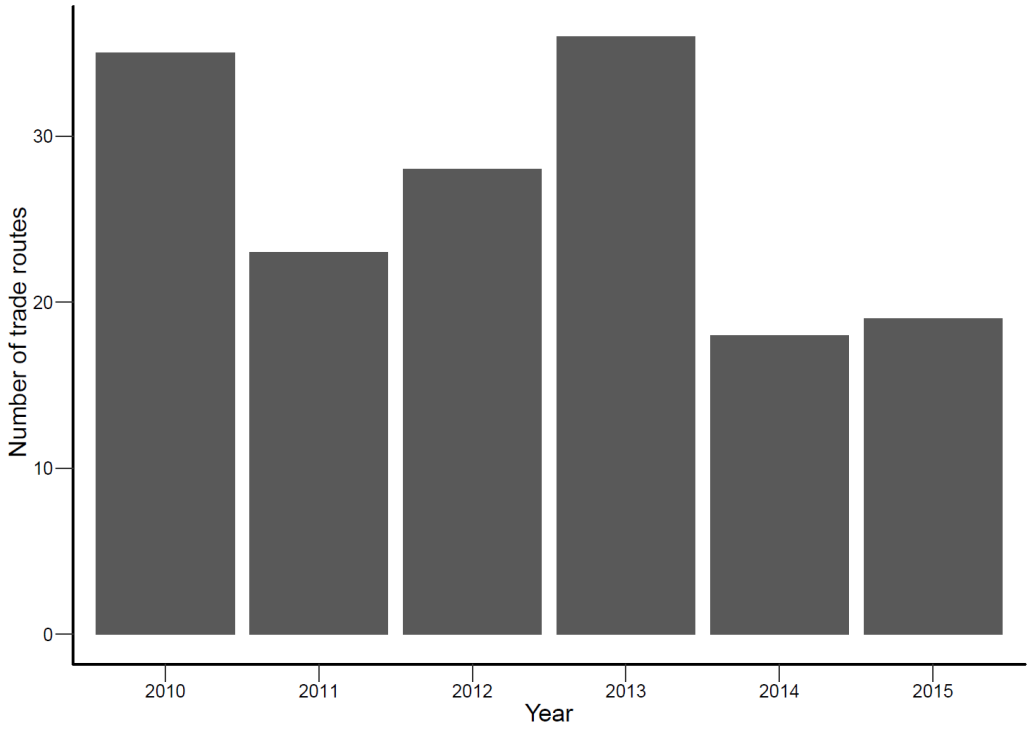

Figure 3.9: Newly detected pangolin (*Manis* spp.) trafficking routes that had not been detected in any of the previous years through time, based on available data of international incidents (n = 539) during the study period 2010–2015.

The top trade routes for large quantities of pangolin commodities varied slightly in comparison to the top trade routes in terms of number of incidents.

- The largest quantities of body parts were trafficked almost exclusively from China and Vietnam (80%), with the exception of the trade route Guinea → Thailand → US, and all large-quantity body part shipments were destined almost exclusively for the US, with the exception of the trade route China → Netherlands (**Figure 3.10**).
- Large-quantity shipments of whole animals were trafficked only within Asia, and 55% of these shipments were destined for China. Other destination countries for large-quantity shipments of whole animals were Malaysia, Vietnam, Thailand, and Singapore. Most of the large-quantity whole animal shipments originated in Indonesia (36%), and Malaysia (36%).
- Of the largest shipments of scales, 55% originated in African countries, namely Sierra Leone, Nigeria, Cameroon, and Uganda. The top destination for these large-quantity shipments of scales was China (64%). Apart from the US, the Netherlands was the only non-range country that received large-quantity shipments – scales from Uganda, and body parts from China (**Figure 3.10**).

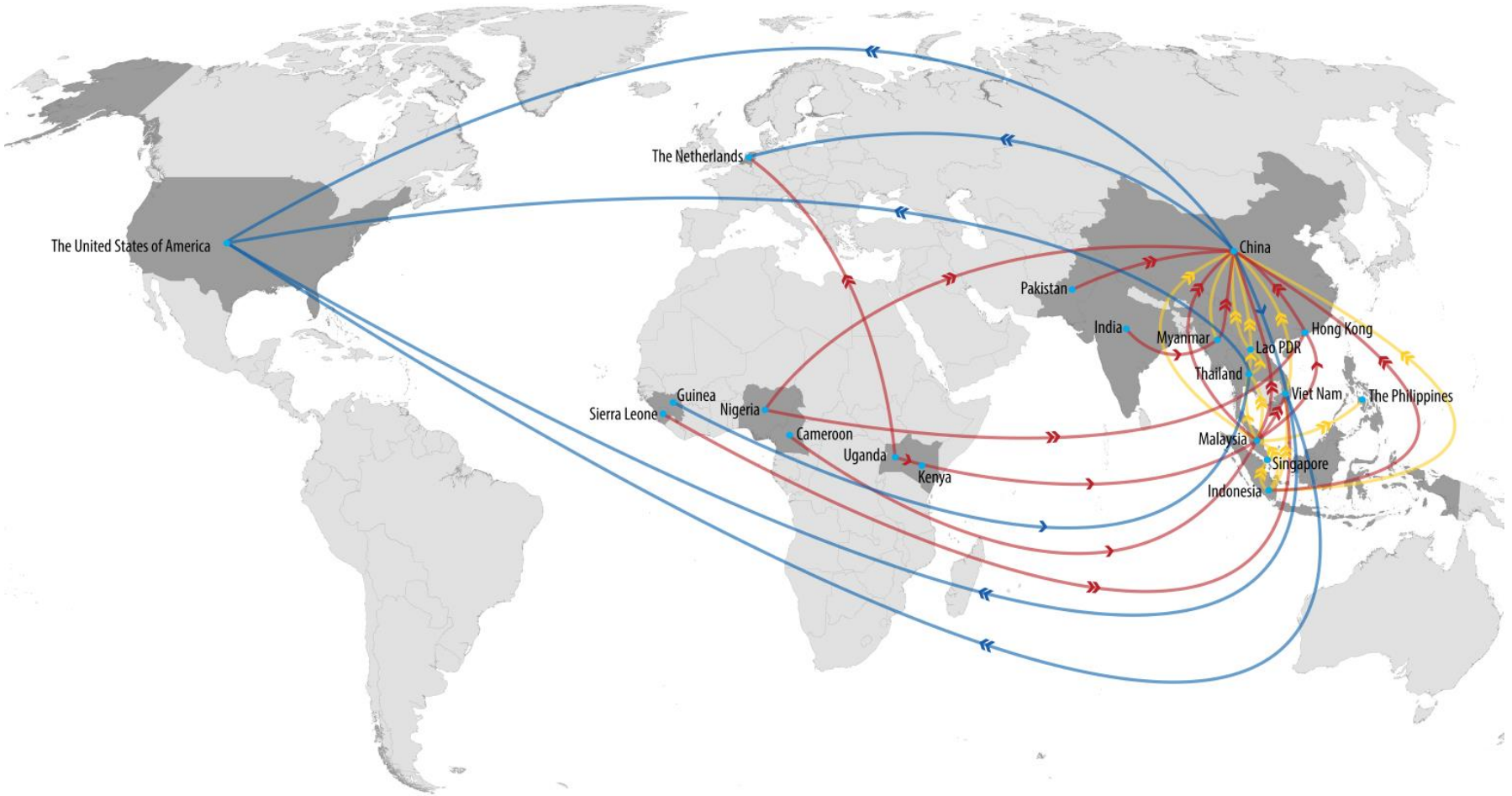

Figure 3.10: The top trade routes used for large-quantity shipments of pangolins (Manis spp.), based on the available data of international incidents with quantitative information. Trade routes for body parts are depicted in blue (sum ≥100 body parts), for scales in red (sum ≥1000 kg), for whole animals in yellow (sum ≥500 animals). Large-quantity shipments are weighted equally (using the same line thickness) across the three different commodities. Single arrow heads (>) indicate a transit edge in a trade route, and double arrow heads (>>) indicate the last edge in the trade route. Note that the start and end points of a trade route have been approximately centralised per country and do not indicate a specific location within a country.

An average of 33 countries (SE = 2.372) were involved in international pangolin trafficking per year. The overall number of countries (estimate = 0.66, SE = 1.52, t = 0.43, p = 0.69), as well as the number of African countries (estimate = 1.06, SE = 0.85, t = 1.25, p = 0.28) involved in international pangolin trafficking increased slightly through time, although this increase was not statistically significant (**Figure 3.11**).

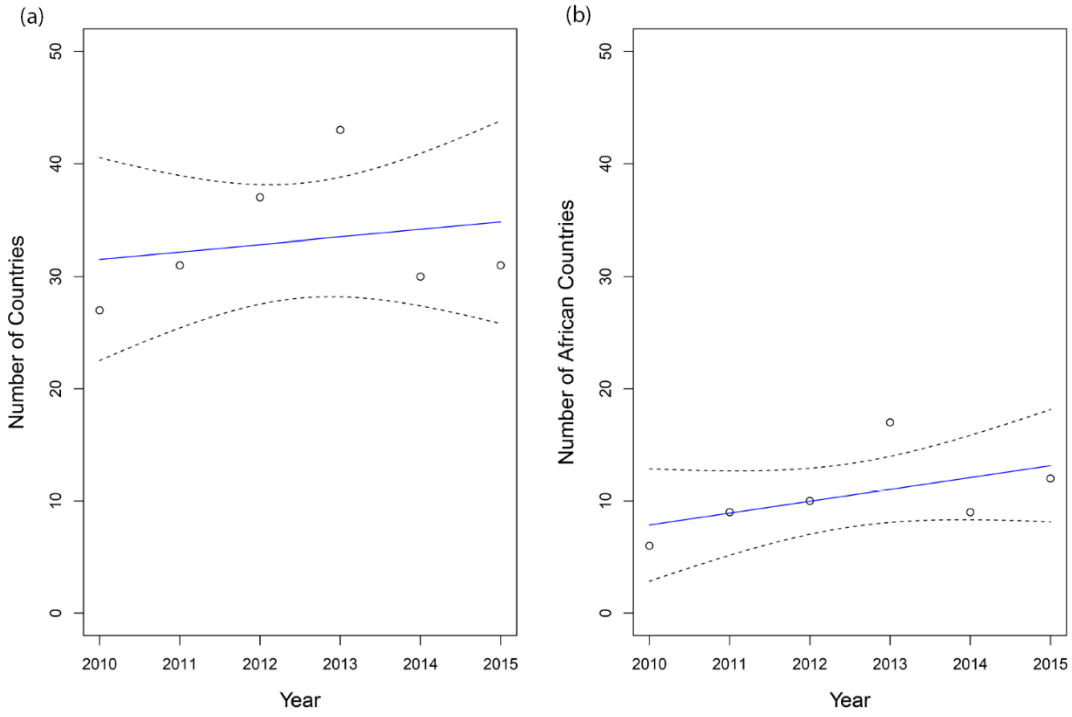

Figure 3.11: a) Number of all countries involved in verified international pangolin trafficking through time from 2010–2015 (n = 539 incidents), and b) Number of African countries involved in verified international pangolin trafficking through time from 2010–2015 (n = 539). The number of incidents was used in generalised linear models to create the fitted estimates (in blue) and 95% CI displayed in the dotted lines.

African countries also exported pangolins and their products primarily to Asia via Europe (44% of the trade coming from African countries), directly to Asia (33%), to Europe (14%), to North America directly (7%) or to North America via Asia (2%) (**Figure 3.12**). The biggest proportion of the trade consisted of intracontinental trade within Asia (45.9% of the total trade), while 17.5% of the total trade voyaged from Asia to North America (specifically only to the US). Trade also occurred from Asia to Europe (6.7%) and interestingly also from Asia via Europe to Africa and from Asia via Europe to South America (although each of these two trade routes were only recorded once in the timeframe and available data studied here; see **Figure 3.12**).

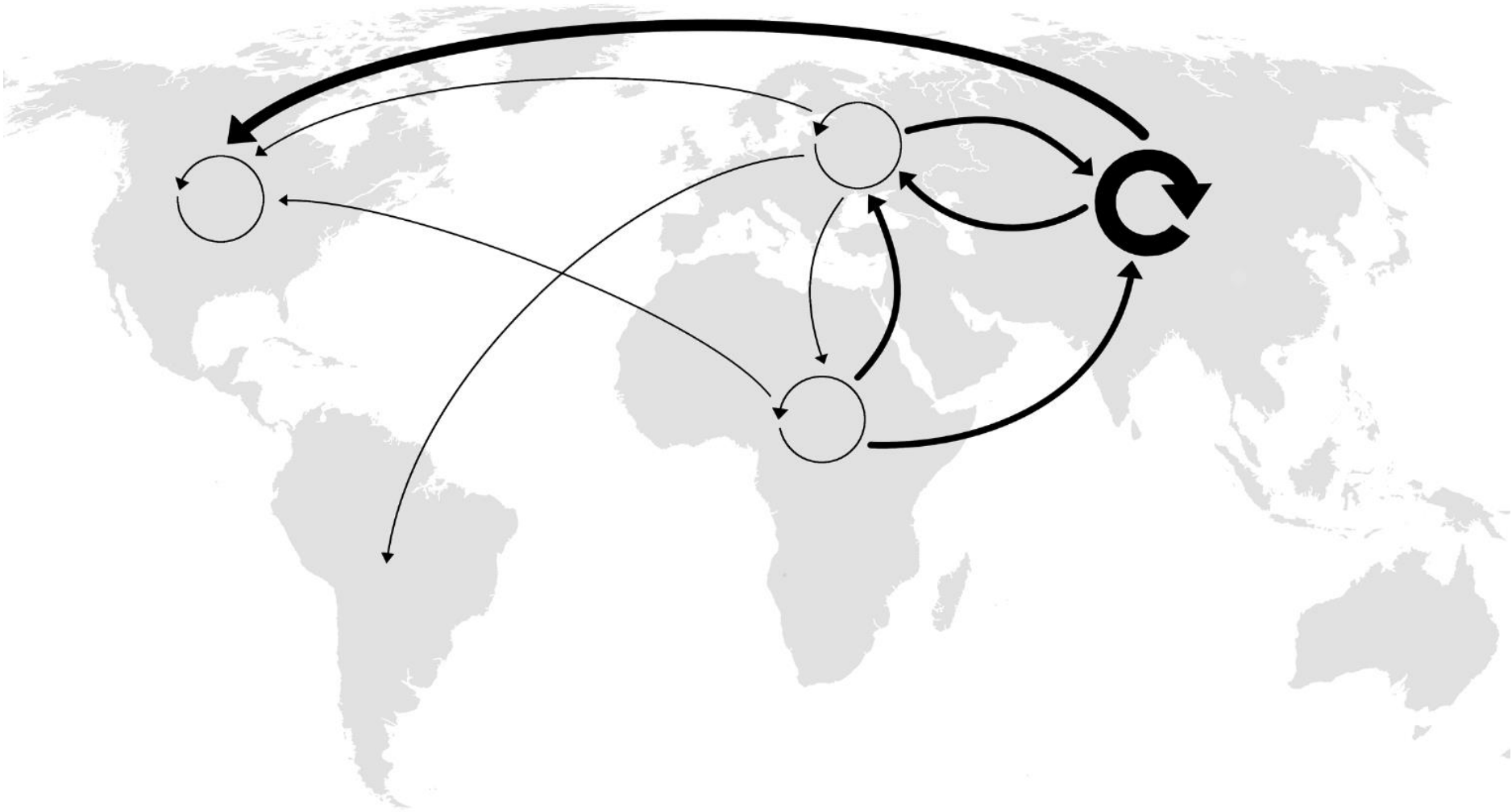

Figure 3.12: The intercontinental trade flow in international pangolin (*Manis* spp.) trafficking incidents between 2010 and 2015 (n = 539). The arrows and circles are weighted by the normalised number of links between continents. The arrows represent the directional intercontinental trade flow, while the circles display the intracontinental trade.

The most common (≥5) direct trade links (exporter to importer) between countries are identified in the network below (**Figure 3.13**). China and the US were the major players in the network, acting primarily as importing countries (and in the case of the US, entirely importing). Furthermore, Vietnam, Malaysia, Thailand, Lao PDR, Hong Kong SAR, Myanmar, and Indonesia were important links in the network. Of the African range countries, Nigeria and Cameroon, followed by Guinea, stand out (see **Figure 3.13**). Notably, these African countries are also among the origin countries for large-quantity shipments (see **Figure 3.10**).

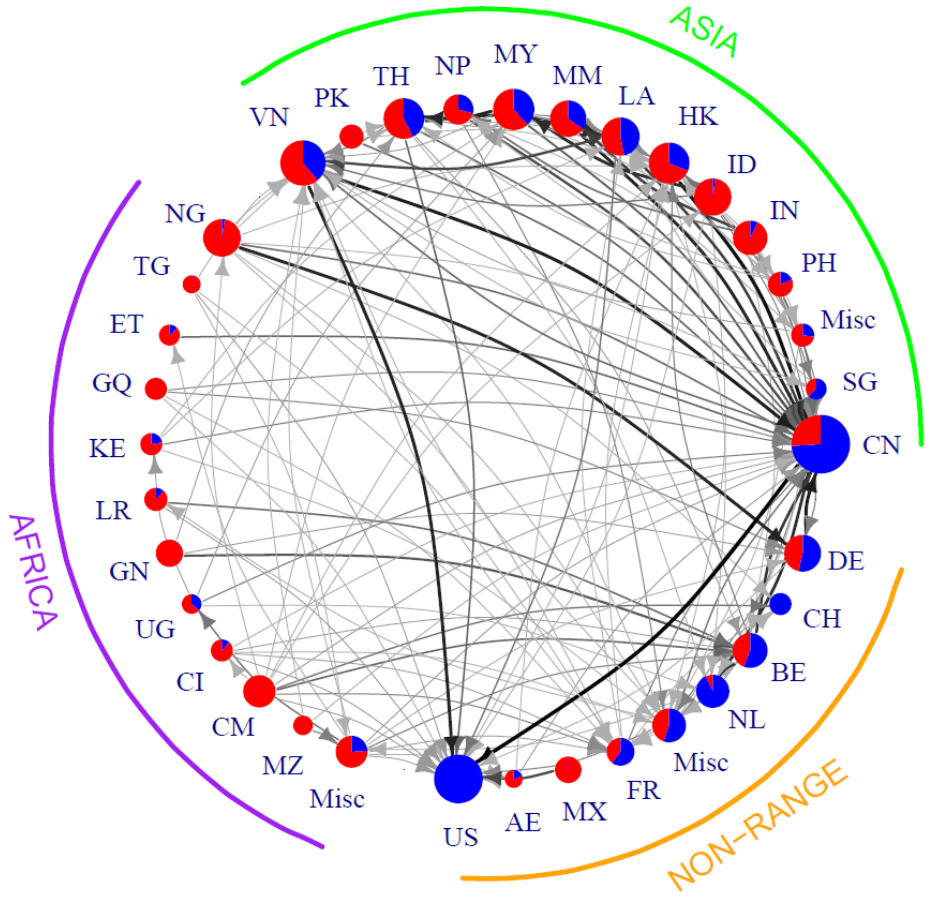

Figure 3.13: International pangolin (*Manis* spp.) trafficking network based on direct trade links between exporter and importer countries from 2010–2015, regardless of complete trade routes. The thickness of the directional trade arrows (edges) and the size of the nodes (and the coloured pie charts, with blue for imports and red for exports) are natural log transformed and are weighted by the number of links between an exporter and an importer, and the total number of incidents a specific country was involved in respectively. The countries are displayed as: i) within the native range of Asian pangolin species; ii) within the native range of African species; or iii) outside the native range of any pangolin species (non-range countries). Refer to **Table S2.1** for corresponding country names associated with each ISO country code. Miscellaneous ("Misc") includes countries involved in less than four incidents.

Contingency type analysis of African and Asian pangolin trade revealed that the modes of transport and commodities traded were different for the different species (**Figure 3.14**). African pangolins were significantly more likely to be transported by air, and to be in the form of scales, relative to Asian pangolins and other modes of transport. African pangolins were also comparatively significantly less likely to be transported by land, to be whole animals or in the form of body parts. Alternately, Asian pangolins were significantly more likely to be body parts, which can potentially be attributed to the high number of incidents in which undefined medicinals were traded. Asian pangolins were also less likely to be transported by air, but this may be due to a large proportion of unknown transport modes for Asian pangolins (see **Figure 3.14**).

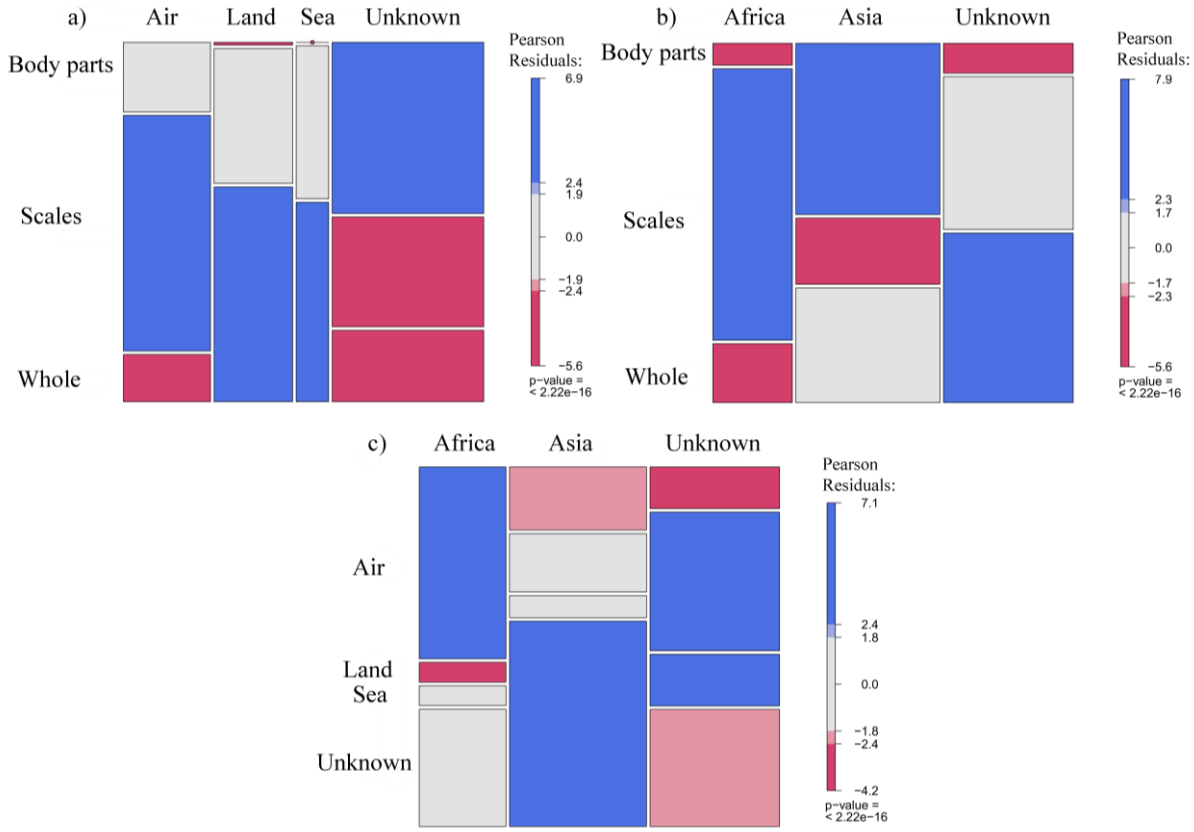

Figure 3.14: Mosaic plots of the deviation in conditional independence between a) Commodity and mode of transport; b) Commodity and home continent; and c) Home continent and mode of transport, for all incidents between 2010 and 2015 (n = 539). The plot is constructed so that the size of each cell (rectangle) is proportional to the observed cell frequency for each trait. The residual-based shading reflects the cell contribution to the Chi-square statistic: shades of blue, when the observed frequency is substantially greater than the expected frequency under independence; shades of red, when the observed frequency is substantially less, as shown in the legend.

The relatively big proportion (44.2%) of "unknown" modes of transport is due to many seizure reports lacking this level of detail, but it should be noted that even if the transport

modes were reported, in most cases these only reflected the mode of transport during the seizure event itself, and it remains uncertain in many cases how a shipment was transported before the seizure in the trade chain, or how it was supposed to be transported after the seizure.

The relative proportion of the number of trafficking incidents increased through time, for trade in pangolin scales and whole animals, while the proportion of trade in body parts appears to be decreasing, relative to the other commodity categories (**Figure 3.15a**). The relative proportion of international trafficking incidents in African pangolins appears to be increasing through time, compared to Asian and unknown species, which have constituted a large proportion of the overall trade (**Figure 3.15b**).

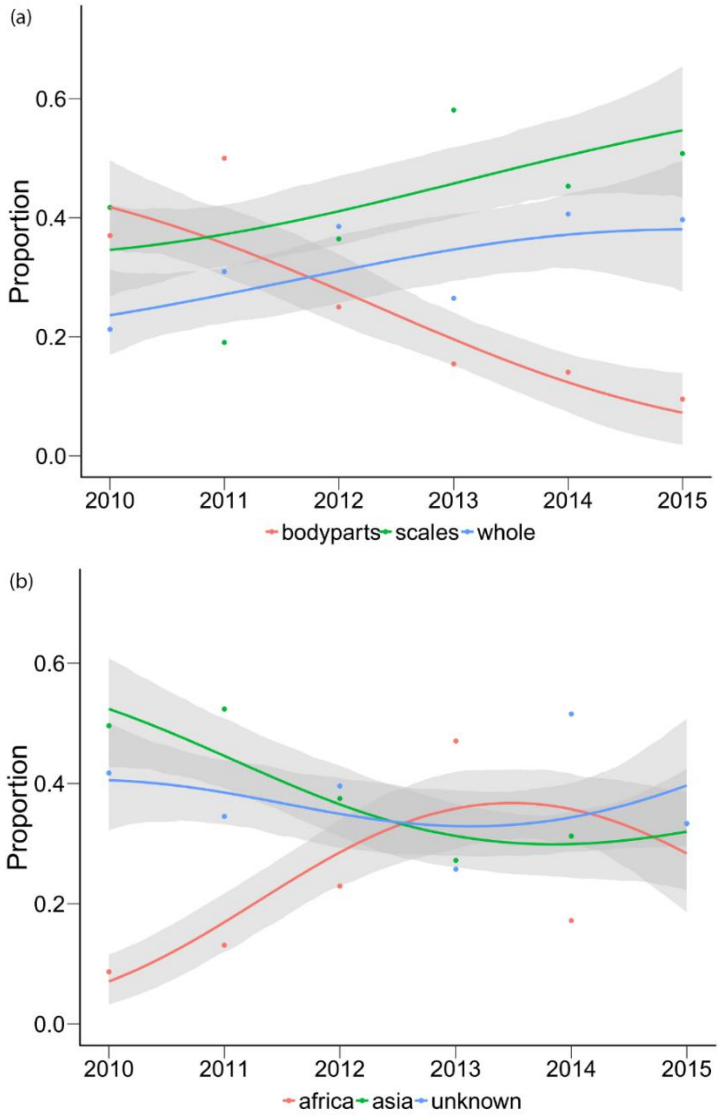

Figure 3.15: The relative proportion of occurrences in each category of a) commodity type, and b) home continent through time for international pangolin (*Manis* spp.) trafficking incidents (n = 539).

3.5 Discussion

The illegal pangolin trade is of global conservation concern, and trafficking occurs well beyond African and Asian pangolin range countries. In this Chapter, the analysis was focused on the number of incidents, trade routes, and quantities available, which is acknowledged to be incomplete, due to the nature of seizure reporting and detection (see e.g., Underwood, et al. (2013), Utermohlen and Baine (2017), and discussion below). The illegal trade involved 67 countries during the period under review, and non-range countries played a considerable role in international pangolin trafficking. However, the countries most commonly involved in international trafficking were largely within Asia, with the exception of several African countries (e.g., Nigeria and Cameroon). Asian countries were mostly implicated as origin and destination countries, while African countries were mostly implicated only as origin countries. It is possible that some of the commonly used trade routes, which have stopped being used in consecutive years, were impacted by improved law enforcement. Shifting trade routes, which have led to a highly mobile trade network are evidenced by the detection of an average of 27 new trade routes emerging per year. It should be noted that the analysis was focussed on a country-by-country basis, therefore the number of individual trade routes would obviously be higher if we had been focussed on specific locations (or ports) within a given country.

Europe was identified as a major transit region, mostly for African pangolins being transported to Asia, but also as a destination in the case of the Netherlands and Switzerland. The Netherlands was also the only European destination country for large-quantity shipments of body parts and scales from Uganda and China respectively. Europe has previously been identified as a transit hub, and also as a major destination for a large variety of wildlife species and their products (Engler and Parry-Jones 2007; Challender and Hywood 2012; Auliya, et al. 2016; Janssen and Blanken 2016; Chapter 2). The European transit countries that were found to be involved in the highest number of incidents were Germany and Belgium, both of which also happen to be among the countries that directly supplied seizure data for this analysis. We acknowledge that some countries may be over-represented relative to others that did not provide data, however, this does not change the fact that pangolin trade is occurring in non-range countries. Some of these non-range countries are potentially unaware that pangolins are being smuggled across their borders, especially Middle Eastern States like the United Arab Emirates (UAE) and Qatar, which were reported to be involved in four incidents each. These countries are also in a

geographically convenient position, and have well connected transport infrastructure, for the trafficking of African pangolins to Asia, and could potentially represent another current (or future) transit hub. This prediction is supported by more recent incidents outside the period analysed, for example, the seizures in May 2017 of 304 kg and 408 kg of African pangolin scales in Malaysia, which were reportedly transiting through the UAE (Anon. 2017b; Krishnasamy and Shepherd 2017).

In terms of the number of incidents, China and the US were identified as the two major destination countries. China appears to be an endpoint for much of the illegal trade, supporting the findings of the existing literature (Challender, et al. 2015b; Gomez, et al. 2016a; Nijman, et al. 2016). Not only was China the most commonly involved country, but it was also the main destination for large-quantity shipments of scales and whole animals. This can most likely be attributed to an ongoing demand for pangolin meat and scales, which is believed to be increasing (Xu, et al. 2016). It has been suggested that urban consumption of meat might be tied to increasing affluence (Challender 2011), while the use of pangolins for medicinal and tonic food purposes in China dates back to the 16th century and is deeply rooted culturally (Coggins 2003; Ellis 2005; Zhang 2009). There also remains a legal market in China for pangolin scales, for which scales must be certified, but uncertified scales are still sold illegally within the country (Vallianos 2016; Xu, et al. 2016).

Alongside China, the US was heavily implicated in pangolin trafficking, most notably in terms of the number of incidents, but also as the main destination for large-quantity shipments of body parts. It should be noted, that across the three commodity categories, quantities are not comparable. The thresholds were chosen differently, based on the distribution of the data within the three commodity categories, and 100 body parts cannot be compared to 1000 kg of scales for example. Nevertheless, the large-quantity shipments for body parts accounted for 85% of all body parts traded (by count), and in all but one case, these large-quantity shipments went to the US.

In terms of the number of incidents, the US is also one of the most heavily involved countries. Arguably, the US appears heavily implicated because they have been effective at preventing illegal pangolin products from entering their country. Other countries, with comparable law enforcement, and reporting practices, e.g., Switzerland, Germany, and Belgium, also directly provided their seizure data for the purposes of this analysis – yet none of these other countries came close to the large number of incidents involving the US. Frequent trafficking into the US may potentially be explained by the historic trade in Asian

pangolin skins to America (Challender, et al. 2015b; Chapter 2), which were mostly used to fabricate leather boots and other goods (e.g., shoes, belts, wallets) (CITES 2000a; Challender 2011). Even today, pangolin leather cowboy boots can be found for sale in the US, for example on eBay (Chapter 4). It is suspected, however, that the illegal leather trade into the US today mostly comes from Mexico, not Asia directly. The strong ties between Mexico and the US in the historic legal pangolin trade have been documented (Chapter 2) and based on the findings of this report it is suspected that Mexico may also be supplying the US with illegal pangolin products. Body parts were the most trafficked commodity into the US, and this commodity category, by definition in this study, was by far the most diverse group of commodity categories, including undefined medicinals, skins, tails, trophies, and leather products among others. Further studies are therefore required to decipher what is driving this ongoing illegal trade into the US, and what exact commodities are being traded, and in what quantities, in order to shed light on the role of the US in international pangolin trade. This is particularly important as high frequency, but comparably low volume shipments, will require a different type of law enforcement response, compared to a large multi-tonne shipment. The level of organisation required for high volume transactions is fundamentally different, which will be reflected in the individual players involved in this trade.

The proportion of incidents involving trafficked scales appears to be increasing through time, as does the proportion of trade involving African pangolins, and scales were more likely to be of African origin. Trade in Asian species on the other hand appears to be decreasing, as does the trade in body parts, which was the commodity category that Asian species were most likely to be trafficked in. This trend may be an indicator of declining Asian pangolins throughout their ranges (although further studies are required to support this) and an increase in trade of African species, a shift which has already been inferred in other studies (Challender and Hywood 2012; Gomez, et al. 2016b; Chapter 2). It remains to be tested if this holds true for traded quantities of African and Asian species as well, as this was not explored in detail in the current analysis.

However, it was found that 55% of all large-quantity shipments of scales (involving 1000 kg of scales or more) originated in Africa, and large-quantity shipments of scales were also increasing through time, as was the weight of these shipments. Furthermore, the 10 shipments involving 1000 kg scales or more accounted for 60% of all scales (by weight)

traded during the study period, highlighting the immense significance of these shipments from Africa.

The theory of a proportional market shift to African pangolins is further supported by the increasing number of African countries involved in the international pangolin trafficking networks through time. The relatively large proportion of "unknown" home continents (i.e., where it was not possible to assign an incident to a home continent) also reflects that pangolins are rarely reported to the species level, as is also the case with other illegally traded wildlife (Smith, et al. 2009; Burgess, et al. 2014), and there is an urgent need for the accuracy of species identification to improve. Increasing research is already being conducted into the identification of different species and their geographic origins using forensic methods (Wasser, et al. 2007; Johnson, et al. 2014; Mwale, et al. 2016; Ziegler, et al. 2016). It is suggested that these techniques should be used in future pangolin seizures as well, in order to assess better the threats to the different individual species of pangolins, particularly because of an increasing threat to African pangolin species.

It is important to note, that country rankings may change if the analyses focussed on the whole dataset of seizures, not only international incidents. Domestic incidents were not included, as this Chapter aimed to focus on international trafficking routes. Due to missing trade route information in many reported seizure incidents, some countries may appear less involved than they likely are in reality, or may not be mentioned here at all. Future analyses need to focus on confirming the identity of these countries, as well as the role they play in pangolin trafficking.

There are many biases inherent to seizure data, which will ultimately influence the results of any seizure analysis. The most obvious ones are reporting and law enforcement biases. There are different levels of law enforcement within each country, as well as the level of reporting (e.g., through media and NGOs, but also reporting by governments and law enforcement agencies). In the seizure data there is also a language bias, meaning in most cases the received datasets were largely based on English-language media reports, while it has been shown that vernacular language reports will provide additional information pertaining to particular non-Anglophone countries and news reports (Nijman 2015). In the available datasets, some of the incidents were reported in languages other than English (mostly in Indonesian, Malay, Thai and Chinese), but newspaper articles in other languages were not specifically searched.

The trade routes are also potentially incomplete due to a number of biases. Destination countries may represent the true final destination, or may just be a transit country, if the true final destination (final importer) was not reported in the incident. An origin country may also be a transit country, if the true origin country (first exporter) was not reported in the incident. Hence, origin and destination countries were defined as the first and last known point in any trade route, respectively. Regardless of whether countries were the intended true final destination in a trade route, they were still an importer of illegally traded pangolin products.

As data were received following the requests to the CITES MAs, the countries that sent data will likely be over-represented in the analysis, compared to others that did not provide data or did not respond. In some cases (such as Namibia) data were not received from the CITES MA, but from an independent NGO; thus the likelihood to receive data from a country also depends on the amount and management of local NGOs in any one country. Also, two major datasets from TRAFFIC were made available for Asia and while every attempt was made to collate seizure data from African countries, similar datasets were not available for Africa (but see Ingram, et al. (2017) for local scale data of hunting and market surveys). It is now also a well-established fact that China is a major destination country for pangolin products (Pantel and Chin 2009; Nijman, et al. 2016), however, there might be a potential reporting bias towards China, especially in media reports covering seizure events that assume China to be the final destination. Future accurate reporting of potential destination countries is important for identifying other major demand countries.

Further analysis of these data will require careful consideration of the potential seizure and reporting biases. It has now been clarified by the CITES Secretariat in the new *Guidelines for submission of annual reports*, that illegal shipments should not be included in the annual legal report, using the source code "I" (CITES 2017a). The source code "I" should only be used in instances of subsequent legal transactions of a previously seized specimen (CITES 2017a). Misreporting has previously caused confusion (Chapter 2) and might have impacted the analysis of CITES trade data in other studies (see also D'Cruze and Macdonald (2016)). Parties are now required to submit an annual illegal trade report, separate from the information entered into the legal CITES trade database. The new report is mandatory, but not subject to compliance procedures, and the first report was due on 31 October 2017 (CITES 2016e).

The reporting of seizures of pangolins specifically has been made a requirement through Notification No. 2017/35 of CITES (CITES 2017b). Parties have been asked to report on information including pangolin seizures, prosecution effort, forensics analysis, stockpile management, and inventories of captive populations, to enable a more thorough assessment on the conservation of African and Asian pangolin species. The results were made available at the 69th meeting of the Standing Committee in November 2017 (CITES 2017b).

The aim of this Chapter was to explore and summarize the pangolin trafficking routes from 2010 – 2015. In conclusion, based on the available data, it was found that China and the US were the two countries most commonly involved (i.e., having the highest number of incidents regardless of the quantity involved in each incident) in international pangolin trafficking from 2010 – 2015. China was also the main destination of large-quantity shipments of scales and whole pangolins, while the US was the main destination for large-quantity shipments of body parts. The quantities entering the US were, however, not comparable to the massive shipments trafficked through Africa and Asia. European countries served as transit points, with the exception of the Netherlands (and potentially Switzerland), which was primarily a destination for pangolins and their products. The Netherlands was also the only European destination country for large-quantity shipments of body parts and scales from Uganda and China respectively.

The involvement of African countries (and African pangolin species) in terms of number of incidents increased through time. African countries also emerged as the major origin countries for large-quantity shipments of scales. However, most trafficking occurred within Asia during the study period, both in terms of number of incidents, but also quantities. Given the global extent of the trade, it is recommended that all CITES Parties, within and beyond the native pangolin range countries, be vigilant of trafficking in these threatened species. Further studies into the quantities and commodities of pangolins and their derivatives being trafficked, and the role of non-range countries are imperative to present a more holistic solution to the problem of illicit trade.

Chapter 4

Of Cowboys, Fish, and Pangolins:

US Trade in Exotic Leather

Statement of Authorship

Title of Paper	Of Cowboys, Fish, and Pangolins: US Trade in Exotic Leather
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted w ork w ritten in manuscript style
Publication Details	Heinrich, S., Ross, J.V., Cassey, P. (2019). Of cowboys, fish, and pangolins: US trade in exotic leather. *Conservation Science and Practice* **1**:e75

Principal Author

Name of Principal Author (Candidate)	Sarah Heinrich		
Contribution to the Paper	Designed the study, collated, curated, analysed and interpreted the data, wrote manuscript and acted as corresponding author		
Overall percentage (%)	90%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	14.12.2019

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Joshua V. Ross		
Contribution to the Paper	Assisted with the development of the work and manuscript editing		
Signature		Date	16/12/19

Gary Glonek for Joshua Ross

Name of Co-Author	Phillip Cassey		
Contribution to the Paper	Supervised the development of the work and assisted with manuscript editing		
Signature		Date	16/12/2019

Chapter 4. Of Cowboys, Fish, and Pangolins: US Trade in Exotic Leather

This chapter has been amended slightly from its original published version to reduce redundancy and ensure consistent formatting throughout the thesis. The original publication can be found online with the following citation:

Heinrich, S., Ross, J.V., Cassey, P. (2019). Of cowboys, fish, and pangolins: US trade in exotic leather. *Conservation Science and Practice* **1**:e75

4.1 Abstract

Illegal wildlife trade is a lucrative business, which is driving many species towards extinction. Pangolins (*Manis spp*.) and arapaimas (*Arapaima spp*.) are two CITES listed genera coveted in the leather fashion industry for their unique skin pattern. The US has contributed to the decline of pangolin species and was historically a large market for pangolin leather products. While the US trade in pangolin products has declined since 2000, we suspect that pangolin leather may now be substituted by arapaima products.

Arapaima leather trade has increased significantly since the year 2011. We found a strong positive correlation between the US states trading in both arapaima and pangolin leather products. The US states that were most involved in this trade had a lower population density and were comparatively wealthier than others. Leather items of both arapaima and pangolin were found for sale on eBay, with 75% of incidents in breach of eBay policy, and potentially illegal. Pangolin leather products were also falsely advertised as arapaima products. We conclude that arapaima leather is increasingly used to satisfy the persisting demand for exotic leather, and further research is urgently needed to determine the effect of the trade on wild arapaima populations.

4.2 Introduction

The global wildlife trade is a lucrative business (Broad, et al. 2002; UNODC 2016), and sometimes species are exploited so heavily that they become threatened or extinct (Courchamp, et al. 2006). However, less availability does not necessarily reduce the demand for wildlife, and reduced availability can even stimulate trade and increase consumer demand (Courchamp, et al. 2006; Rivalan, et al. 2007). When a taxa declines, or becomes unavailable through either overexploitation or increased enforcement, wildlife products can be substituted. This includes substitution from other populations (including captive-breeding) (Rowcliffe, et al. 2005; Broad and Burgess 2016), or by a different species with similar utility (Broad and Burgess 2016; Tensen 2016; Williams, et al. 2017). Here, we investigate the potential substitution of leather products of a threatened group of mammals, by an entirely different taxonomic group. We describe the declining pangolin leather trade in the US, and its potential replacement by the skins of an under-appreciated freshwater fish: the arapaima.

Pangolins are among the world's most heavily trafficked wild mammals (Challender, et al. 2014a). All eight pangolin species are listed as threatened on the IUCN Redlist of Threatened Species (IUCN 2019), and since 2017 they have been listed in Appendix I of CITES; the Convention on International Trade in Endangered Species of Wild Flora and Fauna (UNEP-WCMC 2014). Demand for pangolins exists mostly for their meat and scales; and especially for use in traditional medicines (Pantel and Chin 2009; Challender, et al. 2014a; Nijman, et al. 2016). However, the consumption of pangolin leather, particularly in the US and prior to 2000, is estimated to have contributed significantly to the historical decline of pangolins (Chapter 2). This trade consisted mostly of the importation of skins for use in the leather industry; to manufacture exotic cowboy boots, wallets and belts (CITES 1992, 1999). Today, illegal pangolin trade still occurs in the US, although in much smaller volumes compared to both the legal trade before 2000, and the continuing trafficking conducted in Asia and Africa (Chapter 3).

Pangolins are covered in keratinous scales, giving their underlying skin a very particular look, which is much coveted in the leather industry (**Figure 4.1**). Their skin pattern is unique in the mammalian world, however, it closely resembles the skin pattern that certain fish species with large scales exhibit, such as arapaimas (Class: Actinopterygii, Order: Osteoglossiformes, Family: Arapaimidae, Genus: *Arapaima*). Arapaimas are one of the

world's largest freshwater fish, and they are endemic to the Amazon Basin (FAO 2012). They have been listed in CITES Appendix II since 1975 (UNEP-WCMC 2014), and are currently recorded as Data Deficient on the IUCN Redlist of Threatened Species (World Conservation Monitoring Centre 1996). Their global population status is largely unknown, however, due to exploitation, illegal fisheries, and trade, it is suspected they are decreasing in the wild, and local extinctions have been recorded (Castello and Stewart 2010; Castello, et al. 2015). Arapaima biomass is predicted to be significantly reduced in the future should current fishing rates continue (Capitani 2017), and there are efforts underway to strengthen aquaculture in arapaimas (FAO 2012). Arapaimas are commonly traded in South-east Asia (Nijman 2010), and recently Sinovas, et al. (2017) reported on a relatively new trend in arapaima skins and leather products, being exported predominantly to the US and Italy.

The US is one of the largest markets for leather products of both pangolins (CITES 1999; Chapter 2; Chapter 3) and arapaimas (Sinovas, et al. 2017). Yet this is likely to be a niche market, and the trade dynamics remain unquantified in the scientific literature. Here, we address this important information gap. First, we analysed the historic international trade of leather products entering the US from 1999 – 2015, using Law Enforcement Management Information System (LEMIS) data from the US Fish and Wildlife Service (USFWS). We compared the source of the animals in the trade and tested whether arapaima leather trade increased, once the trade in pangolin leather declined. We then analysed contemporary trade in pangolin and arapaima leather products, from 2017 and 2018, which were offered for sale on the US eBay website. Specifically, we compared the characteristics of the eBay advertisements, and leather products for sale, and focussed on the spatial characteristics within the US, to determine from which states demand for arapaima products originated. We were particularly interested to assess whether the states in which trade in pangolin leather products persists, were the same as those where arapaima products are being traded.

4.3 Methods

We collected data on pangolin and arapaima leather trade from the US eBay website (www.ebay.com; 2017 – 2018) and USFWS LEMIS data (1999 – 2015). We chose to use LEMIS data rather than CITES data, so that we could compare the eBay and LEMIS data on a state level basis, and in order to reliably estimate the number of incidents; these are

summed in CITES as opposed to being presented on a shipment-by-shipment basis in the LEMIS data (CITES 2013a). We also checked the number of incidents in the CITES data, and found there were less compared to the number of incidents in the LEMIS data. LEMIS data predominantly reflected international trade whereas the eBay data provided a more detailed picture of the domestic trade. For further information on the interpretation and use of LEMIS data see Rhyne, et al. (2012) and Romagosa (2014).

The USFWS LEMIS data includes both legal and illegal trade incidents for any wildlife shipment entering or exiting the US. We collated LEMIS data for all pangolin and arapaima incidents for the years 1999 – 2015 (with the exception of the year 2014; which was not made available). The data were subsequently filtered to include leather products only. The commodities of both arapaimas and pangolins were consolidated into the categories presented in **Table 4.1**.

Table 4.1: Traded commodities of arapaimas and pangolins in the US and their corresponding consolidated commodity categories.

	Consolidated category	Original commodities
Pangolin spp.	Leather	Skins, skin pieces, large and small leather products, trims, garments, shoes
	Medicinals	Medicinals (not further specified)
	Other	Bone pieces, scales, specimens (not further specified), live and dead animals, feet, meat, skulls, skeletons, tails, claws, trophies, other unspecified items
Arapaima spp.	Leather	Skins, skin pieces, large and small leather products, trims, garments, shoes
	Live	Live
	Other	Meat, scales, jewellery (not further specified), other unspecified items

Pangolin and arapaima listings were accessed from the ‘Clothing and Accessories’ section of the US eBay website for nine months from the beginning of September 2017 to the end of May 2018. Products for sale that matched any of the chosen keywords, and additionally

displayed the characteristic diamond-shaped pattern of pangolin and arapaima skin (**Figure 4.1**), were entered into a bespoke SQL database (Microsoft Access, Version 2016). We scanned the website five times a week and entered the data into the database immediately. The following keywords were chosen based on preliminary observations and searches of the eBay website: “Pirarucu”; “Arapaima”; “Pangolin”; “Anteater”; and “Exotic”.

Figure 4.1: Example images of leather products advertised on the US eBay website. The boots in a) are made from pangolin skin and were advertised as pre-owned ‘classic anteater boots’ of the brand ‘Lucchese’, valued at US-Dollar (USD) 1500 as a starting price and available for international shipping. The boots in b) are also Lucchese boots, but made from arapaima skin. These boots were advertised as ‘New with defects’, valued at USD 415.65 as a starting price and also available for international shipping. Note that Lucchese has stopped manufacturing boots from pangolin skins, but is now using arapaima skins.

We collected ancillary information on all of the products and sales, which included: i) location of the seller (US State); ii) the type of commodity (boots, belts, wallets, or handbags); iii) quantity and price of the product; as well as, iv) the condition (new or used); v) region of manufacture (if known); and vi) whether or not the product was available for international shipping. We were interested in where demand within the US originated, so only advertisements from sellers within the US were retained; all advertisements from

international sellers were disregarded. Sellers were classified as 'commercial' if they had an eBay store, otherwise they were classified as 'private'. We collated data for genuine, as well as imitation ('print leather') pangolin and arapaima leather products, and noted whether the product for sale had been advertised as being either imitation or genuine, and being either pangolin, arapaima, or unclassified (i.e., not advertised as either arapaima nor pangolin). Finally, the products for sale were classified as being either genuine or imitation, pangolin or arapaima products, regardless of what was advertised by the seller; this classification was based on our own expert visual assessment of the pictures provided in the advertisements (**Figure 4.1**).

For both datasets we converted all pangolin and arapaima leather products into whole estimated animals. In all cases the minimum and maximum number of whole estimated animals were calculated, and the arithmetic average (rounded up to a whole animal) was used in subsequent analysis as a measure of volume. For both taxa, we assumed that a minimum of one and a maximum of two animals were needed for a shoe, boot, garment and large leather product. For smaller leather products, and individual skins, we assumed that only one animal per product was needed. For skin pieces and trims we assumed that a minimum of one and a maximum of the reported number of products was needed.

4.3.1 Analytical methods

All analyses were conducted in the R software environment (version 3.4.3) for statistical and graphical computing (R Core Team 2017). We used contingency-type frequency tests to assess the independence of categorical variables, using the mosaic function of the 'vcd' package (Meyer, et al. 2017). The homogeneity of the frequencies was evaluated with Wald Chi-square tests for independence. To rule out that the trade in arapaima leather was increasing simply due to an overall increase in leather products traded in the US, we tested for a change in the $\log_{10}$ frequency of incidents of all non-arapaima leather products traded in the US from 2010 – 2015 (generalised linear model), and compared this with the trade in arapaima leather.

To evaluate the change in the proportion of animal sources and commodities through time we used multinomial logit regression models from the 'nnet' package (Venables and Ripley 2002). Bootstrapped predictions through time were calculated for each category and used to calculate 95% Confidence Intervals (CI) for the predictions. The 'trade activity' was

calculated by multiplying the volumes and frequency of incidents per state. The involvement of US states based on the trade activity was mapped using the 'usmap' package (Di Lorenzo 2018). To test for a correlation of the trade activity in the different datasets on a state level basis, Pearson's correlations were used, including zeros for states where no trade had occurred.

We tested the effect of different predictors (outlined below) on the involvement of US states (excluding Puerto Rico) in domestic arapaima leather trade (i.e., the US eBay data; note that the LEMIS data only had incidents in seven states). We used the volumes as well as the frequency of incidents of arapaima leather products from the eBay data as response variables. As the data was highly over-dispersed we used negative binomial generalised linear regression models. Because of the apparent fashion for cowboy boots, we predicted that arapaima trade would predominately occur in states with comparatively low population densities and a higher percentage of rural population. Both pangolin and arapaima boots can fetch high prices in the US (e.g., the maximum price for a pangolin product found on eBay was almost USD 13 000, while the maximum price for an arapaima product was almost USD 2000) and we predicted that the states most involved in this trade would be comparatively wealthier than others.

State level data were downloaded from the US government census webpage (www.census.gov), using data from the last centennial census of 2010. The only exception was the GDP per state, for which data for the year 2017 were retrieved from the Bureau of Economic Analysis (BEA) (www.bea.gov) of the US Department of Commerce. We tested if the predictors were correlated and included the following (non-correlated) predictors: *Population Density* (defined as number of people per square mile and using the $\log_{10}$ transformed value); *Rural population* (the proportion of people living in a rural environment, including everyone who was classified as not living in an urban or urbanised area); and *GDP* (the Gross Domestic Product in millions of current US Dollars for the year 2017, using the $\log_{10}$ transformed value). We also hypothesised that states that were trading in pangolin products were more likely to be involved in arapaima trade, due to the similar visual qualities of the skin in both genera. We therefore initially included pangolin data as a binary predictor variable (i.e., whether or not we had found pangolin leather products being traded within a given state). However, since the trade activity per state was highly correlated with the trade activity of arapaima per state (Pearson's correlation $r = 0.94$), this was uninformative and ultimately discarded from the final model.

4.4. Results

4.4.1 International trade from 1999 – 2015

The LEMIS data included a total of 163 pangolin leather trade incidents, involving an estimated 21 411 pangolins from 1999 – 2015. The US trade in pangolin leather has decreased over time, with an abrupt decline after the year 2000 (**Figure 4.2a, b**); while the trade in medicinals constituted the biggest proportion of trade incidents since *c*. 2007 (**Figure S4.1a**).

There were 130 arapaima leather trade incidents reported, involving an estimated 5524 arapaimas from 1999 – 2015. Trade in arapaima leather only commenced in 2011, and has since increased significantly (Poisson regression slope estimate = 0.89, Standard Error (SE) = 0.08, $p < 2e\text{-}16$, 95%CI = (0.75, 1.05); **Figure 4.2a**, **Figure 4.3b**); despite the overall leather trade in the US (excluding trade in arapaima leather products) remaining effectively constant from 2010 – 2015 (Estimate = -0.024, SE = 0.021, p = 0.335, 95% CI = (-0.06, 0.02); **Figure 4.3a**). Arapaima trade before the year 2011 was mostly comprised of live animals, but was quickly superseded by the number of leather trade incidents (**Figure S4.1b**).

Most arapaima and pangolin leather originated from wild caught animals (**Figure 4.2c, d**). For pangolins, the number of wild caught animals declined after the year 2000, while increasingly the source was declared as 'unknown'. The proportion of wild-caught animals increased again after 2007. The proportion of reportedly captive bred pangolins was negligible (i.e., <2%) (**Figure 4.2c**). Arapaimas predominantly originated from unknown sources until approximately 2012. Since then, the biggest proportion of traded arapaimas originated from wild-caught animals. The proportion of incidents involving captive bred arapaimas was also very small (i.e., <5%) (**Figure 4.2d**).

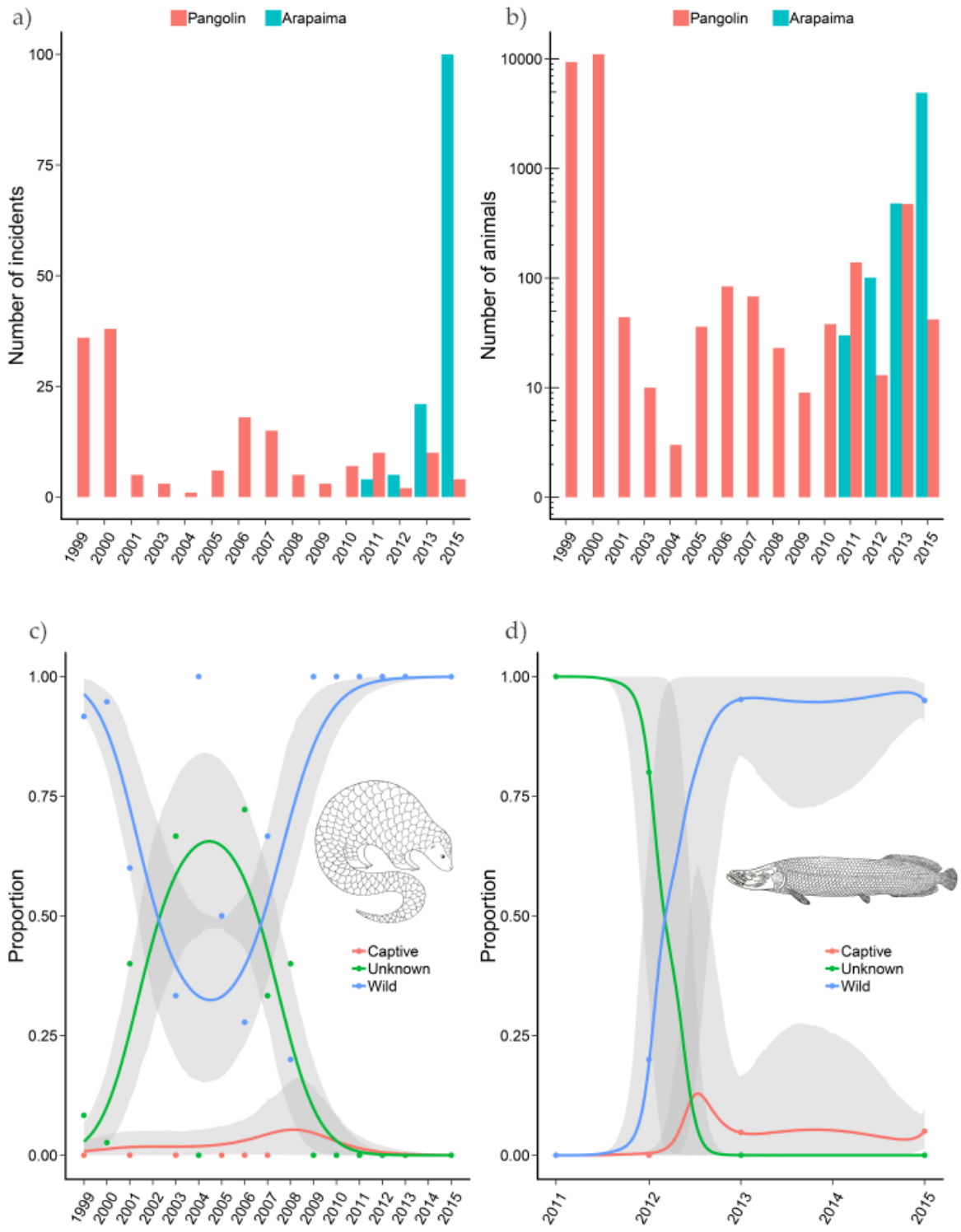

Figure 4.2: a) Frequency and b) Volume of LEMIS incidents through time, and the change in the proportion of animal sources of c) pangolins and d) arapaimas. The frequency of incidents was used in a logit regression model to calculate the fitted estimates and bootstrapped predictions were used to calculate 95% CI (shaded in grey) in panel c) and d). Note that the time period in panel d) on the x-axis is different, and the year 2014 is missing in all four series. The clipart picture in panel c) is used with kind permission by Rachel Shaw, the clipart in panel d) is used under a Creative Commons License.

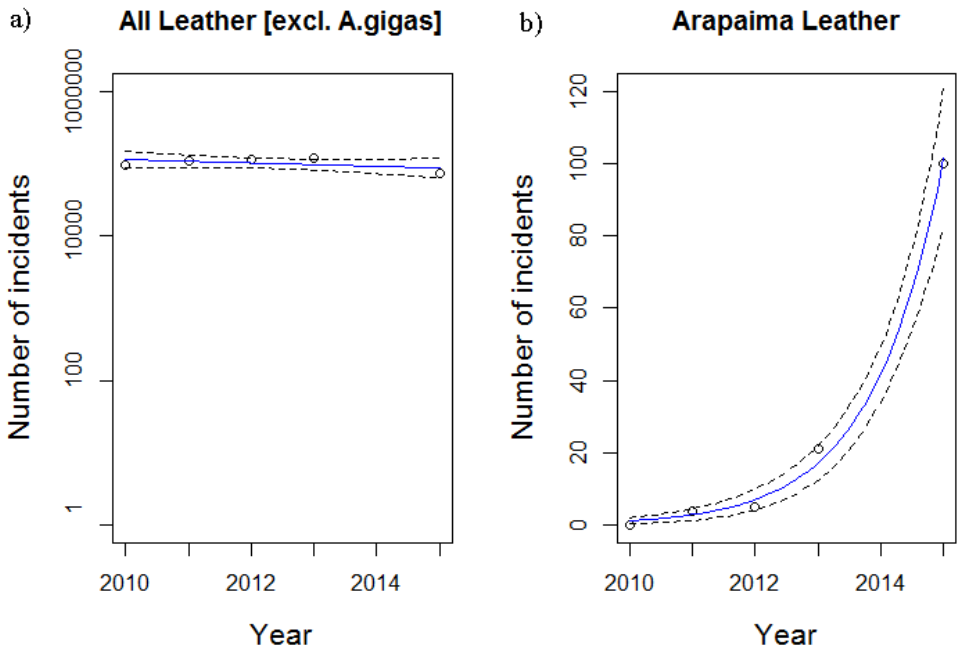

Figure 4.3: Number of incidents through time from 2010 – 2015 for a) all leather products excluding Arapaima leather, and b) only Arapaima leather. The frequency of incidents was used in a generalised linear model to create the fitted estimates (in blue) and 95% CI displayed in the dotted lines. Note that the number of incidents in a) are on a logarithmic scale, and data for the year 2014 is missing in both series.

From 2001 – 2015 the leather products for pangolins originated from 15 different countries across 17 different international trade routes (**Figure 4.4**). US imports from non-range countries (i.e., Mexico, Canada, and the United Arab Emirates) comprised 85% of the total trade activity for pangolins. Incidents originating in Africa comprised 14% and incidents originating in Asia comprised 1% of the total trade activity for pangolins. For arapaimas, all trade incidents originated in Brazil and the four different international trade routes involved five countries, namely Brazil, Mexico, Canada, Italy and the US (**Figure 4.4**).

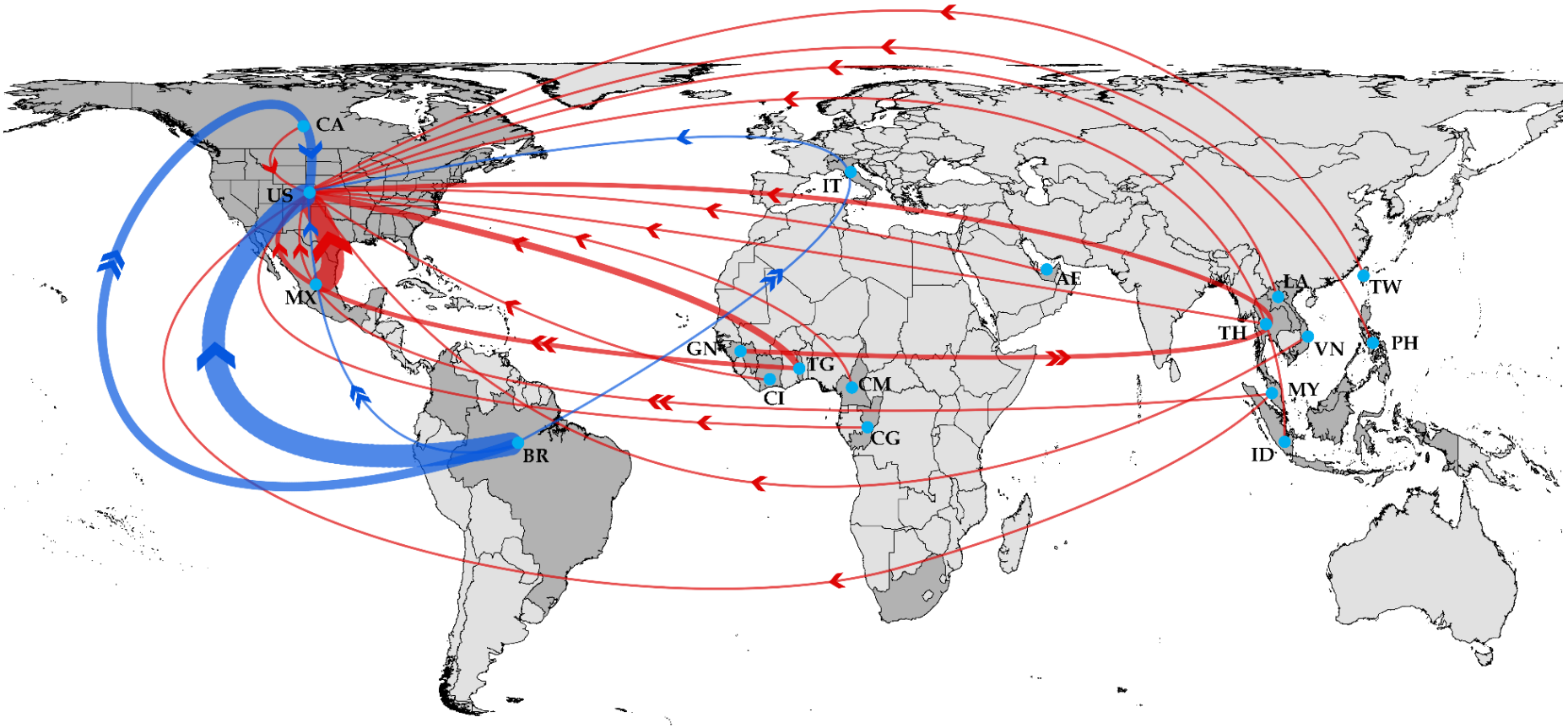

Figure 4.4: Directed international trade routes of pangolin (red) and arapaima (blue) leather products involving the US from 2001 – 2015 as reported in the LEMIS dataset. Double arrows indicate a trade route with a subsequent transit country, while a single arrow indicates the subsequent country is the destination (US). The line thickness is proportional to the normalised trade activity per animal group (pangolin or arapaima). Note that the relative thickness is not directly comparable between arapaima and pangolin trade. Abbreviations: BR = Brazil, CA = Canada, CG = Democratic Republic of the Congo, CI = Ivory Coast, CM = Cameroon, GN = Equatorial Guinea, ID = Indonesia, IT = Italy, MX = Mexico, MY = Malaysia, PH = Philippines, TG = Togo, TH = Thailand, TW = Taiwan, US = United States of America, VN = Vietnam.

4.4.2 Current domestic e-commerce trade

We discovered 478 incidents on eBay from September 2017 – May 2018 with leather products that had been manufactured in at least seven different countries (**Figure 4.5**). Leather products that had been manufactured in Indonesia and China consisted exclusively of imitation leather (i.e., 'print leather'), while leather products that had been manufactured in Canada, France and South Korea included only genuine pangolin products. Leather products manufactured in the US included genuine arapaima (26% of incidents) and genuine pangolin (74%). Leather products offered for sale, which had been manufactured in Mexico, included a mixture of genuine arapaima (41%), genuine pangolin (13%), and pangolin print leather (45%).

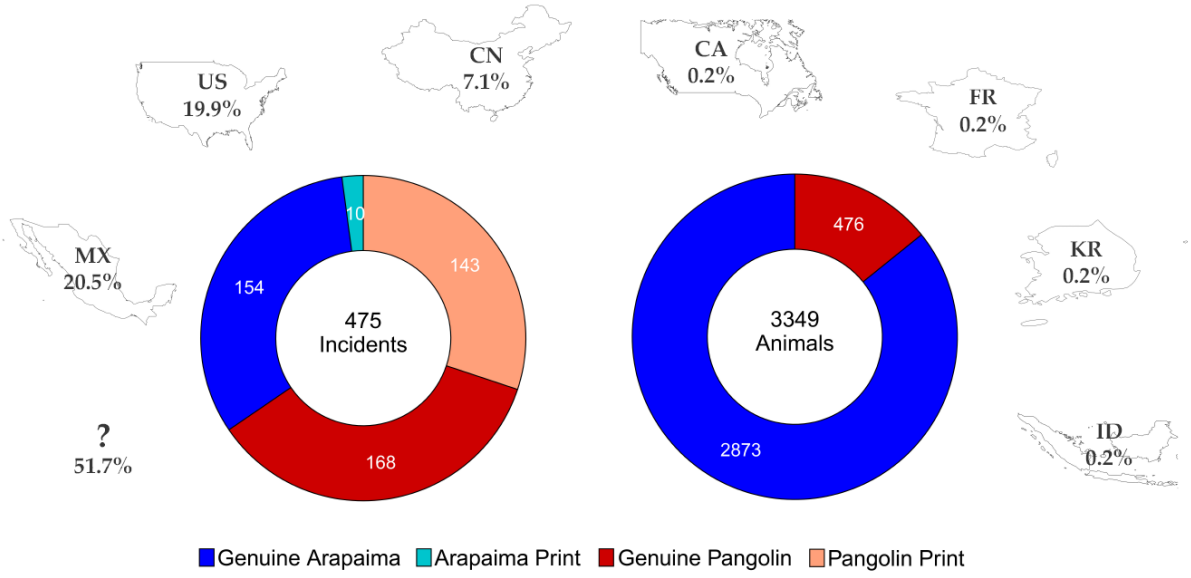

Figure 4.5: The number of incidents discovered on the US eBay website from September 2017 – May 2018 with corresponding number of whole estimated animals of the genuine leather products from either pangolins or arapaimas. Displayed are also the countries of manufacture of the leather products for sale with the corresponding percentage of the total number of incidents, excluding three incidents where the leather type could not be identified unambiguously from the pictures alone. Abbreviations (from left to right): '?' = Unknown, MX = Mexico, US = United States of America, CN = China, CA = Canada, FR = France, KR = South Korea, ID = Indonesia.

The mean starting price for pangolin products was USD 544 (SE = USD 84.58), with the maximum starting price being for a handbag, which was advertised for USD 12 895. The mean starting price for arapaima products was USD 390 (SE = USD 20.23), with the maximum starting price being USD 1800 for a pair of boots. Pangolin leather products were

more likely to be used items, whereas arapaima leather products were more likely to be new ($n = 322$, $\chi^2 = 193.98$, degrees of freedom (df) = 1, $p < 0.001$; **Figure S4.2**). Arapaima products were also more likely to be offered in a 'buy now' auction, whereas pangolin products were significantly more likely to be offered in a bidding auction ($n = 469$, $\chi^2 = 31.53$, df = 3, $p < 0.001$; **Figure S4.3**). Furthermore, we found that genuine leather was significantly more likely to be offered in private auctions, whereas print leather was more likely to be offered for sale by commercial sellers ($n = 473$, $\chi^2 = 95.74$, df = 3, $p < 0.001$; **Figure S4.4**). Some of the leather items for sale were mis-advertised (**Figure S4.5**). For example, genuine pangolin products were sometimes advertised as genuine arapaima (10%) or print leather (3%), and we found a number of pangolin products unclassified (28%). We also found print leather advertised as genuine pangolin (4%) or arapaima (5%). There were, however, no incidents where arapaima products were advertised as pangolin products, and arapaima products were also less likely to be unclassified (**Figure S4.5**).

Across the two datasets we found a total of 18 US states where trade in arapaima leather had occurred, and 29 states in which pangolin leather trade had occurred (**Figure 4.6**). There was overlap in the states trading in both arapaima as well as pangolin leather, with 13 states trading in leather of both genera. Only 17 US states did not trade in either of the two types of leather (**Figure 4.6**). For the states involved in the eBay trade there was a very strong positive correlation for the trade activity of arapaima and pangolin leather products traded per state (Pearson's correlation $r = 0.94$).

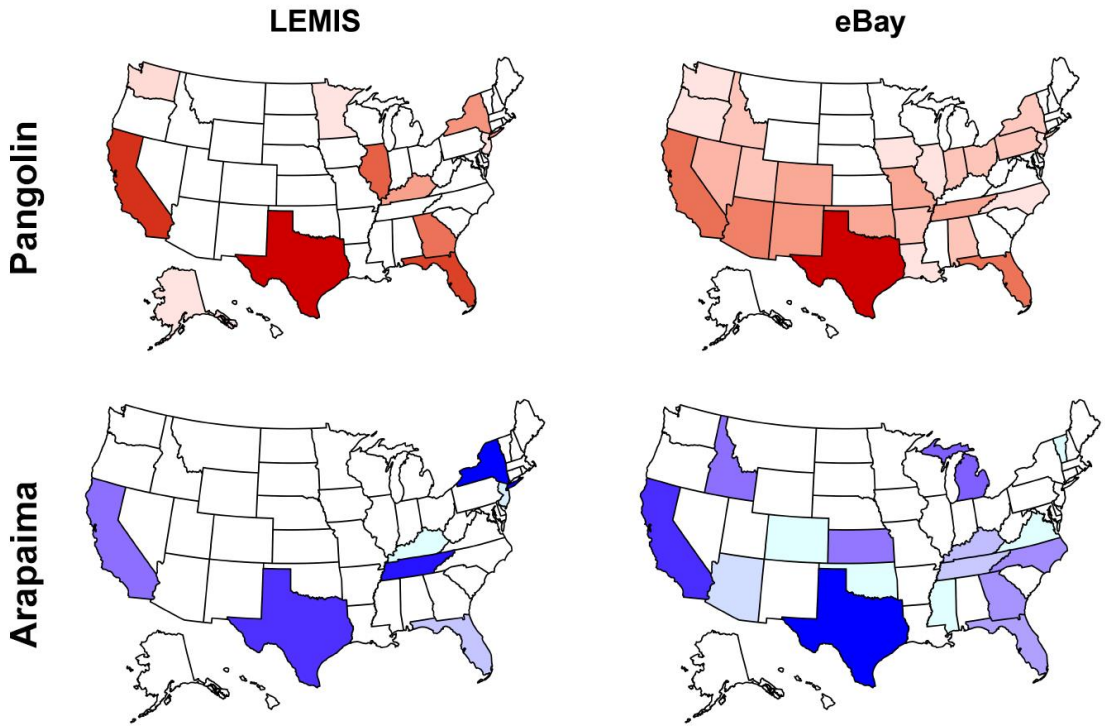

Figure 4.6: Trade activity per state for the different leather products (arapaima or pangolin) and the different datasets (LEMIS or eBay). The darker the colour, the more trade activity per state. Shades of blue corresponds to arapaima, and shades of red to pangolin trade.

The states that were most involved in arapaima leather trade were characterised by a significantly higher GDP (Frequency: Estimate = 4.68, SE = 1.60, p = 0.003, 95% CI = (2.27, 8.13); Volumes: Estimate = 6.73, SE = 2.22, p = 0.002, 95% CI = (2.27, 12.96); **Figure 4.7**) and a lower population density (Frequency: Estimate = -2.65, SE = 1.06, p = 0.012, 95% CI = (-5.49, -0.49); Volumes: Estimate = -5.22, SE = 1.45, p < 0.001, 95% CI = (-9.81, -1.33); **Figure 4.7**).

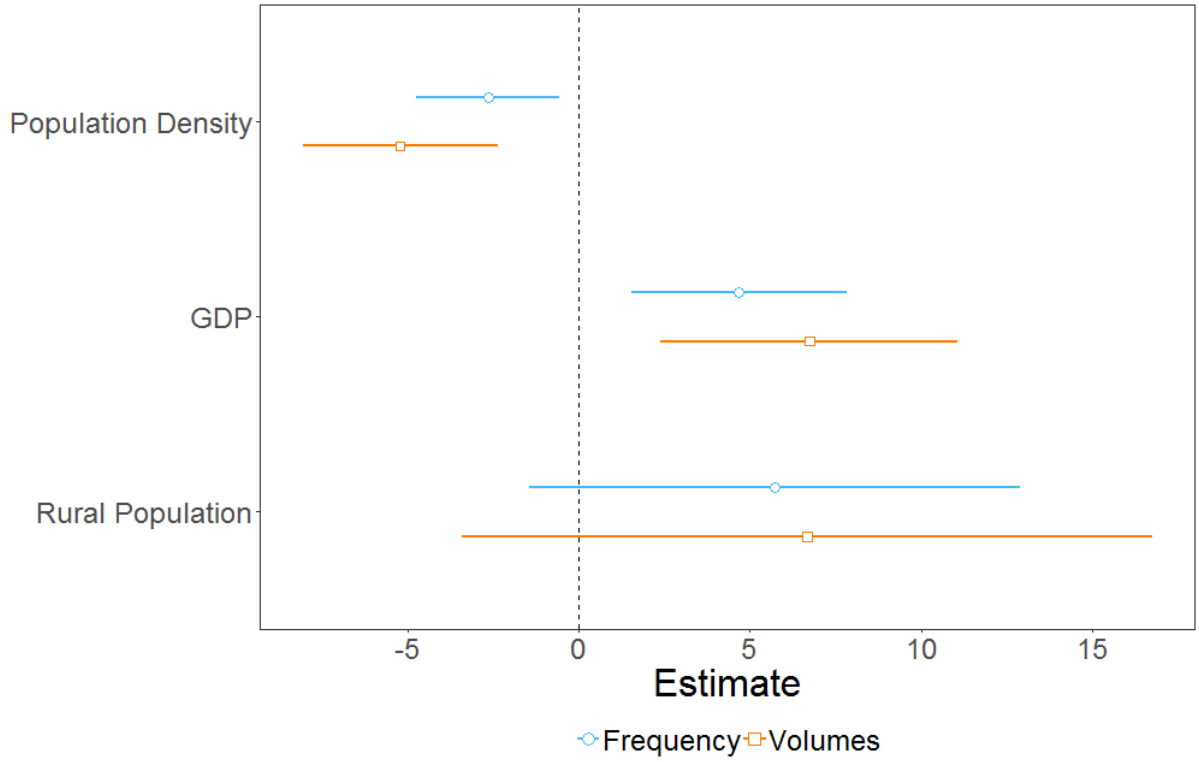

Figure 4.7: Effect of the predictors (Population Density, GDP, and Rural Population) on the frequency (blue) or volumes (orange) of arapaima leather trade incidents per state in the eBay dataset. The resulting estimates of the negative binomial generalised linear regression models are displayed with their corresponding 95% CI.

4.5 Discussion

There are strong indications that arapaima may be substituting pangolin leather trade in the US. Arapaima leather trade has increased significantly since 2011, and the increase in arapaima trade occurred after the decline of pangolin leather products. We also found a very strong positive correlation ($r = 0.94$) between the US states in which both types of leather are being traded today. Additionally, 10% of pangolin products were falsely advertised as arapaima products on eBay. These findings, combined with the fact that the two types of leather have such obvious similar physical patterns, are consistent with arapaimas acting as a substitute for pangolin leather products in the US. Substitution of wildlife products has been reported previously, and published examples include: tiger bone being replaced with lion bone (Williams, et al. 2015; Williams, et al. 2017); captive-bred crocodile skins being substituted for wild-caught animals (MacGregor 2006); or, more broadly, fish being substituted by bushmeat when the fish supply is low (Rowcliffe, et al. 2005). The last example demonstrates that it is important to consider whether supply or demand is driving the trade, in order to develop successful conservation strategies (see also McNamara, et al. (2016)).

When one species is substituted by another, there is always the risk that a currently more common species may become endangered in the future, due to the increased trade activity and exploitation. In the case of arapaimas, these species were already threatened before any increase in the trade of their skins (Castello and Stewart 2010). Increased efforts are underway to farm arapaimas for commercial purposes, as they have great potential for aquaculture (FAO 2012). They have the best growth rate among Amazonian fish species and are obligate air breathers, which makes them an ideal species for surviving in low-oxygen conditions (FAO 2012). Additionally, their meat is reported to be very nutritional and beneficial to human health (Cortegano, et al. 2017).

Aquaculture may be an important tool to reduce the pressure on wild arapaima populations, which are threatened by illegal and unsustainable fisheries and trade, and habitat destruction (Castello and Stewart 2010; Castello, et al. 2015). However, loss of genetic diversity due to selective fisheries and translocation of specimens for aquaculture are also of concern, and existing aquaculture in Brazil may be unsustainable, as aquaculture enterprises are, for example, allowed to collect arapaimas from the wild to ‘support’ captive populations (Castello and Stewart 2010; Castello, et al. 2015).

Of the incidents involving arapaima leather products reported to LEMIS, 89% were from wild-caught animals, and they all originated from Brazil. Arapaima management is determined by state-level legislation in Brazil (Castello, et al. 2015; Sinovas, et al. 2017) and exports of arapaimas are only allowed if they are either wild-caught from management areas, or captive bred (Sinovas, et al. 2017). However, a study from Brazil revealed that almost 80% of arapaima landings were illegal (Cavole, et al. 2015), which was observed to be the highest level of illegal fishing activity reported in the literature. In Brazil, arapaima leather yields higher prices per unit on international markets than arapaima meat, and the leather products are more likely to get exported (Sinovas, et al. 2017). Concerns have been raised that Brazil's national policies regarding freshwater fish management and insufficient monitoring may support the development of unsustainable aquaculture, and may be insufficient to effectively protect arapaimas (Castello and Stewart 2010; Castello, et al. 2015; Lima Junior, et al. 2018). Yet, if sustainable aquaculture and management could be ensured, and arapaima skins were only obtained as by-products of the food industry, arapaima leather products may provide a substitution opportunity to reduce demand for 'exotic' pangolin leather products in the US.

Most of the genuine pangolin leather products we found for sale on eBay were predominately advertised as used items (91%), and it is possible that these were legally obtained at the time of import. However, none of the traders indicated having any accompanying paperwork (i.e., CITES permits or proof of origin), which is required to re-sell legally acquired pangolin leather products domestically. The international sale and offer for sale of these products is prohibited. It is also against eBay policy to offer CITES Appendix I (pangolins) products for sale, or CITES Appendix II (arapaima) products for international sale, and thus 75% of all genuine leather listings were against eBay policy, and potentially in breach of US and international regulations.

The substitution of one taxa by another provides a case-book example of the complexity and diversity of the highly dynamic trade in wildlife products. Pangolins and arapaima are both found in regions highly threatened by unsustainable biological harvesting (Di Minin, et al. 2019), and whilst native protection remains of paramount concern, complementary conservation strategies are urgently required to prevent further risk of extirpation. For example, global pangolin conservation and awareness is increasing, however, arapaimas are also threatened, and have attracted much less attention. Consequently, research and conservation action is needed to reduce consumer demand in the US for exotic leather, and

promote sustainable use of substitute products. Legislation and enforcement of online marketplaces is a continuing issue, which needs to be addressed for all illegal wildlife trade. Finally, improved monitoring of arapaima aquaculture, and populations in the wild is needed. For the latter both the intensity of pressure from harvesting, and the abundance and trends in the wild need to be monitored closely. This will hopefully also inform an urgently required update on the IUCN Redlist status of arapaimas, which was last assessed in 1996 (World Conservation Monitoring Centre 1996).

Wildlife trade, and biological use, is a highly complex and often controversial topic. We found that pangolin leather products were still being traded in the US, although to a much lesser extent since the establishment of the zero-export quota in 2000. More recently, there has been an increase in the trade of arapaima leather products, which are potentially being used as a substitute for pangolin leather. There are examples where the use of exotic skins can be sustainable and even beneficial for species conservation (see, for example, MacGregor (2006)). In most cases, however, it is still difficult to trace the origins of exotic skins to determine if they originated from captive bred or wild animals, and from animals sustainably harvested or not (Ziegler, et al. 2018). Wildlife laundering remains a core issue. In many countries corruption, and enforcement and monitoring issues, as well as inadequate protection of exploited species, increase the difficulties to assess the sustainability of the exotic skin trade (Lyons and Natusch 2011; Nijman, et al. 2012; Janssen and Chng 2018). Ultimately, generalisations about this trade (see e.g., Natusch, et al. (2019)) are unhelpful, as the potential for sustainably trading exotic leather is highly species (and country) dependent. In the case of arapaimas, almost 90% of the arapaima leather originated from wild caught specimens, and the effects of this trade on wild populations is unknown. If it could be ensured that arapaima leather products originated from a sustainable source, they may provide a viable substitute to meet the persisting demand for pangolin leather products in the US. However, since arapaimas are also threatened, more research is urgently needed to identify the level of threat while this trade is still in its relative infancy.

Chapter 5

The Role of Germany in the Illegal Global Pangolin Trade

Statement of Authorship

Title of Paper	The role of Germany in the illegal global pangolin trade
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Heinrich, S., Koehnke, A., Shepherd, C.R. (2019). The role of Germany in the illegal global pangolin trade. *Global Ecology and Conservation* **20**:e00736

Principal Author

Name of Principal Author (Candidate)	Sarah Heinrich		
Contribution to the Paper	Collated, curated, analysed and interpreted the data, wrote manuscript and acted as corresponding author		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Arnulf Koehnke		
Contribution to the Paper	Assisted with the writing and editing of the manuscript		
Signature		Date	

Name of Co-Author	Chris R. Shepherd		
Contribution to the Paper	Supervised the development of the work, assisted with writing and editing of the manuscript		
Signature		Date	

Chapter 5. The Role of Germany in the Illegal Global Pangolin Trade

This chapter has been amended slightly from its original published version to reduce redundancy and ensure consistent formatting throughout the thesis. The original publication can be found online with the following citation:

Heinrich, S., Koehnke, A., Shepherd, C.R. (2019). The role of Germany in the illegal global pangolin trade. *Global Ecology and Conservation* **20**:e00736.

5.1 Abstract

The illegal pangolin trade is of global concern and is placing all pangolin species under high levels of threat. Following the analysis of global pangolin seizures from 2010 – 2015 (Chapter 3), Germany emerged as a transit country, especially for pangolins being shipped from Africa to Asia. We analysed seizure data involving Germany from 2010 – 2018 to characterise Germany's role in international pangolin trafficking and the trafficking dynamics.

The majority of shipments involving Germany came from West Africa, and predominantly from Nigeria. Scales were the most confiscated commodity and we found the postal services to were used as an important means of transport, with 90% of incidents being shipped via airmail packages.

We highlight the need for further monitoring of, and research into, the international trade in Traditional Medicines. Such shipments are often overlooked, as they are particularly hard to detect, if derivatives of endangered wildlife are not clearly identified on the ingredient list of such medicines. We further found a large discrepancy between seizures on administrative records and seizures as reported by the media. Recognising these country-specific biases in media reporting of wildlife seizures may improve analyses of wildlife seizures in the future.

5.2 Introduction

The illegal wildlife trade is among the fastest growing categories of transnational crime and is increasingly classed as a transnational security problem by law enforcement authorities internationally (Runhovde 2015). The immense value of the international trade in wildlife, has resulted in the overexploitation of a growing list of species that are threatened with extinction (Wyatt 2011; Duckworth, et al. 2012; Eaton, et al. 2015). Illegal wildlife trade is often not given the same law enforcement priority as similar crimes, such as narcotic trafficking (Runhovde 2015). It is important that illegal wildlife trade is prioritised because of its criminal and structurally harmful elements for people, civil societies and development (Wyatt 2011; Wyatt 2013) and to ensure species survival. Among the species currently most threatened by illegal wildlife trade are pangolins.

Pangolins (Manidae) have in recent years become the most heavily internationally trafficked wild mammals (Challender, et al. 2014a). Despite being protected in most range countries and being listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), all eight species are threatened by the relentless demand for their body parts, largely from Asia (Pantel and Chin 2009; Challender and Hywood 2012; Nijman, et al. 2016). While most international trade of pangolins (and their parts and derivatives) occurs within Asia, both in terms of number of incidents and quantity, over 70 countries have so far been identified to be involved in this trade (Chapter 2, 3).

As the four Asian species of pangolins have declined throughout most of their range (CITES 2000a; Baillie, et al. 2014; Challender, et al. 2014b; Challender, et al. 2014c; Lagrada, et al. 2014), poachers and traffickers have turned to the four African species (Challender and Hywood 2012; Gomez, et al. 2016b; Krishnasamy and Shepherd 2017; Chapter 3). Poaching and legitimate hunting of African pangolins has existed for decades (see e.g., Bräutigam, et al. (1994)), however, intercontinental trade has added to the existing pressure on African pangolins, which are now being trafficked in previously unseen numbers (Challender and Hywood 2012; Challender and Waterman 2017; Chapter 3). Trafficking of live pangolins from Asian range countries to China and Vietnam is common, but distance makes it difficult for traffickers to move live pangolins from Africa to Asia, and these shipments predominantly consist of scales (Challender and Hywood 2012; Chapter 3).

Wildlife traffickers moving pangolins from Africa to Asia use a variety of methods, hiding the scales in shipments with legitimate products, or falsely declaring them as other items, such as oyster shells (Krishnasamy and Shepherd 2017), and using both air and sea routes (Gomez, et al. 2016b; Krishnasamy and Shepherd 2017; Chapter 3). Traffickers also vary routes to avoid detection, using routes that have low likelihood of detection, weak legislation and paltry penalties, and/or high levels of corruption, however, pangolin trafficking may also be conducted in locations, such as non-range countries like the United States of America (US), and European countries (Chapter 3).

In Chapter 3, we reported that of the top ten countries and territories involved in the most pangolin trafficking incidents from 2010 – 2015, seven were in Asia (China, Vietnam, Malaysia, Hong Kong SAR, Thailand, Lao PDR, and Indonesia) and the remaining three were the US, Nigeria, and Germany. While this was based on the number of incidents only, not the volumes trafficked; it does highlight an often-overlooked role many countries play in the trade. Further, Germany has previously been identified as a hub for other trafficked wildlife, apart from pangolins, and has been reported to be a particularly prominent destination for exotic reptiles (Altherr 2014; Auliya, et al. 2016; Klaas, et al. 2016; Janssen and de Silva 2019).

As such, here we investigate the role of Germany in international pangolin trafficking and aim to not only raise awareness of illicit trade in pangolins through European nations, but to encourage prioritisation of the enforcement of laws and regulations to counter the illegal trade in pangolins. The Africa-to-Asia trade in pangolins is a growing trans-national crime and is placing enormous pressure on Africa's pangolins. As such, improved international collaboration and communication between enforcement agencies is essential.

5.3 Methods

Illegal wildlife trade is frequently reported in the media and through research from academic and non-Government organisations, or via enforcement agencies and government reports (Chapter 3). We obtained pangolin seizure records from the Federal Agency for Nature Conservation (Bundesamt für Naturschutz; BfN), which is the German CITES Management Authority. We also interrogated existing databases and published literature for pangolin seizure records involving Germany as a transit, exporting, or destination

country, and we searched Google^{Tm} alerts from the last three years (in English). An additional Google^{Tm} news search was conducted in March and April 2019, using the keywords “Schuppentier” or “Pangolin” together with “Beschlagnahmung”, “Aufgriff” or “Konfiszierung” and “Deutschland” to search German media.

All seizure incidents were collated, and the seized quantities per incident converted into ‘whole estimated pangolins’. More accurately, these represent the number of pangolins that were likely poached to obtain the trafficked pangolin products, and we used these estimates to compare the seized quantities of the different commodities in a more meaningful way. We calculated the minimum and maximum number of pangolins and used the average (rounded up to a whole animal) as a point estimate for the number of pangolins per incident. As the species was unknown in all incidents, we used the scale weight as described in Chapter 3. For pangolin scales from Africa we thus used a minimum of 0.6 kg per pangolin and maximum of 4.5 kg as a conversion factor, and for scales coming from Asia a minimum of 0.36 kg and a maximum of 3.51 kg of scales per pangolin. For meat, we assumed that a piece of meat equals one pangolin. We grouped the commodities ‘medicine’ and ‘extract’ into a single category ‘medicine’. Medicine is usually reported as a count (number of pieces), and we assumed that a minimum of one pangolin was needed for each shipment and a maximum of the reported number of pieces of medicine.

The data curation and summary were conducted in the R software environment (version 3.4.3; R core Team, 2017).

5.4 Results

From 2010 – 2018 Germany was involved in 39 pangolin seizure incidents, involving an estimated 737 pangolins (**Figure 5.1**). A peak was reached in the year 2013, when 79% of all seizure incidents occurred and 81% of all estimated pangolins for that period were intercepted. In the last two years, i.e., 2017 and 2018, no pangolin seizure incidents involving Germany were reported by the German authorities (**Figure 5.1**).

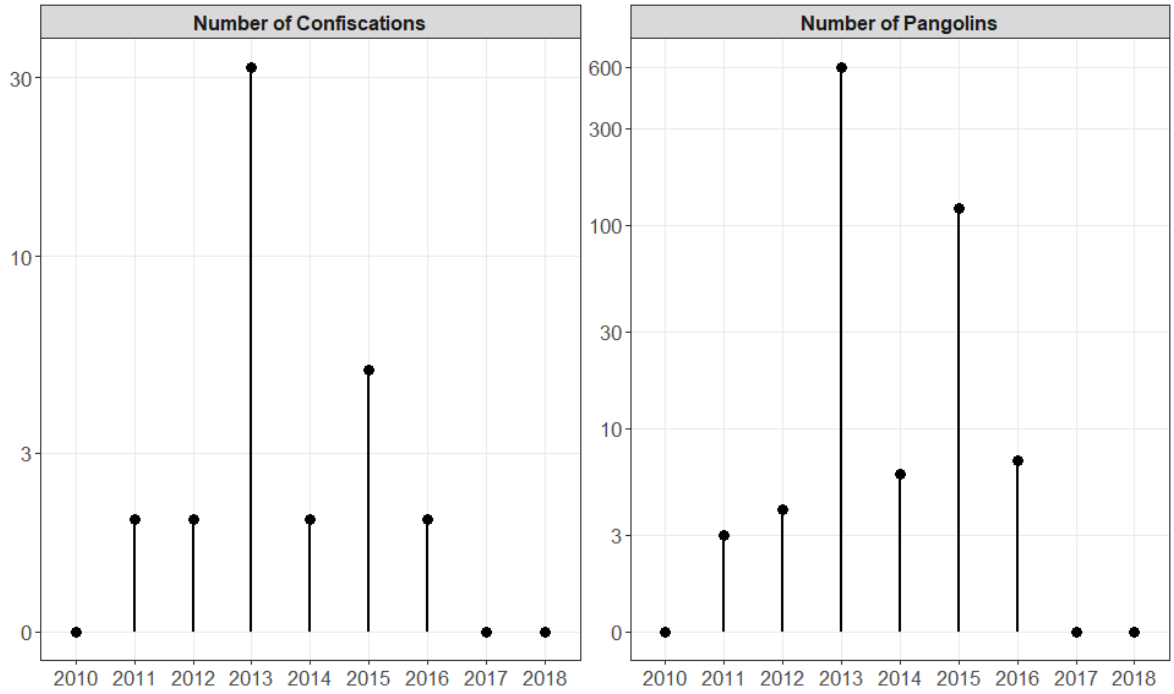

Figure 5.1: Pangolin seizure incidents involving Germany through time from 2010 – 2018, based on a) the total number of seizures, and b) the total number of estimated pangolins. Note that the y-axes are on a logarithmic scale.

Additionally, we found one seizure incident that was made outside of Germany, involving Germany as a prior transit country. In 85% of all incidents (and 98% of estimated pangolins trafficked) Germany was a transit country. In the remaining incidents, it was the reported destination for the intercepted shipments. Notably, 90% of the shipments were sent to Germany via postal services, where they were subsequently seized. The remaining 10% consisted of two shipments that arrived as airfreight, one hidden in the personal luggage of a passenger, and another shipment of unknown transport mode.

Scales were by far the most seized commodity, accounting for 87% of incidents, or 98% of estimated pangolins (**Figure 5.2**). The majority of incidents involving scales (97% of incidents) came from Africa and were supposed to be sent to China/Hong Kong. Medicinals (10% of incidents and 2% of estimated pangolins) were exclusively trafficked out of China, using Germany as a destination country in three incidents, or as a transit country in one incident with the US as the intended destination (**Figure 5.2**). There was only one incident, where meat of a single pangolin had been seized, which was *en route* from Togo via Ghana to Germany (**Figure 5.2**).

Media reporting on pangolin seizures made in Germany was extremely low. Of all seizures from the postal service, we did not find a single incident reported in the German or English

media. The sole seizure reported in the media was the seizure of pangolin meat from Togo via Ghana from a passenger at Munich Airport, which was featured by two local media outlets (Anon. 2015a, b).

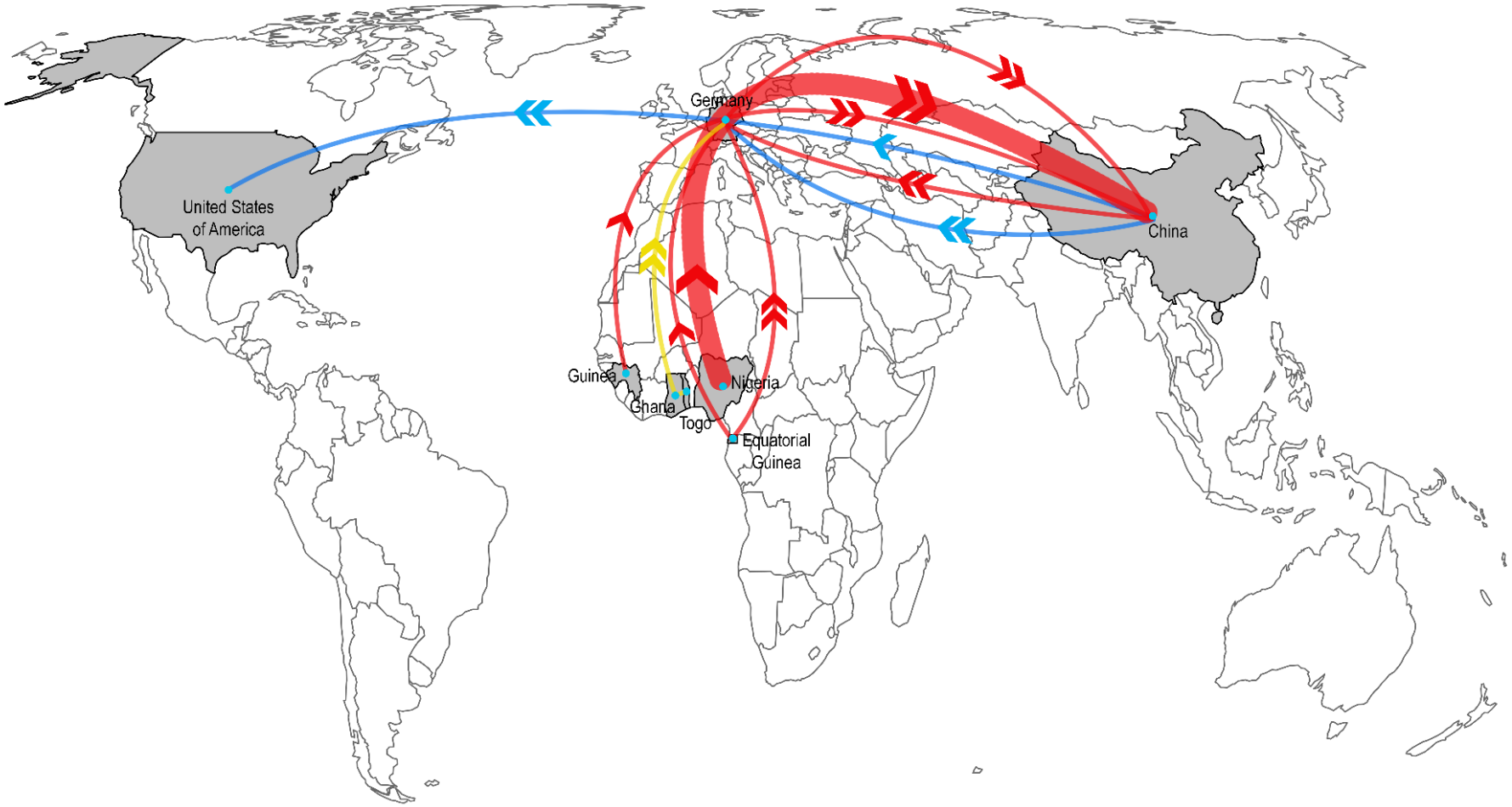

Figure 5.2: Pangolin trafficking routes involving Germany, from 2010 – 2018. The trafficking routes are on a country-by-country basis and are coloured by commodity, with seizure incidents involving scales (red), medicine (blue), and meat (yellow). The thickness of the lines represent the normalised number of seizure incidents multiplied by the seized quantities measured in estimated pangolins, per trafficking route. Single arrow heads (>) indicate a subsequent transit country in a trafficking route, while double arrow heads (>>) indicate the reported final destination in the trafficking route. Note: The start and end points of a trafficking route have been approximately centralised per country and do not indicate a specific location within a country.

5.5 Discussion

Wildlife trade in Germany and the other European Union (EU) Member States is regulated through the European Commission (EC) Wildlife Trade Regulations (Council Regulation (EC) No. 338/97, and Commission Regulation (EC) No. 865/2006). There are four Annexes (Annex A – D) in the EU Wildlife Trade Regulations, with Annex A offering the highest degree of regulation and protection. Annex A contains those species listed in CITES Appendix I, as well as additional species, which are deemed to be in demand internationally, and whose survival is or may be threatened by continuing trade activities. The import of a species into the EU listed in Annex A is only possible if an import permit has been issued by a Management Authority of the member state of destination, and if the applicant provides an export or re-export permit issued in accordance with CITES by a relevant authority of the country of export or re-export (for additional details see EU Reg. No. 338/97). Specimens of species in the Annexes that are in transit between two non-EU countries – as are most of the cases analysed here – need neither an import permit or notification to enter nor a re-export certificate to leave the EU (EU Reg. No. 338/97, Article 7). However, if a specimen is also listed on CITES Appendices I or II, such transit shipments must be accompanied by valid export permits or re-export certificates indicating the shipment's final destination, and must be seized if such documents are found to be absent (EU Reg. No. 338/97, Article 7). This legislation forms the basis of most pangolin seizures analysed here. After the inclusion of all eight pangolin species in CITES Appendix I, all pangolins were transferred from Annex B to Annex A of the EU Wildlife Trade Regulations as of February 2017 (Commission Regulation (EU) 2017/160 of 20 January 2017), and appear to be adequately protected in Germany and Europe.

EU Wildlife Trade Regulations are directly applicable in all EU Member States. The main national legislation relevant to the implementation of the Wildlife Trade Regulations in Germany is the Federal Nature Conservation Act (Bundesnaturschutzgesetz (BNatSchG) of July 29th 2009, last amended on September 15th, 2017). Thereby, all pangolin species are regarded as "strictly protected", the highest category of protection in this legislation. As a result, BNatSchG puts into place for these species prohibitions on possession – including all handling and processing, as well as prohibitions on marketing – including sale and offer for sale, purchase, and shipping for purposes of sale (BNatSchG §44). Ignoring these prohibitions is considered a criminal offence and carries a prison term of up to five years or a fine (BNatSchG §71). EU regulations also prohibit specifically commercial activities

– with some derogations - around species, such as all pangolins, that are listed in Annex A of the regulation, specifically mentioning also the transporting for sale of specimens (EU Reg. No. 338/97, Article 8).

It is an encouraging sign that German Customs have initiated controlled deliveries in several cases, concerning the parcels sent from Nigeria, in collaboration with Hong Kong Customs (BfN 2014). In 2013 at least four people were arrested and imprisoned in Hong Kong following controlled deliveries (although from the report it is unclear whether the arrests were only in relation to the pangolin scale shipments, or whether this also included investigations involving one ivory shipment and several parcels with dried seahorses from Latin America). Following one of these controlled deliveries in 2013, a further 125 kg of pangolin scales were seized on the premises of one of the consignees in Hong Kong (BfN 2014). It was reported, however, that in two cases in 2015, Hong Kong Customs were not able to conduct controlled deliveries as had been offered by German Customs (BfN 2017). In the bushmeat seizure at Munich airport, a media report suggested that the suspect would be fined by the BfN (this being in 2015, before up-listing pangolin species to CITES Appendix I / EU Annex A). Investigations and prosecutions, if necessary with international collaboration, are key to reducing wildlife crime. Seizures alone will not stop the continued illegal killing and trafficking of endangered animals and plants, and investigations and prosecutions, as part of multifaceted interventions, must follow in order for the applicable laws to be effective and to deter any offenders.

The majority of incidents involving scales came from African countries, and here predominantly from countries of the Gulf of Guinea. Countries from the Gulf of Guinea have previously been identified to be heavily involved in pangolin trafficking, as highlighted by Ingram, et al. (2019). Here, we found Nigeria to be the principle exporter of the pangolin shipments seized in Germany. All these shipments consisted exclusively of scales and were meant to be shipped to China/Hong Kong.

In recent years, Nigeria has repeatedly been identified as a major exporter of pangolin products, with predominately Asian countries as the intended final destination (Gomez, et al. 2016b). Some of the biggest seizures of pangolin scales from Nigeria were made only recently. In January 2019, 8.3 tonnes of scales were seized in a single incident in Hong Kong (Anon. 2019b). In the first two weeks of April 2019 another two incidents occurred in Singapore, one shipment containing 12.9 tonnes of pangolin scales, the other containing 12.7 tonnes of scales, and both intercepted on their way to Vietnam (Anon. 2019a). It should

be emphasized that Nigeria is reported as the exporting country in most of these cases, but that it is not necessarily the origin country. It is possible that pangolins are being collected from neighbouring countries, to be exported from Nigeria.

In an analysis of open-source media reports of pangolin trafficking from Nigeria from 2011-2015, Gomez, et al. (2016b) found a total of nine seizures of pangolin parts (predominantly scales) that had been exported from Nigeria. Eight of these were made in Asia and one in France. Since 2015, there were at least another 23 pangolin seizures involving Nigeria, at least 14 of which again had Asian countries as a destination (S. Heinrich, unpubl. data.). Gomez, et al. (2016b) reported zero seizures in 2011, two in 2012, zero in 2013, one in 2014 and six in 2015. Interestingly, 26 of the 28 seizures in Germany that came from Nigeria, were made in 2013, but none of these could be found in open source media by Gomez, et al. (2016b). France was the only European country that was found in open-source media having made a seizure of pangolin scales (250 kg) coming from Nigeria in that study. Gomez, et al. (2016b) searched English media only and therefore seizures reported in German would have been missed. However, a search made in German media for the present study also only found a single seizure incident.

These findings illustrate the dynamic trafficking routes that characterise the illegal wildlife trade. At the same time, the discrepancy between seizures on administrative record and seizures as reported by the media highlight country-specific biases in media reporting of wildlife seizure incidents (see also Nijman (2015) for language-specific biases in seizure data collated from media sources). Certainly, for the case of pangolins, and in contrast to the situation in range- and main consumer countries, there exists very little reporting in German media of pangolin seizure incidents involving Germany. Better media reporting of wildlife seizures, especially of pangolins, would be expected, given the general rise of attention for pangolins (Harrington, et al. 2018). On the other hand, media reporting of seizures could be detrimental to ongoing investigations, such as the aforementioned controlled deliveries. The discrepancies of media reporting highlight that any analysis of wildlife seizures should not rely only on open source media for wildlife seizures, but also include government records to obtain a more holistic picture of trade dynamics.

However, even if all seizure incidents per country are included, every analysis using seizure data comes with inherent biases. These may include different reporting practices among countries and responsible law enforcement agencies, available funding for wildlife related offenses and varying levels of priority of wildlife crime in different countries. These biases

will ultimately influence the results and interpretation of every seizure analysis and it must be emphasized that seizures only represent a fraction of the true levels of trafficking (see also Utermohlen and Baine (2017) and Underwood, et al. (2013)).

The increasing pangolin trade connection from Africa to Asia has previously been identified (Challender and Hywood 2012; Krishnasamy and Shepherd 2017), and European countries play a role as a transit hub for these shipments (Chapter 3). While there appears to be demand for pangolin meat, scales, and medicine in other European countries, such as the Netherlands, France, and Belgium (Chaber, et al. 2010; Chaber, A.L. (2019), pers. comm.; Chapter 3), Germany's role in pangolin trafficking appears to be as a transit country.

All incidents involving medicinal products came from China. In fact, of the five shipments that originated in China, four were medicinal products. The trafficking of pre-prepared medicinal products requires further research efforts. Apart from European countries, the US is another destination of pre-prepared Traditional Chinese Medicine (TCM) products containing pangolin (Chapter 3, 4). Ground-up pangolin scales, extracts prepared from pangolin products or even incense sticks containing pangolin (or other endangered wildlife) are very hard to detect, if the ingredient list does not identify all products. These medicinal products are also shipped to non-range countries, which have historically not received much attention. Coghlan, et al. (2015), for example, revealed that 50% of TCM products, which had been purchased in Adelaide, Australia, contained DNA of undeclared taxa, including endangered species, such as Snow Leopard (*Panthera uncia*). There is likely more (illegal) trade occurring in pre-prepared medicines, which requires research attention and further investigation into this trade and possible solutions for better detecting these products.

Criminal networks often use new routes and methods to move contraband to avoid detection. When losses due to enforcement efforts outweigh profits from successful trafficking efforts, these routes are often changed. This was potentially the case for the highlighted trafficking route from Nigeria via Germany to China/Hong Kong, and notably there were no more seizures involving Germany in the last two years. Pangolins were up-listed to CITES Appendix I in January 2017 and EU Annex A in February 2017. However, given that illegal pangolin trade appears to be increasing in other countries in recent years, the lack of seizures in 2017 and 2018 in Germany is unlikely to be a result of better and stricter protection of pangolins. It is more likely that because these shipments were intercepted so often in Germany, the traffickers moved on to new routes, which would also

explain the sudden drop in seizures after 2013. However, we acknowledge that there may be other unknown reasons why the trade routes may have been changed, or why there were no more seizures in 2017 and 2018.

Another interesting finding of this study was the use of postal services to transport illicit pangolin products. The use of parcels and postal services to transport illegal wildlife globally has been reported previously (Carrillo-Páez 2018; Haysom 2019) and especially with the rise of internet facilitated wildlife trade (Krishnasamy and Stoner 2016; Wingard and Pascual 2018), postal services may become increasingly important in the future. There is very little information provided on postal packages to follow up on these shipments and to initiate an (international) investigation. Increased vigilance by postal offices and collaboration with law enforcement, especially in source countries where the parcels are being sent from, would therefore be crucial to prevent wildlife from being trafficked out of the country, and to have a higher chance of arresting the responsible traffickers.

In conclusion, the majority of shipments involving Germany came from West Africa, and here predominately from Nigeria, which has previously been identified as one of the most important countries involved in international pangolin trafficking. We found the post to be used as an important means of transport, with 90% of incidents being shipped via postal services. We also highlight the need for further research into the international trade in Traditional Medicines. These shipments are often overlooked, as they are particularly hard to detect, and the ingredients are sometimes misdeclared. We further found a large discrepancy between seizures on administrative record and seizures as reported by the media. Recognising these country-specific biases in media reporting of wildlife seizure incidents may improve analyses of wildlife seizures in the future.

Chapter 6

Plight of the Commons: 17 Years of Wildlife Trafficking in Cambodia

Statement of Authorship

Title of Paper	Plight of the Commons: 17 Years of Wildlife Trafficking in Cambodia
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Heinrich, S., Ross, J.V., Gray, T.N.E., Delean, S., Marx, N. and Cassey, P. (2020). Plight of the Commons: 17 Years of Wildlife Trafficking in Cambodia. *Biological Conservation* **241**:108379 (January 2020).

Principal Author

Name of Principal Author (Candidate)	Sarah Heinrich		
Contribution to the Paper	Curated, analysed and interpreted the data, wrote manuscript and acted as corresponding author		
Overall percentage (%)	85%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	16.12.2019

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate to include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Joshua V. Ross		
Contribution to the Paper	Assisted with the development of the work and manuscript editing		
Signature		Date	

Name of Co-Author	Thomas N. E. Gray		
Contribution to the Paper	Provided the seizure data and assisted with the editing of the manuscript		
Signature		Date	

Name of Co-Author	Steven Delean		
Contribution to the Paper	Assisted the analysis and editing of the manuscript		
Signature		Date	

Name of Co-Author	Nick Marx		
Contribution to the Paper	Provided the seizure data and assisted with the editing of the manuscript		
Signature		Date	6.12.2019

Name of Co-Author	Phillip Cassey		
Contribution to the Paper	Supervised the development of the work, assisted with data analysis and manuscript editing		
Signature		Date	16/12/2019

Chapter 6. Plight of the Commons: 17 Years of Wildlife Trafficking in Cambodia

This chapter has been amended slightly from its original published version to reduce redundancy and ensure consistent formatting throughout the thesis. The original publication can be found online with the following citation:

Heinrich, S., Ross, J.V., Gray, T.N.E., Delean, S., Marx, N. and Cassey, P. (2020). Plight of the Commons: 17 Years of Wildlife Trafficking in Cambodia. *Biological Conservation* **241**:108379.

6.1 Abstract

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.

6.2 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 (Nijman 2010; Harrison, et al. 2016), 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 2015b), and smaller mammals, such as pangolins, are being driven to extinction (Challender, et al. 2014a).

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 – 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; McNeely 2003; Loucks, et al. 2009; Gray and Prum 2012). 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 were readily available, leading to a further

decline in wildlife (Martin and Phipps 1996; Loucks, et al. 2009). 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 (Gray, et al. 2017a; EIA 2018).

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 (Martin and Phipps 1996; Ashwell and Walston 2008). 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.*) (Starr, et al. 2010; Gray, et al. 2017b).

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 provide 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 (Martin and Phipps 1996; Ashwell and Walston 2008). 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.

6.3 Methods

We analysed wildlife seizures in Cambodia from 2001 – 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' (**Table 6.1**).

Table 6.1: Reported commodities in the seizure dataset and the conversion parameters that were used to infer 'whole animals' that likely had to be killed for the commodities to be obtained per incident.

Reported commodity	Measure of quantity	Minimum number of animals required	Maximum number of animals required
Meat, dead, live, dried	Weight	Minimum Body mass	Maximum Body mass
live, dead, skins, shells, plastrons, heads, skulls (with or without horns), tongues, chins, organs, genitals, tails, skeletons, meat, or eggs, Horns (birds)	Count	Reported count	Reported count
Limbs (birds), Horns (mammals), Hip bones, jaws (with or without fangs), Tusks and ivory	Count	Reported count/2	Reported count
Limbs (mammals or reptiles), Fangs	Count	Reported count/4	Reported count
Bones, ribs, knee bones, back bones, quills, hairs, feathers, Specimens[5], blood[5], other[5], fat[5], oil[5]	Count	1	Reported count
Teeth (elephants)	Count	Reported count/26	Reported count
Teeth (wild pig)	Count	Reported count/44	Reported count
Nails	Count	Reported count/20	Reported count
Claws[6]	Count	Reported count/8	Reported count

[5] Assumed to be in vials or any other container and the reported quantity referred to that container

[6] Reportedly from *Spilornis cheela*

Where a quantity (count of animals or their parts and derivatives) and a weight in kilograms (kg) were both provided for the same incident, the count was chosen over the weight. If the only available measure for the quantity of animals involved in an incident was reported in weight (kg), we used data of animal body masses from Dunning (2008) for birds, Wilson, et al. (2013) for mammals, and Hallmann and Griebeler (2018) for reptiles, to estimate the number of animals involved. For each incident, we estimated a minimum and a maximum number of animals involved. The rounded (upwards) average was used in subsequent analysis. If only a higher taxonomic level than species was reported, the weight of the smallest member of a Genus or Family was taken as a measure of the maximum body mass, and the weight of the heaviest member of a Genus or Family was taken as a measure of the minimum body mass (data only available for birds and mammals). If no data for the minimum and maximum body mass range were found, the average body mass was used for the calculation of whole estimated animals (if available). If none of the parameters could be obtained, the confiscated animals and their parts were not converted into whole estimated animals.

Data of 369 incidents could not be converted into whole estimated animals. This included a variety of commodities of reptiles, birds and mammals, which were: i) Not identified to the Family level (162 incidents); ii) Body parts, which were reported in weights but could not be unambiguously converted (228 incidents); iii) Species and Families for which no data on body mass were found in the aforementioned sources (62 incidents); and/or iv) where neither weight nor quantity (in count) had been reported (64 incidents). For reptiles, this meant that 4594.6 kg across 174 incidents were not included in the analysis of volumes; for birds 102.9 kg across 23 incidents; for mammals 336.7 kg across 127 incidents; And for animals of unknown Class 33.6 kg across 51 incidents.

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 work 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 – 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 three 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 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.

6.4 Results

6.4.1 Confiscations and temporal trends

Between 2001 and mid-2018, an estimated 125 445 animals were confiscated in 10 829 incidents throughout Cambodia (**Figure 6.1**). 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).

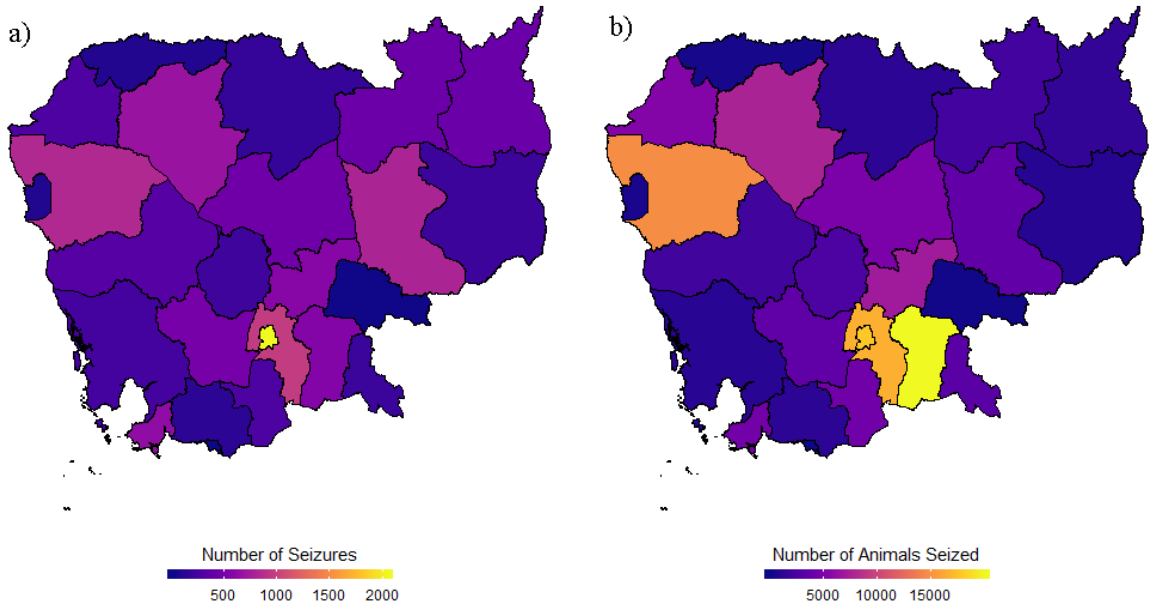

Figure 6.1: Map of confiscations throughout Cambodia. Displayed are a) the total number of confiscations, and b) the estimated total number of confiscated animals on a state level from 2001 – 2018.

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 (**Figure 6.2**). 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; **Figure 6.2a**) in 2017. Similarly, the estimated number of confiscated animals follow 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; **Figure 6.2b**) – a third of what it was in 2003.

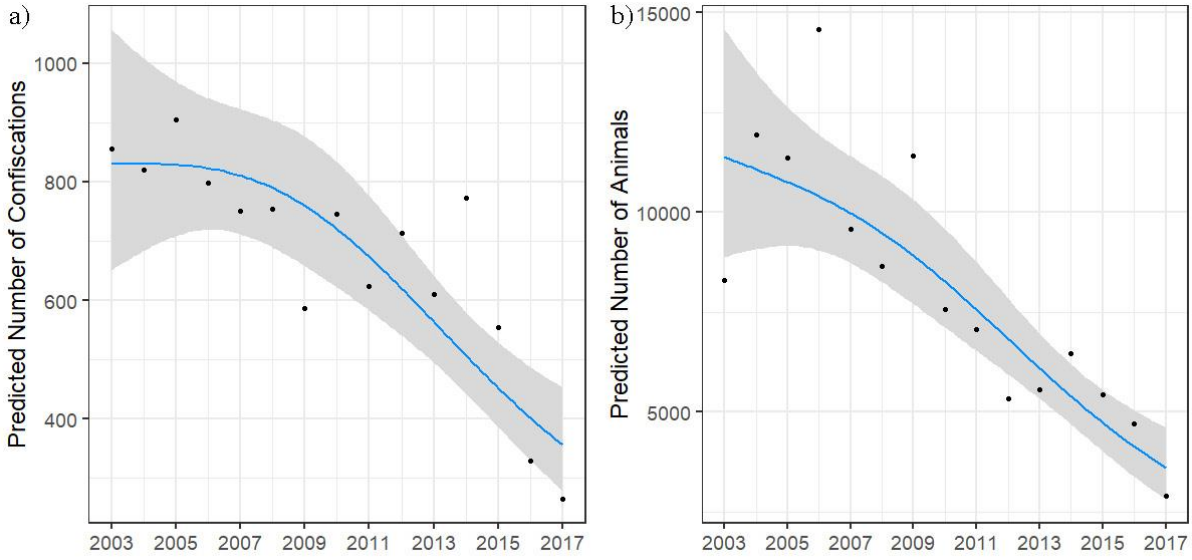

Figure 6.2: The estimated number of a) confiscations, and b) animals, from 2003 – 2017. The estimated relationships (in blue) are predicted from generalised additive models, accounting for the effect of time and effort. Shaded grey areas represent 95% CI. See **Figure S6.1** for the raw data.

6.4.2 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 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 < 0.001) and mammals (mean difference = -2.13, SE = 0.036, p-value < 0.001). The average number of confiscated mammals per incident was also significantly lower compared with reptiles (mean difference = 1.31, SE = 0.033, p < 0.001).

Within the three Classes, 31 different Orders were confiscated (**Figure 6.3**). The songbirds (Passeriformes) had by far the highest overall number of animals, with almost 28 000 estimated whole animals (**Figure 6.3b**). 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 (**Figure 6.3a**). The second most confiscated Order were the even-

toed ungulates (Artiodactyla; **Figure 6.3a**). It should be noted that the quantity we were unable to convert into whole estimated animals (see Methods section) included over 2 tonnes of plastrons and shells of different turtles and tortoises alone, which are not reflected in this analysis.

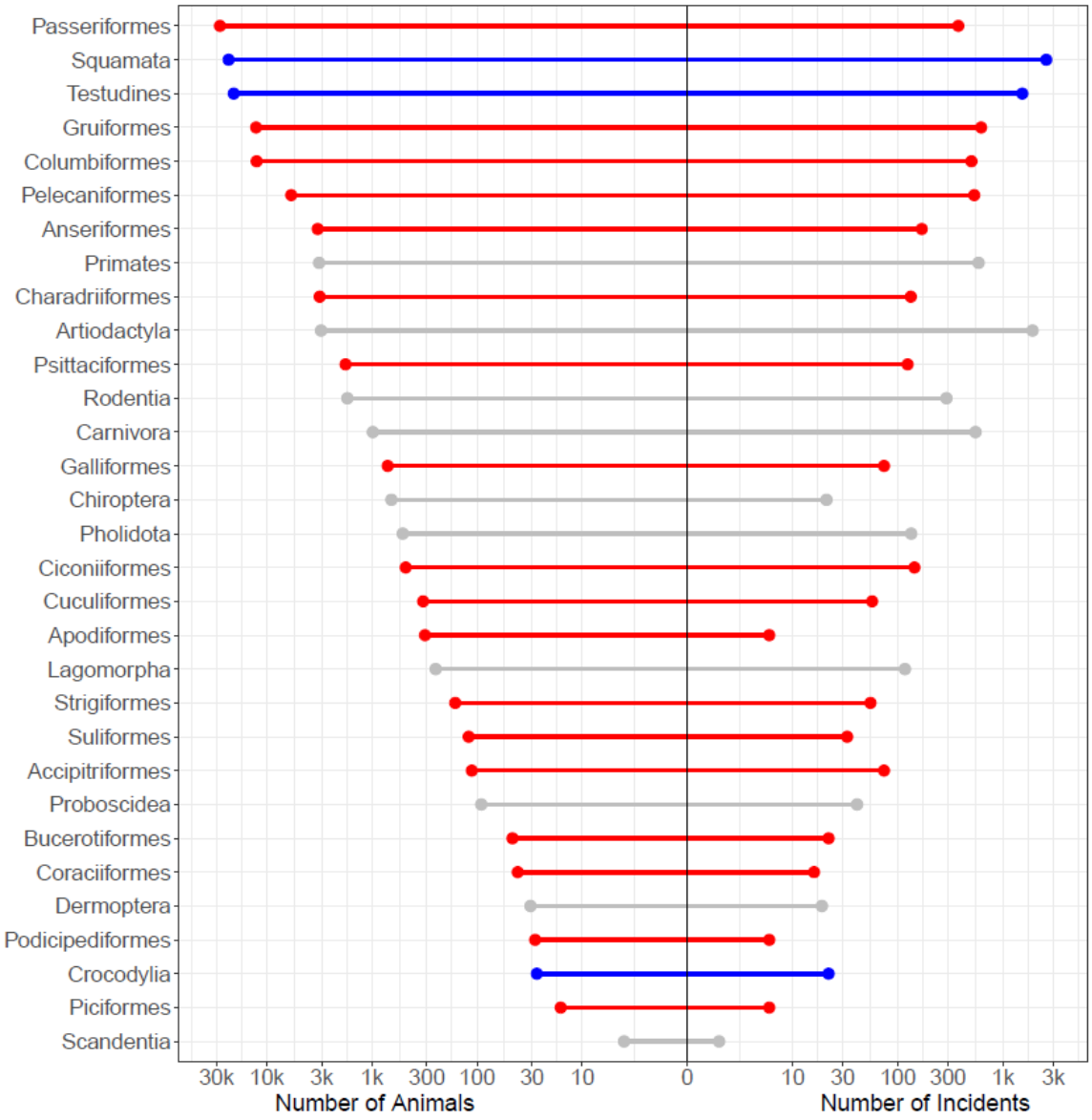

Figure 6.3: The Orders of animals confiscated in Cambodia of either birds (red), mammals (grey), or reptiles (blue). Depicted are the number of animals in 'whole estimated animals' (from the middle to the left), and the number of incidents (from the middle to the right). Note that the x-axes are displayed on a logarithmic scale.

The most confiscated species are displayed in **Figure 6.4**. Of the 15 species confiscated in each of the 15 years (displayed in red), 6 were classified as threatened by the IUCN, namely the Asian box turtle *(Cuora amboinensis*; IUCN Status: Vulnerable), the Asian giant pond turtle (*Heosemys grandis*; IUCN Status: Vulnerable), the Mekong snail-eating turtle (*Malayemys subtrijuga*; IUCN Status: Vulnerable), the Sunda pangolin (*Manis javanica*;

IUCN Status: Critically Endangered), the Burmese python (*Python bivittatus*; IUCN Status: Vulnerable), and the Sambar deer (*Rusa unicolor*; IUCN Status: Vulnerable).

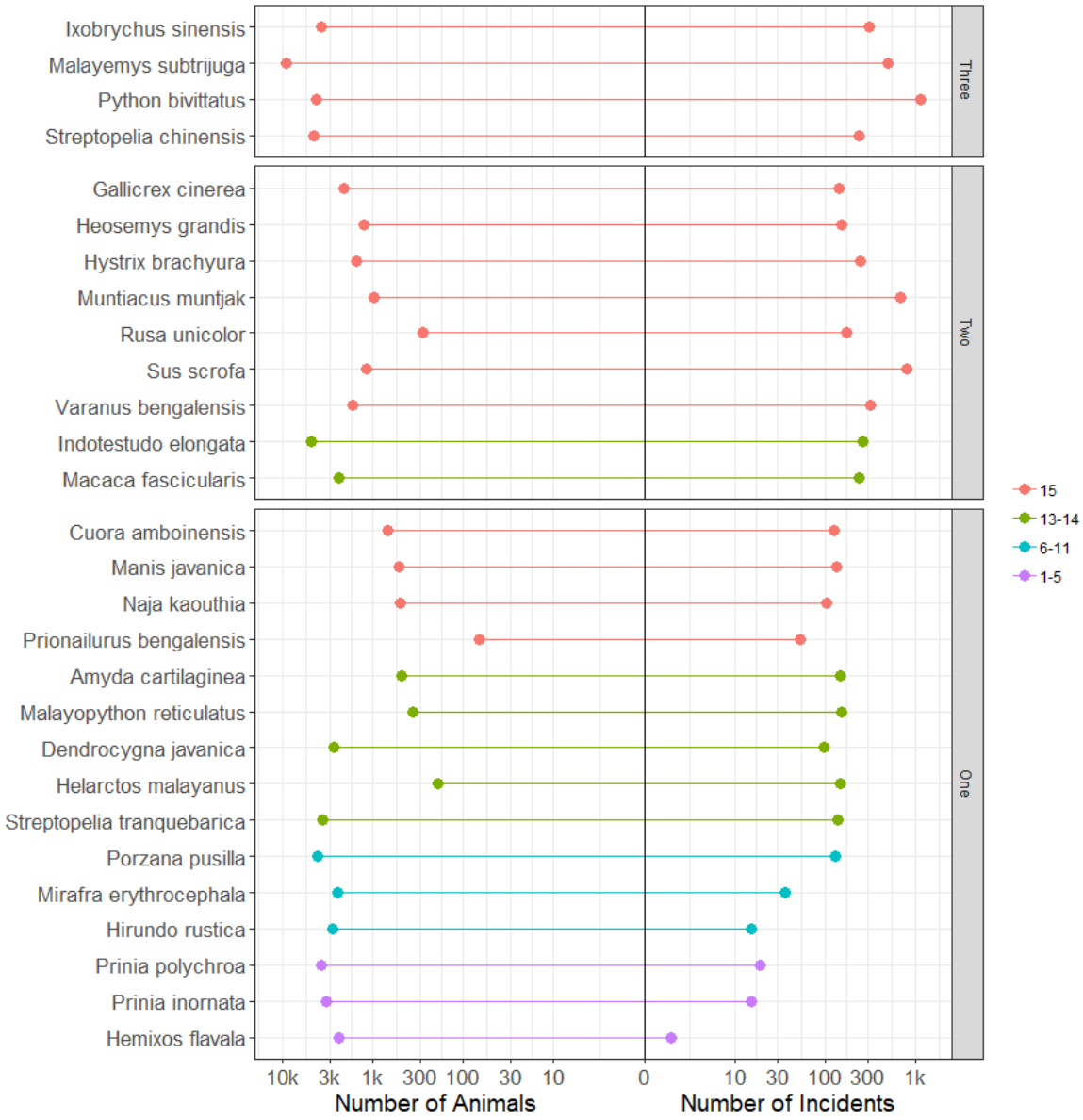

Figure 6.4: Species that were among the 15 most confiscated species, either in terms of (i) the number of confiscations, (ii) the number of confiscated animals, and/or (iii) species that were confiscated in each of the 15 consecutive years. If species fall into all three categories they are displayed in the first panel ('Three'), if they occur in two categories they are displayed in the second panel ('Two'), and if they occur in only one category, they are displayed in the third panel ('One'). The colours indicate the range of years in which a species had been confiscated in (see legend). The species specific number of confiscated animals (from the middle to the left), and the number of incidents (from the middle to the right) are displayed on the x-Axes. Note that the axes are on a logarithmic scale.

6.4.3 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 (**Figure 6.5**). Of these 15 species, six were classified as threatened by the IUCN (see **Figure 6.4**).

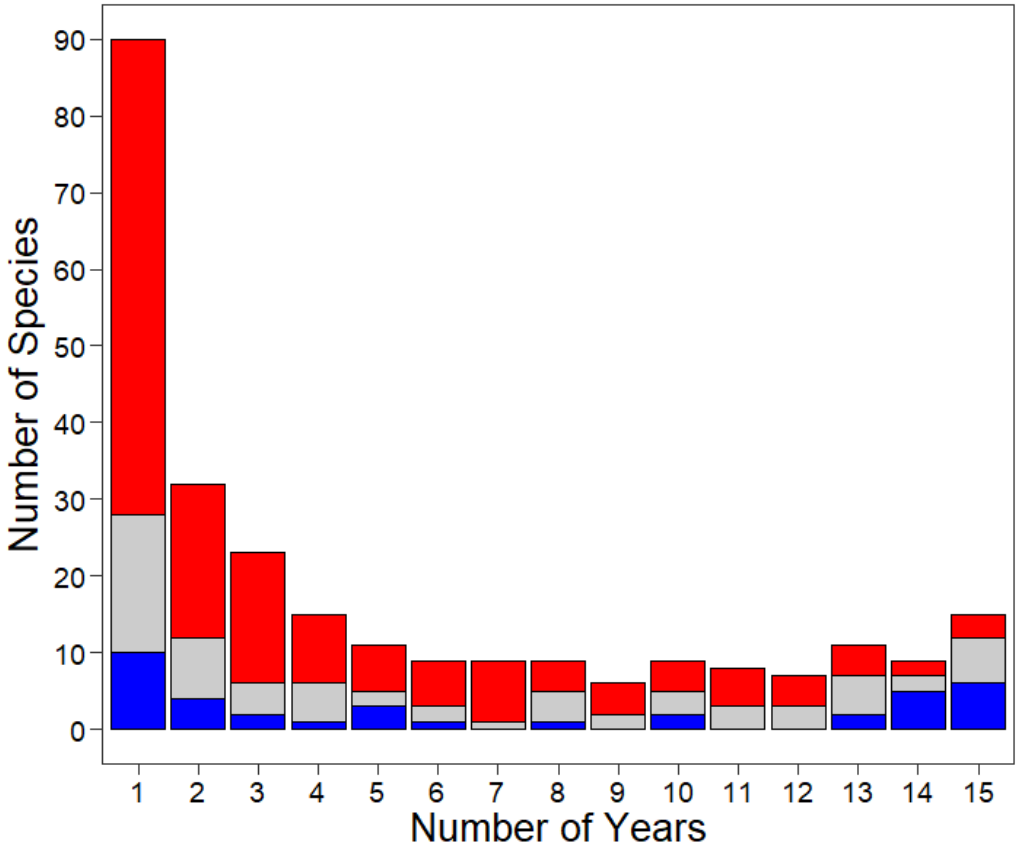

Figure 6.5: The number of species of either birds (red), mammals (grey), or reptiles (blue), with the corresponding number of years in which they have been confiscated.

Species of birds showed the highest overall richness (Slope = 0.017, SE = 0.009, p = 0.063; **Figure 6.6a**), diversity (Slope = -0.059, SE = 0.174, p = 0.736; **Figure 6.6b**) and abundance (Slope = 0.019, SE = 0.024, p = 0.442; **Figure 6.6c**), which were all relatively constant through time. For mammal species, their richness (Slope = -0.016, SE = 0.009, p = 0.076; **Figure 6.6a**) and diversity (Slope = 0.176, SE = 0.174, p = 0.317; **Figure 6.6b**) were relatively constant through time, while their abundance decreased (Slope = -0.059, SE =

0.024, p = 0.019; **Figure 6.6c**). For reptiles, species richness increased significantly through time (Slope = 0.019, SE = 0.009, p = 0.037; **Figure 6.6a**), while their diversity remained constant (Slope = -0.001, SE = 0.174, p = 0.995; **Figure 6.6b**) and their abundance declined significantly (Slope = -0.061, SE = 0.024, p = 0.017; **Figure 6.6c**).

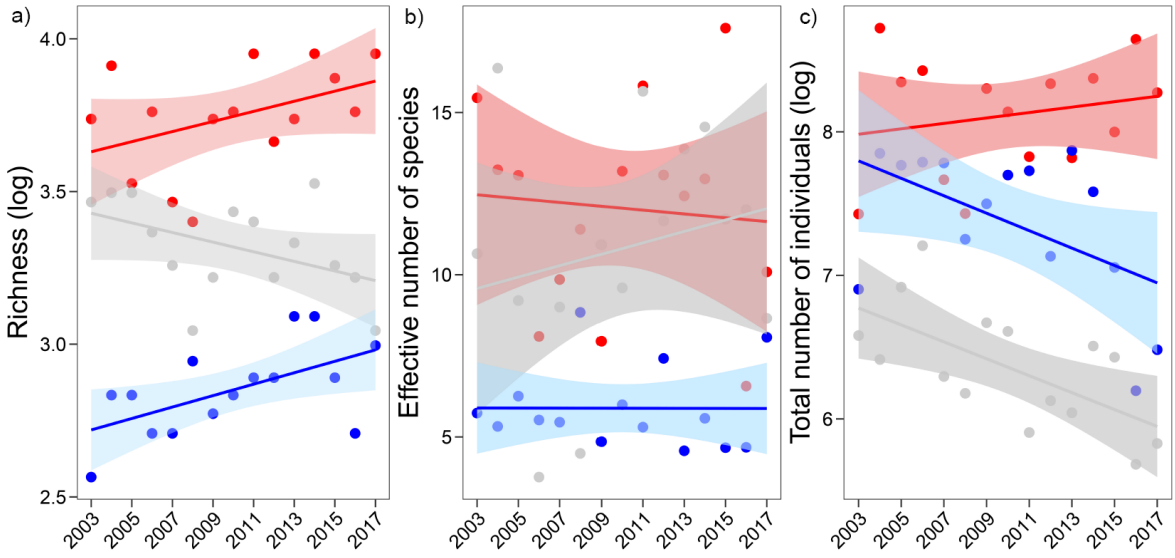

Figure 6.6: Plots of the estimated temporal trends in a) log species richness, b) exponential Shannon diversity (effective number of species), and c) log total abundance for birds (red), mammals (grey), and reptiles (blue). Coloured bands represent 95% CI following the same colour scheme.

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; **Figure 6.7**). 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 (**Figure 6.7**). 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 = 0.004), with the highest variability occurring for birds (**Figure S6.2**).

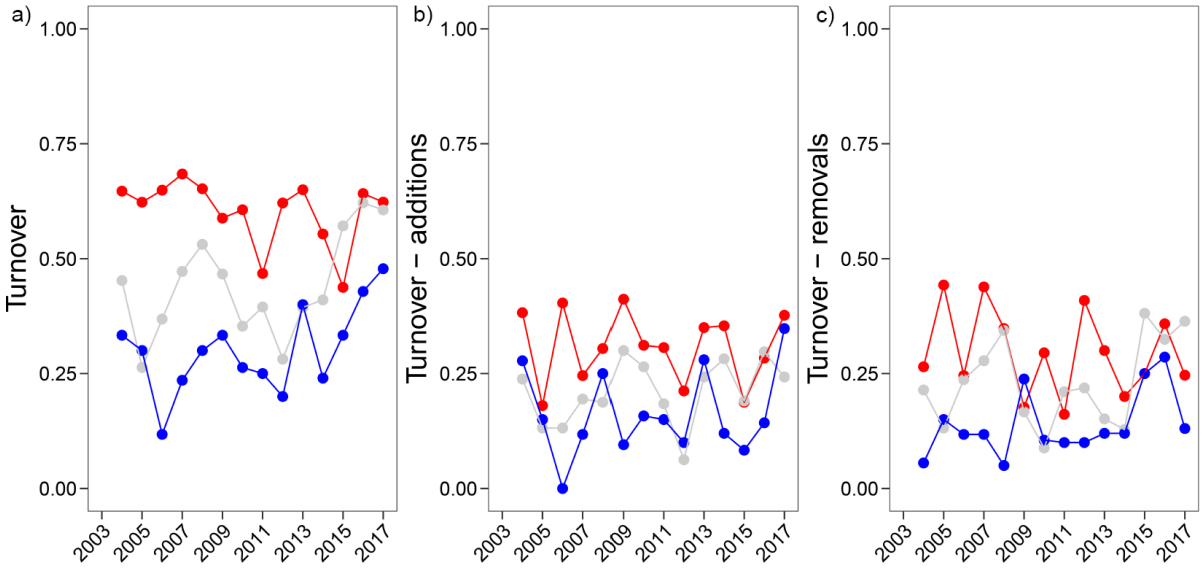

Figure 6.7: Plots of the turnover in the species occurrences over time: a) total turnover, b) additions, and c) removals for bird (red), mammal (grey), and reptile (blue) species.

6.4.4 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 6.2**). 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, $p < 0.001$), or not to be listed at all under the Forestry Law (mean difference = -1.07, SE = 0.47, $p = 0.024$). They were also more likely to be listed in CITES (mean difference = 0.85, SE = 0.39, $p = 0.028$). 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.

Table 6.2: 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 %

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; **Figure 6.8a**). 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 (**Figure 6.8b**). 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 (**Figure 6.8c**).

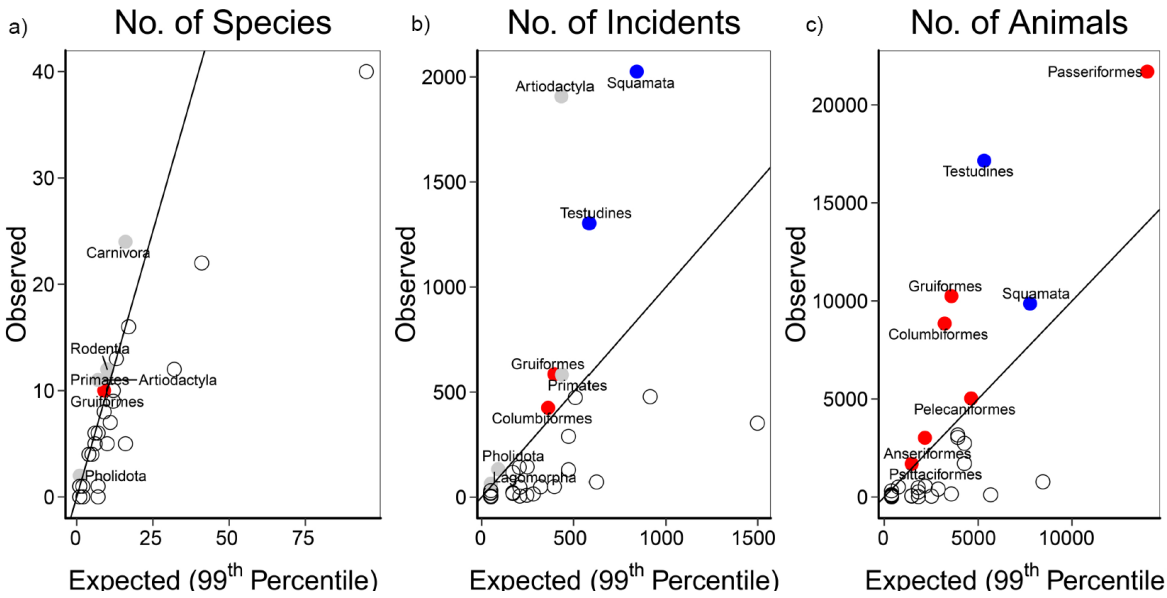

Figure 6.8: Permutation tests for over-represented species in Cambodian confiscations, based on a) the number of species listed under the Forestry Law, b) the number of incidents per species, and c) the number of animals per species. The observed number of species was inferred as being significantly 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 (grey), or reptiles (blue).

The 65 Families within the 14 Orders that were shown to be overrepresented in either one of the three analyses are presented in **Figure 6.9**. 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 (**Figure 6.9**).

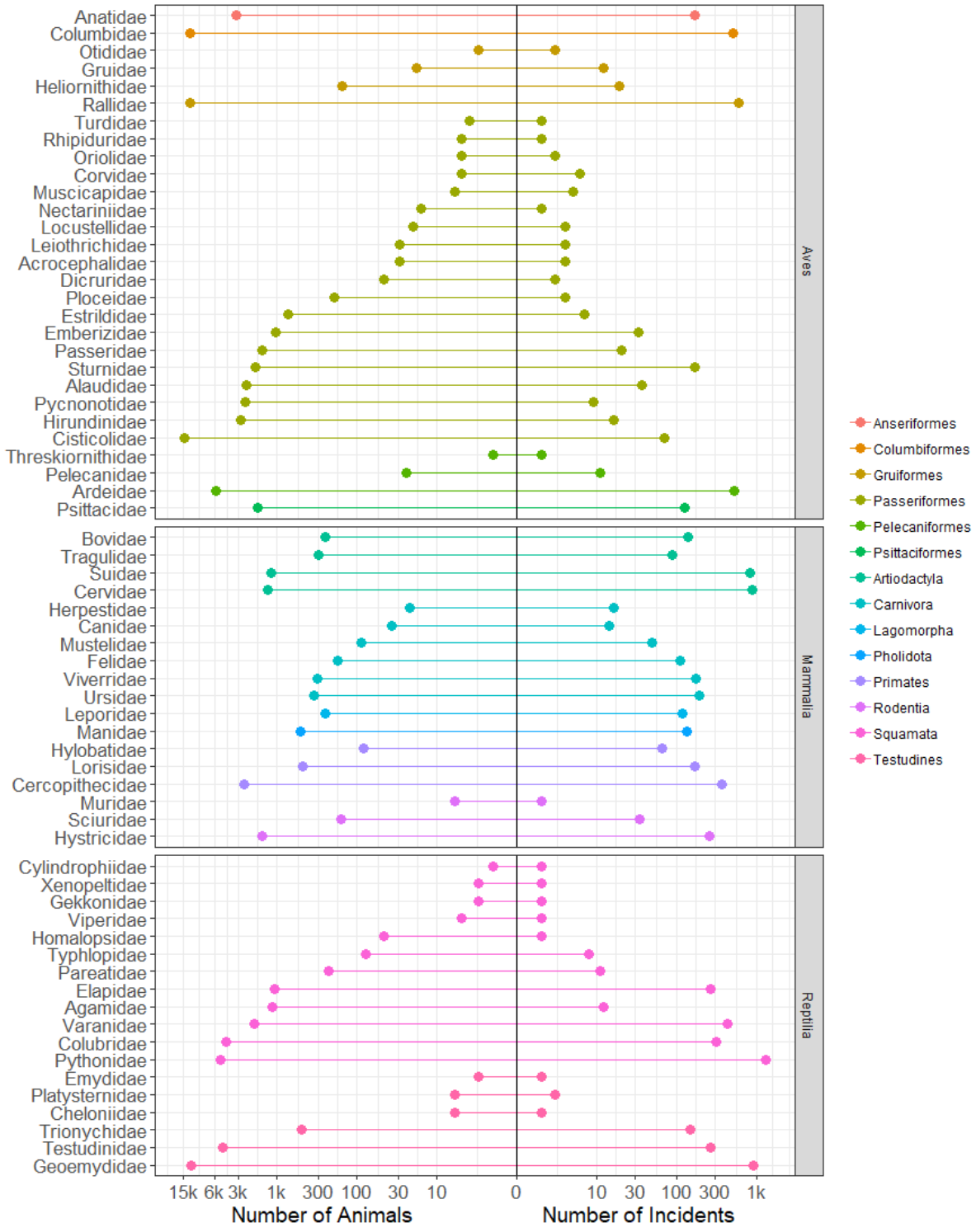

Figure 6.9: Families within the Orders that were found to be overrepresented in Cambodian trafficking, with the corresponding number of confiscated animals (from the middle to the left) and the number of incidents (from the middle to the right). Note that the x-axes are on a logarithmic scale and within each of the Orders the Families are ordered by the number of confiscated animals.

6.5 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 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 tonnes 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 (MaMing, et al. 2012; Brochet, et al. 2016; Gray, et al. 2018). 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 (Gilbert, et al. 2012; Regueira and Bernard 2012; Su, et al. 2014; Bhattacharya 2016; Brochet, et al. 2016). Many species involved in this trade are currently lacking adequate

protection from overexploitation (Regueira and Bernard 2012; Shepherd, et al. 2013; Chng, et al. 2015; Lee, et al. 2016), 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 **Figure 6.9** 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 (Thomson 2008; Natusch and Lyons 2014) 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 (Newton, et al. 2008; Challender, et al. 2014b). 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 re-stock, 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 more than 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 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.

Chapter 7

Pangolins in Trouble

Statement of Authorship

Title of Paper	Pangolins in Trouble
Publication Status	☑ Published ☐ Accepted for Publication ☐ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
Publication Details	Heinrich, S., Ross, J.V., Cassey, P. (2019). Pangolins in Trouble. *Frontiers for Young Minds* **7**:107

Principal Author

Name of Principal Author (Candidate)	Sarah Heinrich		
Contribution to the Paper	Wrote manuscript and acted as corresponding author		
Overall percentage (%)	90%		
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.		
Signature		Date	14.12.2019

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate to include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Joshua V. Ross		
Contribution to the Paper	Assisted with the development of the work and manuscript editing		
Signature		Date	16/12/19

Gary Glonek for Joshua Ross

Name of Co-Author	Phillip Cassey		
Contribution to the Paper	Supervised the development of the work and manuscript editing		
Signature		Date	16/12/2019

Chapter 7. Pangolins in Trouble

This chapter is not a typical scientific study, but rather a translation of the current knowledge about pangolin trade for an interested younger scientific audience (aged 8 – 15). The published article was reviewed by young reviewers and scientific advisors and can be found on the journal's website (https://kids.frontiersin.org/) with the following citation:

Heinrich, S., Ross, J.V., Cassey, P. (2019). Pangolins in Trouble. *Frontiers for Young Minds* **7**:107. Doi: 10.3389/frym.2019.00107

7.1 Abstract

The illegal wildlife trade (also called *wildlife trafficking*) is of growing concern worldwide. Wildlife trafficking is threatening a large number of plant and animal species. Many people sell and buy different wildlife species (both alive and as body parts), and the survival of these species may be threatened if this trafficking continues.

In this article, we will tell you the story of the pangolins, which have been called the world's most heavily trafficked wild mammals. Pangolins are the only mammals that are covered in scales. Eight species of pangolins exist, and all of them are threatened because they are trafficked in such high numbers. If current trafficking continues, these amazing animals may be lost forever.

7.2 Have you ever heard of a pangolin?

Have you ever heard of a pangolin (**pang**-*guh*-lin)? Although the names sound similar, pangolins are not to be confused with penguins. Pangolins look a bit like walking pinecones, but they are actually mammals. In fact, they are the only mammals that are covered in hard scales, and because their primary food source is ants, pangolins are also called scaly anteaters. There are eight species of pangolins, four of which live in Africa and four in Asia (**Figure 7.1**). Pangolins are very diverse. Some live in tropical forests, where they use their long tails to climb trees, while others walk on two legs through the vast deserts and savannahs of Africa. Pangolins are a very ancient line of mammals, and fossil evidence suggests that they have been around for over 40 million years. Recently, pangolins

have become quite famous. Sadly, this happened for all the wrong reasons, and they are now known as the most heavily trafficked wild mammals in the world (Challender, et al. 2014a).

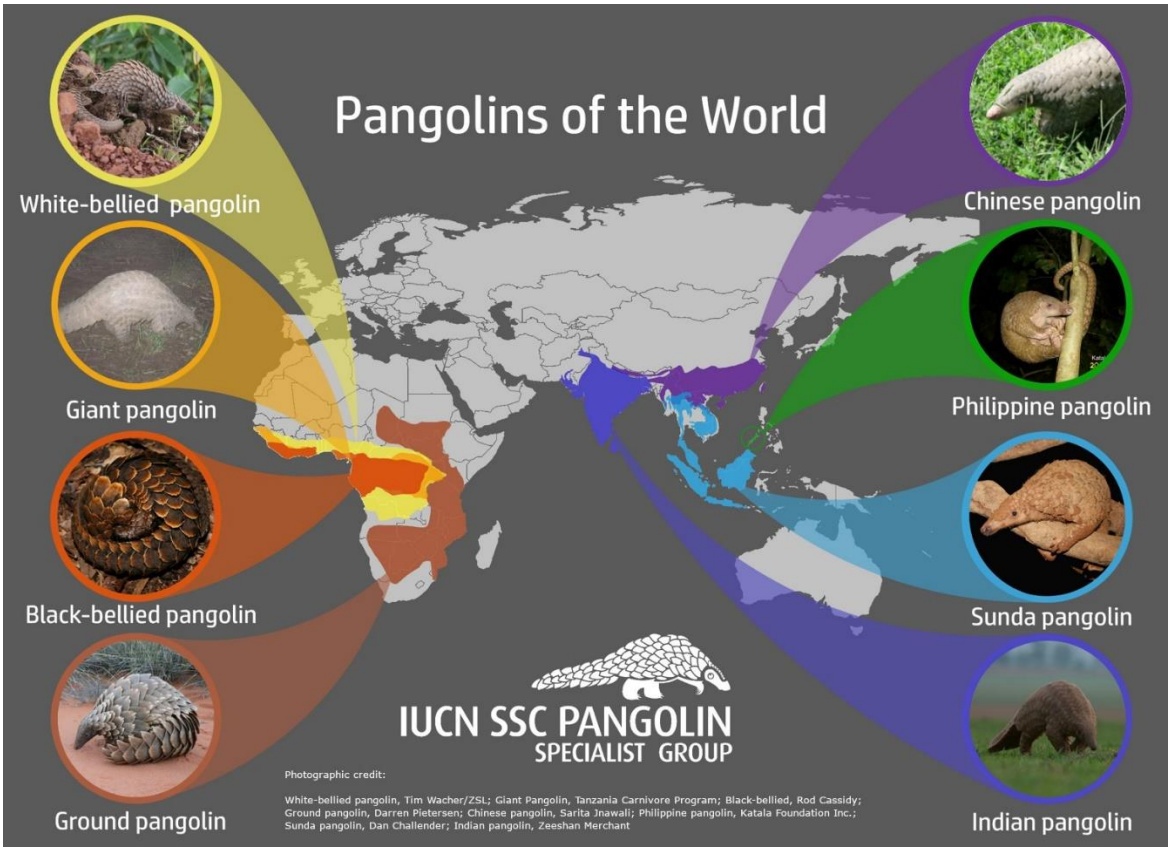

Figure 7.1: The eight pangolin species of the world and their distributions (courtesy of the IUCN SSC Pangolin Specialist Group).

7.3 What is wildlife trade and trafficking?

Wildlife trade, which can be legal, and wildlife trafficking, which is illegal trade, includes thousands of species (and millions of individual organisms) that are traded every year. Wildlife trade is very diverse and includes species of plants, fungi, and all kinds of animals, such as reptiles, birds, mammals, amphibians, fish, and insects. There are many reasons why species are traded. The most common reasons wildlife is traded are that the traded plants and animals are used for food, medicine, pets, or to create luxury items, such as souvenirs, jewellery, clothing, or furniture. In some parts of the world, people depend on wildlife for these reasons. For species that occur in high numbers, the wild populations of animals are not usually affected too much when people use them in these ways.

Some species of wild animals are relatively easy to breed in captivity. The offspring (meaning the babies) of these captive bred animals can then be traded. This is often the case for some furbearing animals, which are kept and bred in captivity so that their fur and pelts can be made into clothing, such as coats or hats. Sometimes, however, species only occur in lower numbers, or cannot easily be bred in captivity. This is true for pangolins. When wildlife species only occur in low numbers and cannot easily be bred in captivity, then their use by people becomes a problem and can lead to the extinction of the species.

The trafficking of wildlife is of growing concern worldwide. Wildlife trafficking occurs when people sell or buy wildlife illegally. Some species are protected by law because they are endangered and their survival in the wild is threatened. It is important to know that most endangered species are threatened not only by trade and trafficking, but also by other factors, including habitat destruction, climate change, or the introduction of invasive species that do not normally live in the area. It is believed, however, that wildlife trafficking is contributing greatly to the loss of species worldwide.

7.4 An agreement to protect species from international trade: CITES

To control the trade in species that are threatened because of trade, a global agreement was established in 1975. The **C**onvention on **I**nternational **T**rade in **E**ndangered **S**pecies of Wild Fauna and Flora, or 'CITES' for short, was established to help protect wildlife species that are threatened by international trade, or species that may be threatened in the future if current levels of trade continue. It is important to know that CITES only regulates the legal *international* wildlife trade, but not the trade that occurs within a country. Not all wildlife species are listed in CITES, but only those that have been shown to need special protection from international trade. Examples of animals that are listed in CITES include tigers, rhinoceroses, and – you may have guessed it – pangolins.

7.5 The global pangolin trade

Now, you may wonder why pangolins are traded so much. Most of the demand for pangolins comes from Asia. China is the main destination for pangolins, but pangolin trade occurs on a global scale – even Europe, Australia, and America are involved. The pangolin meat and scales are the biggest reason these animals are traded. The scales are used in

traditional medicines, because some people believe that they are a remedy for a variety of illnesses. This is probably untrue, as pangolin scales are made of keratin – the same material our fingernails are made of. Pangolin meat is also consumed in restaurants, especially in Vietnam. Pangolin meat is among the most expensive meats that can be bought in Asia, and people buy this expensive food, for example, to impress their friends or business partners. Other parts of the pangolin body are also used, such as the organs (for medicine again), or the skin. The skin is used to make luxury leather items, such as cowboy boots, belts, or wallets. In the past, most of these luxury items were sold in the United States of America, but this is illegal today.

For a long time, it was legal to trade pangolins in many countries. The use and trade of pangolins date back centuries. It has only been recognised quite recently that pangolins were being traded and trafficked in such large numbers that they required special protection to protect them from extinction. In the year 2000, a ban was established that made it illegal to trade any of the Asian pangolin species internationally for commercial purposes (which means that they couldn't be sold anymore). This ban had two consequences. First, the trade switched from the Asian pangolin species to the African species. The trade in African pangolin species was regulated at the time, but they were still allowed to be traded internationally. To add to the pressure on the species, the African pangolins were now not only traded within Africa but were also increasingly shipped to Asia (Chapter 2). Second, the establishment of the trade ban for Asian pangolin species hasn't stopped the trade but has made it illegal (**Figure 7.2**). When trade of Asian pangolins became illegal, people still wanted to eat and use pangolins, so the pangolins were increasingly hunted and sold illegally (Challender, et al. 2015b). This had very negative effects on pangolin populations, which had been in decline already before the international trade ban in 2000. It is estimated that more than a million pangolins were trafficked, from 2000 to 2013, which ultimately gave pangolins the sad title of the most heavily trafficked wild mammal in the world.

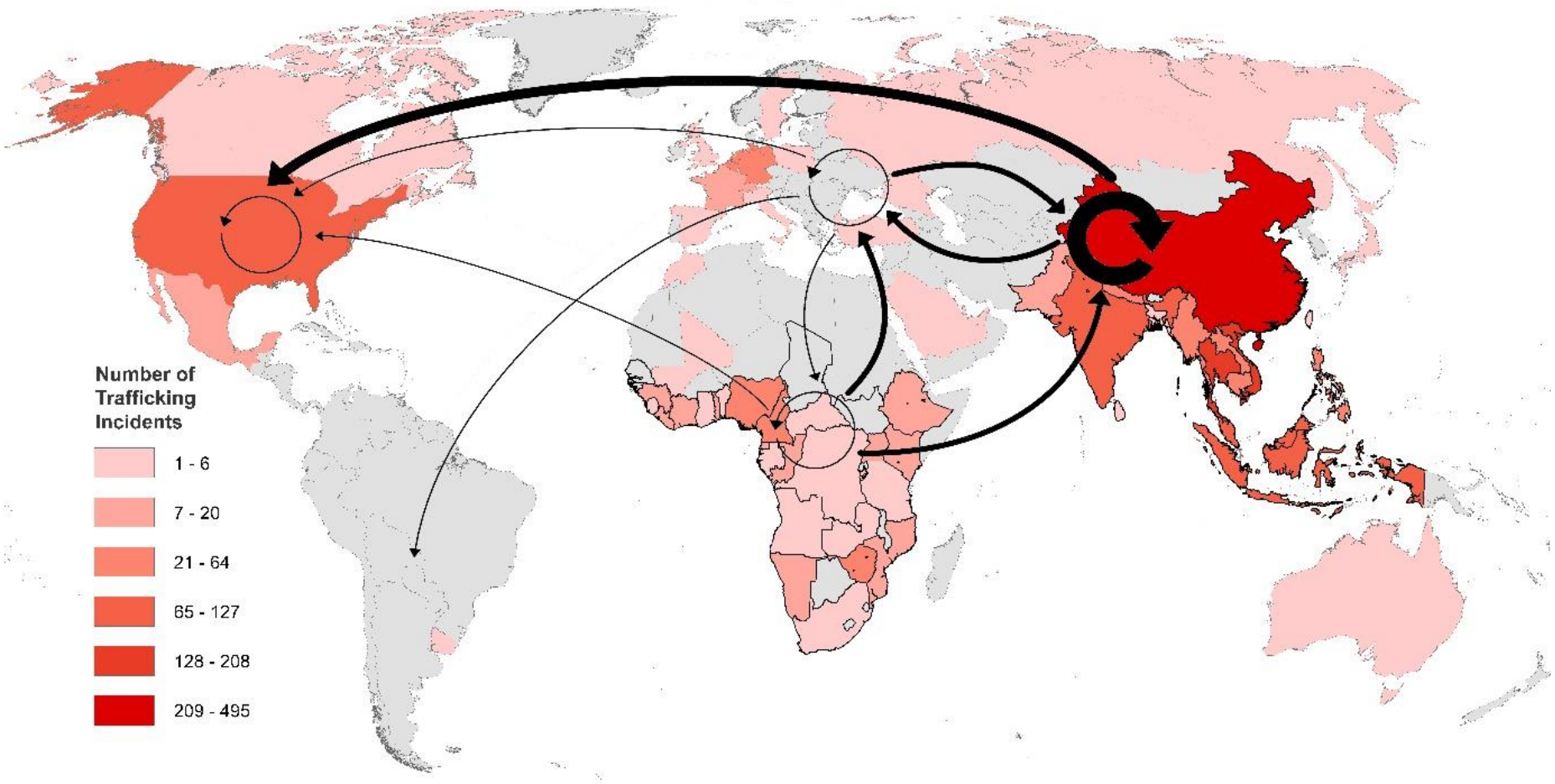

Figure 7.2: The countries involved in pangolin trafficking from 2010–2015, based on the number of trafficking incidents per country (indicated by the color-coded areas listed in the key), and pangolin trafficking routes between continents (amended from Chapter 3). The arrows represent trafficking routes (the thicker the lines, the more trafficking occurred). Circular arrows represent trafficking within a continent (for example, North America, Africa, Europe, Asia).

7.6 The future of pangolins is in our hands

Only 2 years ago, in January 2017, all eight pangolin species were fully protected by CITES. This finally provided pangolins with the protection they needed, at least in theory. As with the trade ban established in 2000 for the Asian species, things haven't quite work out as planned. The trafficking of pangolins continues to this day. Currently, scientists are trying to estimate the true number of pangolins in the wild. It is a bit of a mystery how traffickers, the people who are involved in the illegal trade, still find so many pangolins. In two recent seizures (when the police or customs intercept and confiscate shipments of illegal products), almost 26 tonnes of pangolin scales were found. That means approximately 50 000 pangolins had to die for those two shipments! Most of the big shipments nowadays appear to be coming from Africa, and some of them are intercepted *en route* between Africa and Asia. However, there is much more trafficking going on than we know about. The traffickers operate illegally, and we can therefore only estimate how many pangolins are trafficked based on what is seized by police and customs. Many traffickers are very smart and they often do not get caught when they are trafficking pangolins. That is a big problem that puts the survival of pangolins at risk.

At the moment, the future looks very gloomy for pangolins, but there is still hope! Now that you know about the trouble that pangolins are in, you can help by spreading the word about them. The more people know about pangolins, the better! If we can raise awareness and get people to change their attitudes towards eating and using wildlife, pangolins may still be able to recover. Given the long history of pangolin trade and trafficking, it is surprising that these amazing animals are still around. Yet, here they are, surprisingly resilient and they may just need a little more help from us in the coming years. There are many things that need to be improved to help pangolins. These include better law enforcement efforts in many countries, advertisement campaigns to reduce demand in countries where pangolins are consumed, better protection for pangolins in the countries they live in, and providing alternative jobs for the people who rely on hunting wildlife. All of these things will need to be addressed very soon, but it can be done. The future of pangolins, and many other species that are severely threatened by wildlife trafficking, is ultimately in our hands.

Chapter 8

Discussion

Chapter 8. Discussion

Illegal wildlife trade is a major threat to biodiversity worldwide, and the illegal trade in pangolins is currently driving these eight mammal species towards extinction. While I am writing these lines, more pangolins are poached from the wild. They are killed to fulfil a promise they cannot keep. Pangolins are magical creatures, but their scales are surely not – scientific evidence is lacking to support the claim that their scales contain any medicinal substance that would justify their continued killing (see also Jacobs, et al. (2019)). Every year, new and record-breaking seizures are reported from around the world (Harrington, et al. 2018). Unsustainable pangolin exploitation has occurred for decades (Harrisson and Loh 1965; Challender, et al. 2019a), but the increase in recent large-quantity shipments suggests that pangolins are in trouble and their populations are likely dwindling.

This thesis has contributed to provide a deeper understanding of pangolin trade and trafficking patterns. I have analysed the historical legal trade in pangolins (Chapter 2), as well as contemporary trafficking dynamics (Chapter 3), both on a global scale, as well as on a country level, for countries that emerged as contributors from my previous analyses. As such, I have characterised the trade of pangolins in the United States of America (Chapter 4), Germany (Chapter 5), and Cambodia (Chapter 6), as well as Lao PDR (Appendix I) and Indonesia (Appendix II). Within these individual chapters, I have highlighted and discussed country specific issues, with the aim to aid conservation and law enforcement efforts.

Pangolins could go extinct within our lifetime if concerted conservation and enforcement measures are not implemented immediately. The specific actions that are needed will likely differ from country to country and may depend on the context within a given country. The following discussion provides an overview of four broad areas, which need to be strengthened to ensure the survival of all pangolin species. These broad areas include: i) better protection for pangolins at the source; ii) improved law enforcement efforts at all points of the trade chain; iii) demand reduction for pangolins and their products in destination countries; and iv) increased research on pangolins and pangolin trafficking.

8.1 Protection at the source

Pangolins are protected to varying degrees in all range countries, yet they continue to be poached, trafficked and consumed, and require better protection at the source. In all range

countries, habitat conservation is key. Adequately protected areas are required to prevent pangolins from being poached in the first place. These areas also enable the successful safe release of confiscated, native pangolins, without the risk of them being collected from their release sites immediately again. All confiscated animals should be checked by a veterinarian before they are released to ensure they are fit to survive and to prevent transmission of diseases, e.g., through parasites (Clark, et al. 2009; Khatri-Chhetri, et al. 2016). The release sites of animals rescued from illegal wildlife trade should be chosen carefully. The species needs to be confirmed prior to release and the animals should ideally be released back to the areas they originated from, to conserve genetic diversity. For example, it has been shown that there are at least three lineages of Sunda pangolins *Manis javanica*, which are genetically and potentially ecologically distinct (Nash, et al. 2018), and six cryptic lineages of white-bellied pangolins *M. tricuspis* (Gaubert, et al. 2016). Releasing animals in areas where they do not originate from, even if they belong to the same (currently recognised) species, might decrease their genetic diversity and thereby their resilience and chances of survival in the future (Nash, et al. 2018). In some range countries the necessary protected areas to safeguard and release pangolins will need to be established, where they do not yet exist.

For these areas to be effective and safe, rangers need better support and resources to patrol the areas and protect the animals within them (Kideghesho 2016; WWF 2016). Community based conservation approaches and alternative livelihoods for the people living in and around these areas should be supported by governments, NGOs, and all relevant stakeholders. Local people still hunt pangolins (and other threatened wildlife) for subsistence and/or local trade, whereas others are contracted by (often foreign) organised criminal groups, or simply turn a blind eye to poachers, who illegally hunt pangolins. Biggs, et al. (2017) identified four pathways for potential community level actions: i) strengthen disincentives for illegal behaviour; ii) increase incentives for wildlife stewardship; iii) decrease costs of living with wildlife; and iv) support livelihoods that are not related to wildlife. Community based conservation approaches (e.g., for vicuñas or crocodilians (Roe 2008)) and opportunities for alternative livelihoods (e.g., through tourism (Twining-Ward, et al. 2018) have been shown to be effective in some countries, and could be implemented more widely (Challender, et al. 2015a). However, especially in light of the involvement of organised criminal groups and increasingly militarised poachers, these approaches should not be the only strategy, and law enforcement efforts need to be improved at all points of the trade chain (Bennett 2011; Phelps, et al. 2014).

8.2 Improved law enforcement efforts

Challender and MacMillan (2014) have argued that current law enforcement approaches are failing and are an "inadequate long-term strategy" to conserve high-value species. They argued instead to incentivise capacity within local communities, drive down prices by allowing more regulated trade, wildlife farming etc., and to reduce demand. However, concerns have been raised that, while it sounds reasonable in theory, these approaches may not work on their own in practice (Phelps, et al. 2014). In many regions, poaching and illegal trade are conducted openly and go largely unpunished (e.g., Shepherd (2010)). Corruption is still a widespread problem at any point of the trade chain (Broussard 2017). In the case of pangolins, range states are among the most corrupt countries worldwide, with c. 80% of the 52 pangolin range countries ranking below the average Corruption Perception Index (CPI) in 2018 (https://www.transparency.org/cpi2018). Wildlife farming and captive breeding are highly susceptible to wildlife laundering and their benefit for the conservation of species have been questioned many times (Brooks, et al. 2010; Lyons and Natusch 2011; Tensen 2016; Janssen and Chng 2018). In the case of pangolins, commercial farming is not an option. Pangolins are extremely difficult to keep and breed in captivity (Hua, et al. 2015; Challender, et al. 2019b). In the few instances where it has succeeded, the keeping, let alone breeding, is challenging and costly, thus making it unprofitable to breed pangolins on a commercial scale (Challender, et al. 2019b). It is also unclear how consumers would respond to the availability of captive bred pangolin products (Challender, et al. 2019b), and research suggests that consumers prefer wild over captive bred meat (Drury 2009; Challender, et al. 2019b). It is further unknown how captive breeding would influence the interaction between illegal and legal markets, and if captive breeding would incentivise poaching and laundering of illegally caught pangolins (Challender, et al. 2019b).

Multifaceted interventions are needed to tackle illegal wildlife trade (Challender, et al. 2015a). Communities should be empowered to help in pangolin conservation and demand reduction campaigns may be worthwhile, however, the role that law enforcement plays in countering the trafficking should not be diminished. Law enforcement approaches aren't failing, nor are they an inadequate long-term strategy, but they need to be much improved, using advanced methods to defy increasingly sophisticated smuggling methods (see also Bennett (2011)). Crucially, the existing laws in every country need to be implemented consistently. Improving Law enforcement efforts also means that investigations need to be initiated and followed through to prosecution of the people behind the trafficking (UNODC 2017) – especially the "kingpins"; not only the intermediaries and poachers. It is widely

recognised that seizures alone will not stop illegal wildlife trade and without consequences for violations of the existing laws and regulations, they will remain largely ineffective (Broussard 2017). McClenachan, et al. (2016), for example, showed that fines need to be much higher than the market value of the trafficked animal, in order to have a positive conservation impact. In terms of pangolin trafficking, Zimbabwe is a valuable example of the effectiveness of tougher penalties acting as a strong deterrent against pangolin poaching and trafficking in the region (Shepherd, et al. 2016). Stronger penalties in Zimbabwe may have resulted in a deterrent effect, because of the maximum jail sentence of nine years, which is often imposed following pangolin confiscations. People appeared to be aware of the severe penalties and consistently surrendered pangolins to officials in Zimbabwe (Shepherd, et al. 2016). It is still possible that pangolins are smuggled out of the country undetected, however, it appears that Zimbabwe is not yet involved in any of the massive seizures that are coming from Africa.

Most pangolin trafficking is an organised activity (following the definition of the United Nations Convention against Transnational Organised Crime (UNTOC) of an 'organised criminal group'). Currently 192 countries are signatories to UNTOC and the Protocols Thereto (https://treaties.un.org), and there is scope to increase its use in terms of wildlife trafficking (Broussard 2017). It involves substantial efforts to plan and coordinate gathering tonnes of pangolins scales and sending them from one continent to another. There are law enforcement techniques, such as controlled deliveries, and undercover operations, which are widely used for other types of organised crime, and these should be more commonly implemented. Generally, wildlife crime needs to be treated as the serious crime that it is, and many more resources need to be allocated to countering it. In many countries, the relevant authorities are doing a good job of managing wildlife and countering illegal trade with the resources available to them. However, resource constraints are a major limitation in countering wildlife crime and the relevant authorities need much greater internal support in the form of financial and human resources (Bennett 2011).

Further, remaining legislative loopholes need to be closed. Some countries do not protect non-native species, e.g., Thailand (Moore, et al. 2016; Broussard 2017; UNODC 2017) and if a non-native (pangolin) species is sold within the country, it can be difficult or impossible to prosecute the offenders. Legislation similar to the US Lacey Act provides a valuable example how this could be addressed (Altherr 2014; Broussard 2017), and countries need to allow for the protection of non-native species in their national laws (Nijman and

Shepherd 2015a). Furthermore, China still has an open, legal market for pangolin scales (China Biodiversity Conservation and Green Development Foundation 2016; Vallianos 2016; Challender and Waterman 2017). This potentially facilitates the laundering of illegally traded pangolin scales and raises concerns about the sustainability of this market. These scales are supposedly only obtained from existing stockpiles in the country, however, on average 26 tonnes of pangolin scales are released from these stockpiles onto the market every year (Challender and Waterman 2017). Even if these 26 tonnes all came from existing stockpiles, it is highly unlikely that China can sustain this amount in the future and they will ultimately have to come up with other solutions, e.g., by replacing pangolin scales in TCM with other products.

Another concern is the increasing cyber-enabled wildlife trade and the severe challenges that enforcement authorities face to adequately identify, investigate, and prosecute the advertising and sale of illegal wildlife products online (Wingard and Pascual 2018). Increasing volumes of wildlife are sold via e-commerce platforms worldwide, and pangolins and their parts have been found to be offered for sale online in a variety of countries (Hastie and McCrea-Steele 2014; Xiao, et al. 2017; Haysom 2019; Chapter 4). As geographically limited jurisdictions are a major boundary in prosecuting the online offenders, it would be important to have an international, harmonised legal framework for combatting online wildlife trade (Wingard and Pascual 2018). With 57 signatory countries, the Budapest Convention is currently the only international framework dealing explicitly with cybercrime, and could potentially be expanded to cover online wildlife trade specifically (Wingard and Pascual 2018). Importantly, and despite the many challenges in doing so, better and more systematic online monitoring of trade in pangolins and their parts (but also all other threatened wildlife), and prosecution of the people advertising and buying these animals and related products, are urgently required. The increasing importance of cyber-enabled wildlife trafficking has been recognised previously (Hastie and McCrea-Steele 2014; Krishnasamy and Stoner 2016; Xiao, et al. 2017; Wingard and Pascual 2018; Haysom 2019), and relevant stakeholders are increasingly working on addressing this trend. The “Coalition to End Wildlife Trafficking Online”, for example, is a joint initiative of TRAFFIC, WWF, and IFAW collaborating with the private sector (e.g., online platforms, such as Facebook and eBay), which is aimed to take down illegal online advertisements (https://www.endwildlifetraffickingonline.org/). The Coalition aims to reduce online wildlife trafficking by 80% by 2020.

8.3 Demand reduction

Another essential way to decrease wildlife trafficking is to reduce the demand for wildlife products in destination countries. Current approaches to reduce demand consist of behaviour change approaches, including: i) education and awareness raising; ii) outreach, relationship building and trust; iii) social influence; and iv) behavioural insights and nudges (Wallen and Daut 2018). In terms of pangolins, using celebrities from consumer countries, such as Jackie Chan (https://wildaid.org/jackie-chan-fights-for-pangolins/) and Angela Yeung ("Angelababy"; https://wildaid.org/chinese-superstar-angelababy-speaks-out-for-pangolins/), as pangolin ambassadors to influence people's behaviour have been attempted. However, there are relatively few studies to evaluate the effectiveness of demand reduction campaigns, and for pangolins specifically there are no published studies to date. Awareness about pangolins appears to have increased globally (Harrington, et al. 2018), but it is possible that this is predominantly the case among the conservation community, as well as westerners, who are not the main consumers of pangolins. On the other hand, it has been reported that demand for pangolin meat may be decreasing in China (Xu, et al. 2016), which is an encouraging sign, but TCM use containing pangolin products continues unabated (Xu, et al. 2016). Collaboration with other stakeholders needs to improve, for example, with traditional medicine practitioners to promote prescriptions of alternatives to pangolin body parts.

Awareness of pangolins and their conservation status among law enforcement officials also appears to have increased, especially after the CITES Appendix I listing, but species identification remains an issue. This, however, is key to be able to assess the threat to the different pangolin species. Better reporting practices by law enforcement officials are also needed. Seizure reports should ideally include detailed information about the species involved, the suspected trade route (source, transit and destination countries), transport mode, number of people involved, and whether or not an investigation has been initiated (and subsequently, whether or not the investigation led to the prosecution of suspects). A centralised database of global pangolin seizures, similar to the Elephant Trade Information System (ETIS), would greatly facilitate the analysis and information transfer between relevant stakeholders.

8.4 Research needs

Lastly, more research on pangolins is urgently needed. The population levels of all pangolin species, as well as many basic facts about their biology and ecology, remain unknown (Challender and Waterman 2017). Pangolins are shy and elusive and are inherently difficult to monitor. Efforts are underway to increase our understanding about these animals (e.g., Khwaja, et al. (2019)), but resources and technical difficulties are restricting factors in these studies. Pangolins also have an unusually low body temperature (e.g., Heath and Hammel (1986)), and it has been shown that mammals with a similarly low body temperature, e.g., armadillos, are a reservoir for and can contract leprosy (Truman 2005; Stefani, et al. 2019). Research is needed to find out if the same may be true for pangolins, which could have far-reaching consequences for the consumption of pangolins.

Future research should also aim to identify the drivers of pangolin consumption in different consumer countries to design successful demand reduction campaigns. Importantly, the success of such campaigns (as well as other pangolin conservation strategies) needs to be monitored and analysed. Demand reduction campaigns promoting alternative products should be carefully designed to ensure that the alternative does not result in the over-exploitation of a previously common species (Pearce 2003; Chapter 6), that may become threatened as a result of such a campaign. Other unwanted consequences could include species substitution by consumers switching to another already threatened species and leading to their additional endangerment (see Chapter 4).

The true levels of pangolin trafficking and detection also need to be estimated, using more sophisticated modelling techniques, and accounting for the many biases that are inherent to seizure data. Further, the monitoring of global pangolin trafficking needs to be continued and (new) dynamics and trends frequently evaluated; similar to the analysis in Chapter 3. The countries that emerge from such analyses as important contributors to pangolin trafficking can then be analysed in more detail to identify potential legislative loopholes, hotspots for pangolin trafficking within the country, or the role the country plays in international pangolin trafficking, so that enforcement and conservation initiatives can be designed and implemented. For example, the US was identified to be a consumer country (Chapter 4), whereas Germany served predominantly as a transit country (Chapter 5), and Indonesia as a source country (Appendix II). The different role a country plays (i.e., source, transit, and/or destination), as well as the identity and volumes of specific commodities that

are predominantly smuggled (e.g., scales or whole pangolins), will also inform specific law enforcement measures in a country.

Regular global assessments are essential to monitor the threat to the different species of pangolins. For these to be accurate, easy-to-use identification guides for the different pangolin species, and importantly their different body parts, especially their scales, need to be improved. The current guides (e.g., Cota-Larson (2017)) could be supplemented to support species identification, including, for example, the identification of body parts through machine-learning algorithms embedded in mobile phone applications (LeCun, et al. 2015; Di Minin, et al. 2018). There is also scope to use genetic markers (e.g., Wasser, et al. (2015)) or olfactory cues (e.g., Ueland, et al. (2016)) to identify pangolin species in trade.

Further, standardised conversion parameters for pangolin body parts need to be developed (see also Ullmann, et al. (2019)). In Chapter 2, and further refined in the Chapters thereafter, I developed pangolin conversion methods, which could be used by other researchers to follow the same method, thus making studies on pangolin trafficking levels more comparable. However, there is currently a lack of data of exact conversion parameters. For example, only for the Sunda and Chinese pangolin the specific conversion parameters for scale weight exist in the peer-reviewed scientific literature (Zhou, et al. 2012), but these data are lacking for all African species, as well as Indian and Philippine pangolins. However, scales are likely the most confiscated commodity of pangolins nowadays and the scale weight per animal differs substantially among species (see also Chapter 3), as does the number of scales per animal per species (Ullmann, et al. 2019). Unpublished data from researchers in West Africa indicates that the white-bellied pangolin, for example, has even less scale weight than previously assumed, thus almost doubling the presumed number of confiscated white-bellied pangolins to date.

8.5 Conclusion

Pangolin trafficking, and unsustainable wildlife trade and trafficking more broadly, is not just a conservation concern but a highly political issue. Apart from technical challenges, the solutions to wildlife trafficking are hindered by a lack of political will. The wildlife trafficking crisis could be better tackled if it were treated as the serious crime that it is. A crime that it is depleting our natural resources, with detrimental effects for people, and in

the long term, leading to the extinction of many species. Pangolins are considered to be the most heavily trafficked wild mammals and their populations are dwindling. Concerted efforts and determined actions are now required to save the remaining pangolins of this world.

Appendix 1

Observations of the Illegal Pangolin Trade in Lao PDR

Appendix 1. Observations of the Illegal Pangolin Trade in Lao PDR

The following report is included in this thesis as part of my contributions to further scientific studies. I am not the primary author of this report, but have contributed as a co-author. The original report can be found online on the TRAFFIC website (www.traffic.org) with the following citation:

Gomez, L., Leupen, B.T.C., Heinrich, S. (2016). Observations of the illegal pangolin trade in Lao PDR. TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

A1.1 Summary

Lao People's Democratic Republic (Lao PDR) is known to play an important role in the international wildlife trade and is a range country for two pangolin species, the Sunda Pangolin *Manis javanica*, and Chinese Pangolin *M. pentadactyla*. Its wildlife laws currently fail to protect non-native pangolin species and do not meet the requirements for the effective implementation of CITES. In addition to having weak legislation, Lao PDR is strategically located next to China, Myanmar, Thailand and Vietnam and forms an important transit hub for these countries, which all have an active wildlife trade profile for aspects of supply, transit and end-use demand.

This report explores Lao PDR's role in the illegal pangolin trade and discusses the findings of two market surveys, conducted in several locations as well as the outcomes of an analysis of pangolin seizures that involved Lao PDR as either an origin, transit, seizure or destination country between 2010 and 2015.

Opportunistic market surveys were conducted between April 2016 and July 2016 within seven cities in the northern regions of Lao PDR. An estimated total of 2734 pangolin scales were found in 13 shops at these different locations. The largest quantity of scales was observed in Luang Prabang, with an estimated 1200 scales found in two shops. Prices for pangolin scales ranged from USD 1/ (small) piece to USD 1/gram, with large scales sometimes weighing as much as 20 grams. Lao PDR's pangolin trade appeared to be mainly focused on a Chinese clientele in the areas surveyed. Shop owners and employees were

predominantly of Chinese ethnicity and prices were often given in Chinese Yuan (CNY). In Luang Prabang and Vientiane, pangolin products were mostly found in popular tourist spots, alongside other illegal wildlife products, such as elephant ivory and rhino horn.

Forty-three reported pangolin seizures involving Lao PDR were recorded between 2010 and 2015, involving an estimated 5678 pangolins. Most of these seizures involved shipments being smuggled into the country from Thailand and out to China and/or Vietnam. In five incidents shipments were confirmed to originate from Africa, confirming the increasing occurrence of African-sourced pangolin trade, which complements and substitutes supply from the four declining Asian species.

The large discrepancy between observed local trade and the seizure records confirms Lao PDR's role as a transit country in the international pangolin trade. Improved control of Lao PDR's pangolin trade will be an essential step in reducing the global pangolin trade. In order to achieve this, TRAFFIC recommends the following:

CITES and national legislation

- Proposals to list all eight pangolin species in Appendix I of CITES should be supported at CoP17 (i.e., Proposals 8 and 12) as this places an overall higher degree of international protection, and will enhance efforts to safeguard pangolins and support regulatory control mechanisms by non-range countries.[7]
- National legislation requires urgent improvement to enable effective law enforcement, which is currently ineffectual due to weaknesses in the law that prevent arrests, prosecutions and convictions. Currently considered a Category 3 country by the CITES National Legislation Project, meaning that its "*legislation (...) is believed generally not to meet the requirements for the implementation of CITES*", Lao PDR needs to amend its national wildlife laws to incorporate CITES implementing legislation, including legislation protecting all species of pangolins not native to the country and providing for stricter deterrents / penalties for serious wildlife related offences, especially when perpetrated through organised groups, transnationally and repetitively.

[7] Note that all eight pangolin species have since the time of writing been up-listed to Appendix I at CITES CoP17

Law Enforcement

- Law enforcement capacity should be enhanced to improve proactive investigation into international wildlife crime in general and the pangolin trade in particular. Multi-agency collaboration, both at national and international levels, should be enhanced to tackle the international and organised criminal networks involved in smuggling pangolins across Lao PDR's borders. This should include members of Lao PDR Wildlife Enforcement Network (WEN), notably the environmental police, Customs, the Department of Forest Inspections (DOFI), prosecutors and judges, to investigate mid-to-high profile cases that involve organised and transboundary activities.
- Increased surveillance of trade in Special Economic Zones (SEZ) and in the other trade "hotspots" identified in this report is also needed.
- Increased prosecution rates including more severe penalties should be realised in order to deter potential wildlife criminals.
- Lao PDR should aim to improve its reporting to the CITES Secretariat as per the new annual illegal trade reporting requirements, i.e., CITES Notification 007 that was issued in February 2016. Seizure reports, including comprehensive accounts of actions and outcomes, specifics of seizure and prosecution details are imperative to the analysis of the country's wildlife trade levels and trends, and, eventually, a better understanding of the international illegal wildlife trade.
- Better co-operation and co-ordination between the Customs agencies of Lao PDR and Thailand is required in order to increase detection rates along the Lao-Thai border (which has proven to be a crucial transit point in the international pangolin trade).
- Better co-operation and co-ordination is also needed between Lao PDR and China and Vietnam, which should include extra vigilance concerning exports from Lao PDR to these two countries.
- In the case of Chinese citizens caught smuggling wildlife products from Lao PDR into China, or involved in illegal purchase, sale or transport of protected species in Lao PDR, moving seizures and apprehension of suspects to prosecution (in both Lao PDR and China) would help increase deterrents to illegal wildlife trade.

Future Research

- Continued research into Lao PDR's role in the international illegal wildlife trade in general, and the pangolin trade in particular, is needed in order to obtain a current and improved understanding of the trade levels and dynamics in this crucial transit hub. Such research should include seizure analyses and market monitoring, especially in SEZs.
- Beyond Lao PDR, additional research into the global pangolin trade will help guide law enforcement efforts, with the goal of improving the effectiveness of interventions. Such research should include: 1) continued research into the Asian pangolin trade, including seizure and trade route analyses, and drivers of demand; 2) increased research into the trade of African pangolin species to Asia, including seizure and trade route analyses, and drivers of demand.

A1.2 Introduction

Pangolins are heavily threatened by illegal wildlife trade. It is widely agreed that immediate action is needed in order to save pangolins from extinction, which has spurred increased efforts, including the drafting of a conservation action plan (Challender, et al. 2014a). With the depletion of pangolin populations in China, the country's pangolin market now relies heavily on supply flows from neighbouring countries (Challender, et al. 2016; Nijman, et al. 2016). A recent study into the pangolin trade in Myanmar's Mong La district found large quantities of pangolin products to be openly available, most of which was destined for the Chinese market (Nijman, et al. 2016). Similarly, supply is increasingly moving through Lao People's Democratic Republic (Lao PDR).

Lao PDR is a landlocked country, bordering China, Vietnam, Cambodia, Thailand and Myanmar. Its total land mass measures 236 800 km². The country was once a haven for thousands of species of flowering plants and hundreds of species of birds and mammals (Nooren and Claridge 2001). Unfortunately, wild populations of Laotian flora and fauna have declined due to continuing pressure from habitat conversion and unsustainable harvest and trade of wildlife (Phanthavong 2008). Its geographical location, weak environmental laws, poor enforcement and high corruption levels have made the country a persistent hub

of increasing global significance for illegal wildlife trade (Duckworth, et al. 1999; EIA 2015; TRAFFIC 2015). Previous research suggested that Lao PDR plays an important role as both a source and transit country for wildlife trafficking (Phanthavong 2008). In recent years, the country has been implicated in numerous criminal incidents involving rhino horn, elephant ivory, Tiger *Panthera tigris* parts, turtles and pangolins (TRAFFIC 2015).

Lao PDR's involvement in the international pangolin trade goes back at least several decades, with pangolins being among the most heavily traded animals in the 1980s and 1990s (Duckworth, et al. 1999). During this time, the majority of all wildlife confiscations in Lao PDR involved pangolins (Nooren and Claridge 2001). Both the Sunda Pangolin and the Chinese Pangolin are native to Lao PDR. These two species are protected under the country's Wildlife and Aquatic Act 2007, in which they are classified in the first Prohibition category. Animals listed in this category are considered "rare, near extinct, (of) high value and (…) of special importance in the development of social-economic, environmental, educational, scientific research". The Act prohibits the unlicensed extraction and/or possession of pangolins or their parts. Any violation of the Act that involves "damage to the species" of 200 000 Lao Kip (LAK) (approximately US Dollar (USD) 24) and over, will result in a fine worth double the damage (triple the damage in case of a repeated offence) and/or a prison sentence of three months to five years. No further explanation is given as to what is meant by the rather vague notion of "damage to the species", nor is it made clear how the monetary value of such damage is determined. Lao PDR has been Party to CITES since May 2004. All pangolin species are currently listed in Appendix II of CITES[8], prohibiting any uncertified international trade. In the year 2000 a zero annual CITES export quota was established for all four wild caught Asian pangolin species traded for primarily commercial purposes (CITES 2000b).

A1.3 Methods

A1.3.1 Seizure data

Pangolin seizure data for the period 2010 – 2015 were extracted from a variety of sources, including TRAFFIC publications, open source media, Customs, police, CITES reports, grey literature and several non-governmental organisations (NGOs). Only seizure records

[8] Note that since the time of writing all eight pangolin species were transferred to CITES Appendix I

that involved Lao PDR as a seizure, origin, transit or destination country were included in the analysis. A "seizure country" was defined as the country where the seizure took place. An "origin country" was defined as the first known point of a trade route. A "transit country" was defined as a country, which had functioned as both an importing and a re-exporting country in the trade route, and a "destination country" was defined as the last known point of a trade route. It should be noted that the reported seizures are likely only to represent a fraction of the illegal trade (see e.g., Nijman (2015)), and will therefore underrepresent its true extent.

The acquired seizure data were analysed for general trends relating to the commodity types being traded, and the countries involved during the research period. All analyses were conducted in the R software (version 3.3.1) environment for graphical computing and statistics (R Core Team, 2015). In order to visualise the geographical network of pangolin trade around Lao PDR through time, the previous country in the trade chain ("exporter") and the following country in the trade chain ("importer") were identified regardless of the countries' role (i.e., seizure, origin, transit, or destination country). The R package 'igraph' (Csardi and Nepusz 2006) was used to construct a network diagram representing the trade flow between these countries.

In order to quantify the number of pangolins implicated in the trade, those that were not reported as entire animals were converted into "whole pangolins". The average weight of each pangolin species was assumed following Gaubert (2011). In cases where the species of the seized individuals was unknown the average weight across pangolin species was used for the analysis. In these cases, the scale weight per pangolin was assumed, according to Zhou, et al. (2012), Heath (1992b), and Heath (1992a). For one incident where White-bellied Pangolin and Giant Ground Pangolin were reported, the known scale weights for Sunda Pangolin and Temminck's Ground Pangolin *M. temminckii* respectively were taken into account (Heath 1992a; Heath 1992b; Zhou, et al. 2012) as they are believed to be similar. In one case where the scale quantity was unknown, one individual was assumed to be required for the shipment. For one incident with 16 reported scales, it was assumed that a minimum of one and a maximum of 16 pangolins were required, and the average (rounded up to a whole pangolin) was used in subsequent analysis. For another incident where 40 "medicinals" were reported, at least one pangolin and a maximum of 40 pangolins were assumed to be involved, and again the average whole number of pangolins was used. The same was done for five reported skin pieces. In another incident, pangolins along with other

animals were reported as weighing 150 kg. It was assumed that half of the reported weight was made up by pangolins and again the average weight of the heaviest and the lightest pangolin species was used for subsequent analysis.

A generalised linear multivariate regression model was fitted to test for the relative change in the number of whole seized pangolins ($\log_{10}$ transformed), in relation to: 1) the number of incidents; and 2) time.

A1.3.2 Market surveys

Opportunistic market surveys were conducted between 18 and 28 April 2016 and between 19 and 21 July 2016. During this period, seven cities in the northern regions of Lao PDR were visited: Vientiane (the country's capital), Luang Prabang (one of the country's main tourist spots), Luang Namtha, Muang Sing, Boten (all near the border with China), the Golden Triangle Special Economic Zone (SEZ) (in Bokeo Province) and Houayxay (on the border with Thailand) (**Figure A1.1**). Only Vientiane was visited twice (18–21 and 26–28 April), but different parts of the city were covered during each visit. These cities were selected on the basis of previous research into Lao PDR's wildlife trade, which had identified them as important (Chinese) tourist destinations and/or (potential) wildlife trade hubs (Nijman and Shepherd 2012). It should be noted that because of this, the customer preferences and the demand for pangolin products in these cities is likely to differ from those in other Laotian cities.

Survey locations included public markets, street stalls, public malls, traditional medicine shops, hotel shops, tourist markets and tourist shops. Shops were visited opportunistically, meaning that no predetermined list of shops was used during the survey. Shops were selected based on the type of products that could be observed for sale. Only those shops that were found to have pangolin products for sale were recorded and included in this report. Price information was only acquired in some cases as some vendors were unwilling to share such information with the investigators. Prices were provided in Chinese Yuan (CNY), LAK or USD. In case of the former two, prices were converted at a conversion rate of 1 USD = 6.66 CNY and 1 USD = 7947.69 LAK, respectively (https://www.oanda.com/currency/converter/, accessed on 10 August 2016). Photographic evidence was obtained opportunistically.

Identifying different pangolin species by their scales can be a difficult task; there is considerable overlap in size between all but the largest scales of the different species (Nijman, et al. 2016). When scales are sealed in plastic bags and/or displayed out of reach, there is no reliable way of determining the species. Therefore, no distinction is made between the different pangolin species in the survey results. Although it is likely that most pangolin products in Lao PDR belong to any of the three "continental" Asian species (i.e., Sunda Pangolin, Chinese Pangolin and Indian Pangolin), the remaining five species may also be on sale. Especially in stores where pangolin products are found next to (presumably African) ivory, the possibility that the pangolins were also imported from Africa should be considered.

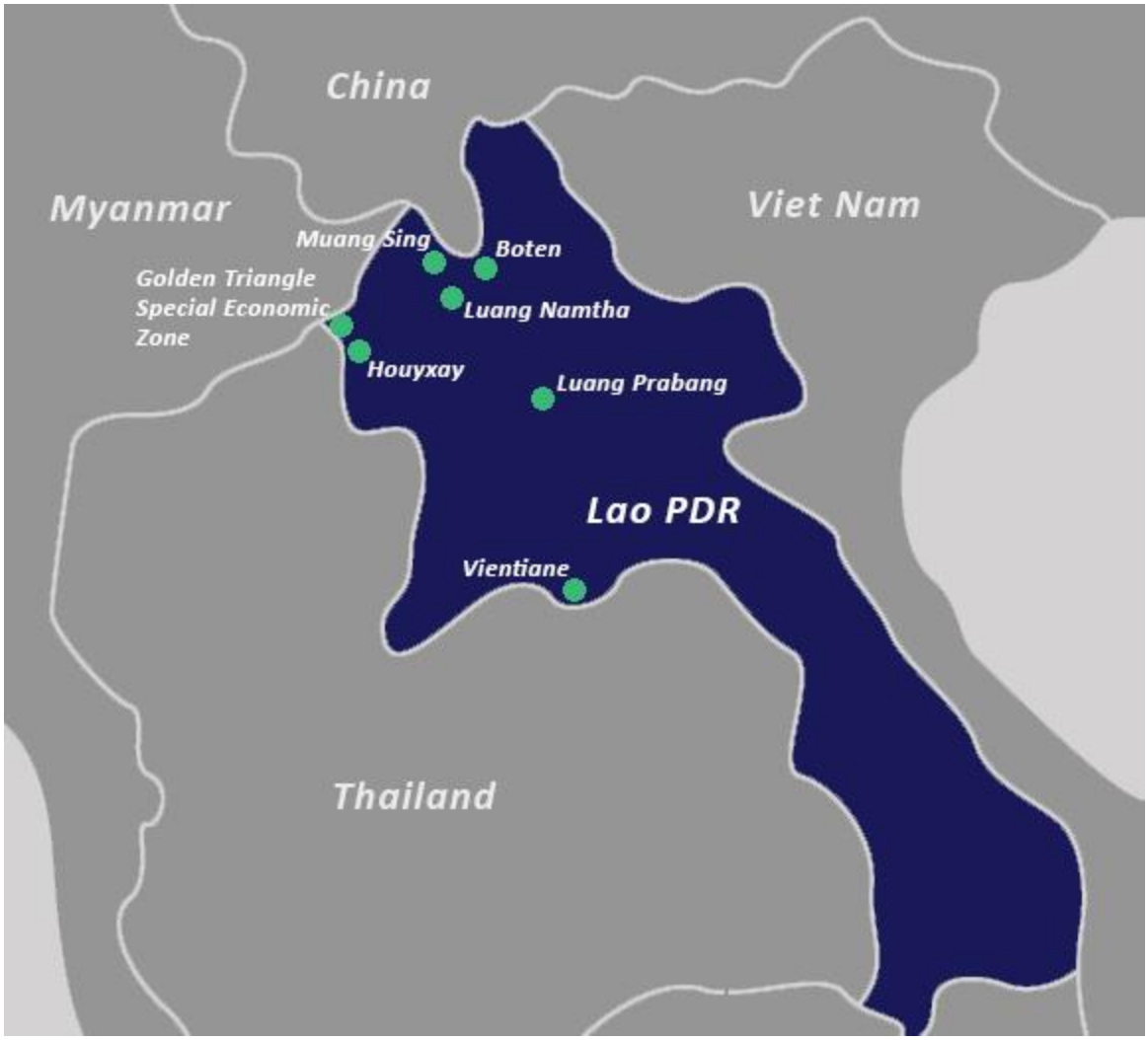

Figure A1.1: Market survey locations within the northern regions of Lao PDR between April and July 2016.

A1.4 Results

A1.4.1 Seizure data

Between 2010 and 2015, Lao PDR was involved in a total of 43 reported trafficking incidents, in which it was either a seizure (2.3 %), origin (32.6 %), transit (44.2 %) or destination country (23.3 %). The total number of all illegally traded commodities during the period of 2010 – 2015 accounted for an estimated c. 5678 whole pangolins. The volumes of estimated whole seized pangolins increased significantly through time during the research period (estimate [log] ± SE = 0.21 ± 0.05, t = 4.32, P = 0.02, R^2 = 0.77), regardless of the number of incidents (estimate [log] ± SE = 0.01 ± 0.04, t = 0.34, P = 0.75) (**Figure A1.2**).

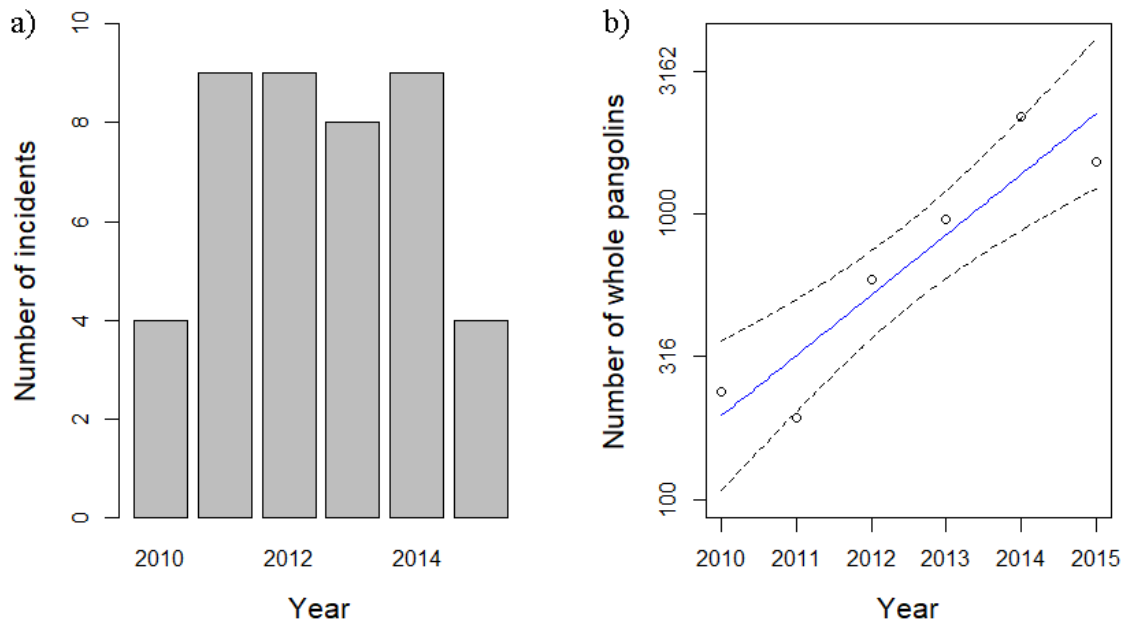

Figure A1.2: a) The number of incidents, and b) the number of pangolins (measured in the number of estimated whole pangolins) in the illegal trade involving Lao PDR through time. A linear model was used to create the fitted estimates (in blue) and 95% CI displayed in the dotted lines.

A total of 29 imports into Lao PDR and a total of 34 exports from Lao PDR were recorded (**Figure A1.3**). None of the countries that exported pangolins to Lao PDR were also found to import pangolins from Lao PDR at a different time during the research period, and vice versa. Pangolins and their parts were in most cases smuggled from Thailand into Lao PDR (75.9 % of imports), or from Malaysia (10.3 % of imports), Africa (6.9 % of imports), Singapore (3.5 % of imports) or France (3.5 % of imports). Most pangolin exports from

Lao PDR were destined for China (47.1 % of exports), Vietnam (38.2 % of exports), or the United States (14.7 % of exports).

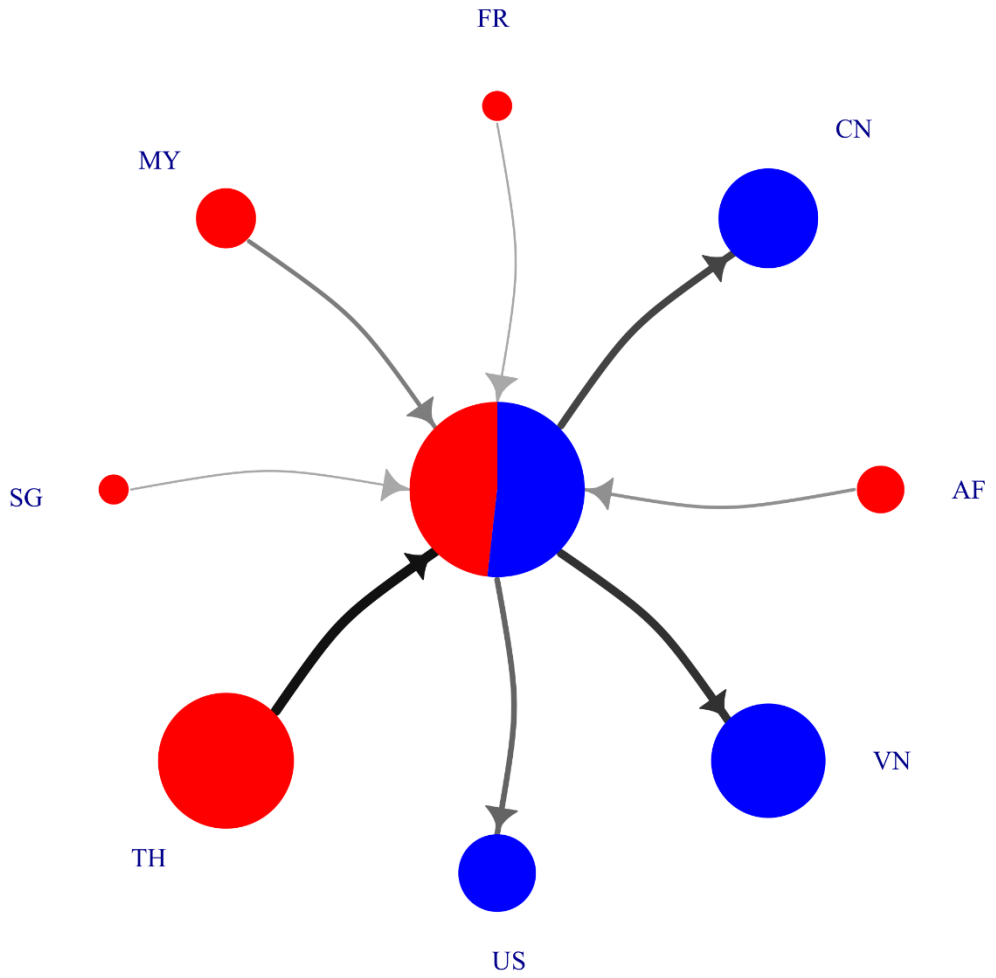

Figure A1.3: Network of pangolin trafficking incidents, not showing complete trade routes, but rather shipments directly going in and out of Lao PDR (central circle). Darker lines and larger circles indicate a greater number of links, with the maximum being 22 links between Thailand (TH) and Lao PDR in the period 2010 to 2015. The colour red within the circles represents exports; blue represents imports and the following abbreviations were used: FR = France, CN = China, AF = 'Africa', VN = Vietnam, US = United States of America, TH = Thailand, SG = Singapore, MY = Malaysia.

A total of 11 countries were involved in the pangolin trade with Lao PDR (**Table A1.1**). All seized shipments originating from African countries (n = 5) consisted of scales, while all other shipments in or out of Lao PDR (presumably from Asia) were either live animals (n = 18), "individuals" (whole animals, but uncertain whether dead or alive) (n = 11 incidents), scales (n = 2), a mix of live animals and scales (n = 3), dead animals (n = 1), claws, tails and skin pieces (n = 2), and "medicinals" (n = 1).

Eleven incidents reportedly involved the Sunda Pangolin, while the Chinese Pangolin, the White-bellied Pangolin, and the Giant Ground Pangolin were all reported in one incident each. All other incidents only reported "pangolins" (*Manis* spp.).

Table A1.1: The number of pangolin seizures involving Lao PDR per country during the period 2010–2015.

Country	Number of Incidents
Lao PDR	43
Thailand	22
Vietnam	14
China	18
Malaysia	12
United States of America	5
Nigeria	3
Indonesia	2
"Africa"	1
France	1
Kenya	1
Singapore	1

Shipments from Africa constituted 11.6 % of all incidents. The first incident occurred in 2013, when 263 kg scales from two African species (White-bellied Pangolin and Giant Ground Pangolin) were seized from a bus in Vietnam coming from Vientiane, Lao PDR. A shipment destined for Lao PDR, in 2014, involved 250 kg of pangolin scales originating in Nigeria and transiting via France, where it was seized. In another incident from 2014, 6 bags containing another 263 kg of pangolin scales were seized in Vietnam. It is uncertain whether the shipment actually originated from Africa, but the bags containing the scales had a Kenyan label stamped on them. In 2015, two more incidents occurred, with one

involving 324 kg of pangolin scales and 505 kg of elephant tusks, coming from Nigeria via Singapore (where it was seized) and supposedly on its way to Vientiane, Lao PDR. The second incident occurred on Koh Samui (Thailand) where 587 kg of pangolin scales and 789 kg of elephant ivory were seized from a flight coming from Singapore. The shipment originated in Nigeria and was bound for Lao PDR. Of the total c. 2028 kg recorded seized scales, 83.2% were supposedly of African origin (**Table A1.2**).

Thirty-three incidents (76.7 %) exclusively involved Asian countries (i.e., did not involve African or non-range countries), and accounted for an estimated c. 3015 whole pangolins. These consisted of 61 kg live pangolins + 1679 whole live pangolins (n = 21 incidents), c. 75 kg individuals + 534 whole individuals (n = 11 incidents) and c. 340 kg of pangolin scales (n = 4 incidents). The five largest of these incidents all involved a smuggling route from Thailand via Lao PDR to either China or Vietnam. In one incident in 2012 a suspect was transporting 138 live pangolins hidden in plastic baskets from Thailand's southern Chumphon Province to its northern province of Nong Khai (**Table A1.2** – No. 17). From there the shipment was supposed to be transported to Lao PDR where it was to be sold to Chinese customers. In 2013 nearly 200 live pangolins were discovered in Thailand's province of Udon Thani (**Table A1.2** – No. 28). These animals were believed to be destined for China or Vietnam, via Lao PDR. In 2014 there were three incidents. The first incident involved a seizure of 169 pangolins in Thailand's Province of Nakhon Ratchasima, again destined for China or Vietnam, via Lao PDR (**Table A1.2** – No. 32). The second incident involved a seizure of 150 kg of pangolin scales, as well as 100 live pangolins in the Malaysian state of Perak (**Table A1.2** – No. 37). The shipment was *en route* from Sumatra, through Malaysia and into Thailand. It was assumed that the animals were then to be transported via Lao PDR to China. The third incident involved 113 live Sunda Pangolins and 180 kg of Sunda Pangolin scales, which were being transported from Malaysia to Thailand, where they were seized in the southern Thai province of Chumphon (**Table A1.2** – No. 36).

Table A1.2: Recorded pangolin seizures involving Lao PDR during the period 2010–2015.

No	Date	Year	Seizure	Origin	Destination	Items Seized	Quantity	Source[9]
1	7-Feb	2010	USA	Lao PDR	USA	Tail/Claw/ Unknown	1/1/1	LEMIS
2	28-Jul	2010	Vietnam	Lao PDR	Vietnam	Unknown	150kg[10]	Media
3	18-Aug	2010	Thailand	Malaysia	China via Lao PDR	Live	105	TRAFFIC
4	15-Oct	2010	Thailand	-	Lao PDR	Whole[11]	106	Media
5	17-Jan	2011	Vietnam	Lao PDR	Vietnam	Whole	1	NGO
6	18-Jan	2011	Vietnam	Lao PDR	Vietnam	Whole	2	CITES
7	3-Feb	2011	USA	Lao PDR	USA	'Medicinals'	40	LEMIS
8	24-Mar	2011	Vietnam	Lao PDR	Vietnam	Dead	15	CITES
9	8-Jun	2011	USA	Lao PDR	USA	Dead	1	LEMIS
10	22-Nov	2011	Thailand	-	China via Lao PDR	Whole	50	
11	2-Dec	2011	Vietnam	Lao PDR	China	Whole	50kg	NGO
12	22-Dec	2011	Thailand	-	Lao PDR	Whole	18	
13	26-Dec	2011	Thailand	-	Lao PDR	Live	74	TRAFFIC
14	23-Feb	2012	USA	Lao PDR	USA	Scales	16	LEMIS
15	1-Mar	2012	Malaysia	Malaysia	Lao PDR	Live	50	TRAFFIC
16	23-Apr	2012	Vietnam	Malaysia	Vietnam via Lao PDR	Live	71	TRAFFIC

[9] Sources include, but are not limited to: TRAFFIC: reported in TRAFFIC's seizure database and/or the TRAFFIC Bulletins; CITES: reported by different CITES Management Authorities; NGO: compiled through reports from different NGOs; LEMIS: reported in the Law Enforcement Management Information System of the United States of America; Media: reported through open source media.

[10] Total weight of pangolins including other wildlife.
[11] Whole animal, uncertain whether dead or alive.

No	Date	Year	Seizure	Origin	Destination	Items Seized	Quantity	Source
17	May	2012	Thailand	-	Lao PDR	Live	138	Media
18	19-Jul	2012	Thailand	-	China OR Vietnam via Lao PDR	Live	12	Media
19	4-Sep	2012	Vietnam	Lao PDR		Live	118	TRAFFIC
20	14-Nov	2012	Thailand	-	Lao PDR	Live	52	TRAFFIC
21	25-Dec	2012	Thailand	-	Lao PDR	Live	42	Media
22	26-Dec	2012	Vietnam	Lao PDR	Vietnam	Live	100	TRAFFIC
23	16-Jan	2013	Vietnam	Africa[12]	Vietnam via Lao PDR	Scales	263kg	CITES
24	25-Mar	2013	Thailand	Malaysia/ Thailand	China via Lao PDR	Live	104	TRAFFIC
25	25-Apr	2013	Vietnam	Lao PDR	Vietnam	Whole	1	CITES
26	18-May	2013	Thailand	-	China via Lao PDR	Whole	110	TRAFFIC
27	17-Jun	2013	China	Lao PDR	China	Live	2	TRAFFIC
28	16-Sep	2013	Thailand	Thailand	China OR Vietnam via Lao PDR	Live	200	TRAFFIC
29	26-Oct	2013	USA	Lao PDR	USA	Skin	5 pieces	LEMIS
30	22-Nov	2013	Thailand	Malaysia	China via Lao PDR	Live	122	TRAFFIC
30	22-Nov	2013	Thailand	Malaysia	China via Lao PDR	Live	122	TRAFFIC

[12] Country not further specified in the report

No	Date	Year	Seizure	Origin	Destination	Items Seized	Quantity	Source
31	23-Jan	2014	Vietnam	Kenya	Vietnam via Lao PDR	Scales	263kg	NGO
32	28-Mar	2014	Thailand	-	China via Lao PDR	Whole	169	NGO
33	16-May	2014	Thailand	-	China via Lao PDR	Live	130	NGO
34	2-Jul	2014	France	Nigeria	Lao PDR	Scales	250kg	TRAFFIC
35	6-Jul	2014	Thailand	Malaysia	China via Lao PDR	Live	34	CITES
36	9-Sep	2014	Thailand	Malaysia	China via Lao PDR	Live/Scales	113/180kg	CITES
37	13-Sep	2014	Malaysia	Indonesia	China via Thailand and Lao PDR	Live/Scales	100/150kg	NGO
38	22-Oct	2014	Thailand	Malaysia	China via Lao PDR	Live/Scales	75/10kg	CITES
39	27-Nov	2014	Vietnam	Lao PDR	Vietnam	Live	7	NGO
40	8-Mar	2015	Thailand	Malaysia	China via Lao PDR	Live	61kg	CITES
41	30-Oct	2015	Lao PDR	Indonesia	Lao PDR	Live	81	TRAFFIC
42	10-Dec	2015	Thailand	Nigeria	Lao PDR	Scales	587kg	TRAFFIC
43	12-Dec	2015	Singapore	Nigeria	Lao PDR	Scales	324kg	Media

A1.4.2 Market surveys

Scales were found to be the only pangolin commodity type openly available in the surveyed markets and shops. Observed amounts ranged from 20 to 1200 scales per survey site (**Table A1.3**).

Table A1.3: The open availability of pangolin scales observed during the market surveys in April and July 2016.

Date	Survey locations	No. of Outlets observed with pangolins scales	Quantity of scales (estimated)	Notes
19, 20 & 27 April 2016	Vientiane (capital)	4	520	Price quoted: Range USD 2/piece to USD 1/gram (some pieces weighing as much as 20 grams). Use described by vendor: traditional medicine to treat 'itchiness'; pendants
21 April 2016	Muang Sing	2	750	Supposedly from China Price quoted: 80 000 KIP/bag (~USD 10/bag); Each bag estimates to contain approximately between 60 – 80 scales Use described by vendor: traditional medicine to treat stomach aches
22 April 2016	Boten	2	190	Sold openly in a container (~150 scales); and packed in several small bags (~10 scales/bag) Price quoted: CNY 15/piece (~USD 2/piece)
22 & 23 April 2016	Luang Namtha (province capital)	2	52	Sold individually as pieces; and packed in one bag ~ 50 scales
24 April 2016	Luang Prabang (province capital)	2	1202	Two large pieces observed in one shop to be made into pendants One shop with 10 bags containing approximately 150 scales each

Date	Survey locations	No. of Outlets observed with pangolins scales	Quantity of scales (estimated)	Notes
20 July 2016	Golden Triangle SEZ (Bokeo Province)	1	20	One small bag observed openly for sale
21 July 2016	Houayxay	none	-	
Total		13	2734	

The observed scales were either packed into bags which varied in size (i.e., ranging from as little as 10 scales per bag to as much as 150 scales per bag), or were displayed openly as individual pieces or in containers (**Figure A1.4**).

Pangolin scales observed at a shop in Luang Namtha

Pangolin scales observed at Chinese Market inVientiane

Pangolin scales observed at a jewellery shop in Luang Prabang

Pangolin scales observed at the Muang Sing market

Pangolin scales observed at the Muang Sing market

Pangolin scales observed in Boten

Figure A1.4: Open availability of pangolin scales in various locations in Lao PDR, showing varied display or packaging methods, observed during the market surveys in April and July 2016.

They were mostly being sold for use as traditional medicine, although two shops (one in Vientiane and one in Luang Namtha) were found selling individual scales as jewellery (to be made into pendants). The largest quantity of scales was observed in Luang Prabang with

an estimated 1200 scales from two jewellery shops, while the lowest quantity (20 scales) was found in the Golden Triangle SEZ. The highest recorded price for pangolin scales was USD 1/gram, as stated by one vendor at the Chinese Market in Vientiane who also claimed that larger scales can sometimes weigh as much as 20 grams.

In Luang Prabang and Vientiane, pangolin scales were found in popular tourist spots alongside other wildlife contraband such as elephant ivory, shredded rhino horn, Helmeted Hornbill *Rhinoplax vigil* casques, bear claws and tiger teeth. In Muang Sing, scales were observed at the main market in the traditional medicine section. Wildlife products on sale here for purported medicinal purposes included elephant skin, tiger bone, serow horn and porcupine stomach. In comparison, much smaller quantities of scales were recorded in Boten, Luang Namtha and in the Golden Triangle SEZ, Bokeo Province.

It should be noted, however, that many of the shops in the Golden Triangle SEZ were either closed or looked abandoned at the time of survey in July 2016. According to one restaurant owner, this was not a peak tourist time (i.e., from China), and tourists were generally expected towards the end of the year. In Boten, pangolin was observed on the menu in one restaurant (although restaurants were not targeted by this survey). Of the seven locations visited, Houayxay was the only place where no pangolins were observed for open sale.

A1.5 Discussion

A1.5.1 Lao PDR as a transit country

The number of recorded seizures associated with Lao PDR between 2010 and 2015 confirms the country's role as an important hub in the international pangolin trade. Within this trade dynamic, Lao PDR appears to function predominantly as a transit country. This is supported by the stark contrast between the relatively low numbers of pangolin scales observed in open trade during the market surveys and the large numbers of specimens (live/dead animals, body parts, products and derivatives) reported in the seizure records. In most of the seizure data, Lao PDR was marked as a transit country (44.2 %). As seizure records are notoriously inconsistent, especially when it comes to the completeness of trade routes, it is possible that even in records where it was indicated as an origin or a destination country, Lao PDR was likely a transit location in the overall trade chain. In these cases, only one exporter and one importer were identified in the whole incident, and while it is

possible that the complete transaction merely involved the two identified countries, the possibility that the two countries were in fact part of a larger trade route should be considered. In the seizure data, an "origin country" represents the first known point in the trade route. Whether this country was the actual country of origin of the seized specimens, or a country of transit or re-export, remains uncertain. Similarly, a "destination country" represents the last known (intended) point in the trade route, without there being any certainty as to whether this country really represents the final destination. Therefore, pangolins "originating" from Lao PDR, may in reality have been brought into the country from abroad, and shipments "destined" for Lao PDR may in reality have been on their way to Lao PDR in order to be re-exported (most likely to end-use markets such as Vietnam or China).

Even Lao PDR's local pangolin trade appears to mainly cater to foreign customers in the areas surveyed. In Vientiane and Luang Prabang, pangolin scales where predominantly found in the tourist parts of town and prices were often given in Chinese Yuan. In Vientiane's Chinese market, the shops that offered pangolin scales for sale were run by ethnic Chinese and employed Chinese speaking staff (Or, pers. obs.). Relatively large quantities of scales were also found in Muang Sing; a tourist city close to the Chinese border. Chinese and Vietnamese demand appears to be an important stimulus for the international pangolin trade. Of Lao PDR's recorded pangolin seizures, no fewer than 47.1% were destined for China. In China, pangolins are either consumed as a luxury meat with purported tonic benefits or used for medicinal purposes. According to Challender, et al. (2016), pangolin scales have been imported into China from neighbouring range countries including Lao PDR, Vietnam and Myanmar since the early 1990s as Chinese pangolin populations declined. This is further corroborated by the Environmental Investigation Agency's (EIA) recent study of the illegal wildlife trade in the Golden Triangle SEZ, which, according to EIA, exists largely to cater for the growing number of Chinese tourists (EIA 2015). Nijman, et al. (2016) had similar findings in Myanmar in which the "Chinese market" was identified as the main driver of the pangolin trade there.

Restaurants in Lao PDR are known to serve wildlife dishes including tiger *Panthera tigris*, elephant, Sambar *Rusa unicolor*, muntjac, Eurasian Wild Pig *Sus scrofa* and pangolin (Nooren and Claridge 2001). During this study, no restaurants were surveyed for pangolin meat. However, it was casually observed to be available in at least one restaurant in Boten. EIA (2015) also reported on pangolin meat being available in restaurants within the Golden

Triangle SEZ. Again, places like Boten and the Golden Triangle SEZ cater to Chinese tourists who consider pangolin a luxury meat.

Demand from Vietnam appears to be another main driver in the international pangolin trade, with 38.2 % of recorded seizures in Lao PDR indicating Vietnam as the next destination. While it remains unclear how many of these shipments would have been subsequently re-exported to China, Vietnam has been known to be a large consumer of pangolin products for both meat, as well as medicine (Challender, et al. 2015b) and is likely to function as a second important end destination. Vietnam is a persistent consumer market in Asia for wildlife species and a key factor in the decline of species in Vietnam and surrounding regions (Shairp, et al. 2016). After two decades of rapid economic growth, newly wealthy consumers are purchasing wildlife to advertise their status—including luxury wild meats, the price of which is often associated with the rarity of a species and its wild origins (Drury 2011; Shairp, et al. 2016). Pangolins are often the most expensive meat on the menu in Vietnamese restaurants (Gannon 2014; Shairp, et al. 2016).

A1.5.2 Key routes and commodities traded

In most cases, incomplete information made it impossible to determine exact trade routes. However, certain trends were clearly detectable. A large number of the shipments that went through Lao PDR were smuggled in from Thailand. Of the 43 seizure records, there were 22 incidents that involved Thailand. The province of Nong Khai, in north-eastern Thailand was particularly implicated—not surprising given it is separated from Lao PDR only by the Mekong River, including a road bridge leading to Vientiane, making it a key smuggling route in the region for contraband including illegal wildlife (Chouvy 2013). Like Lao PDR, Thailand appears to be an important transit country in the international pangolin trade. On several occasions, pangolin shipments were brought into Thailand from Indonesia and/or Malaysia with the intention to smuggle them into Lao PDR and subsequently into Vietnam and/or China (**Figure A1.5**).

Another concerning trend is the increasing incidence of trade into Asia of African pangolin species. As Asian pangolin populations continue to decline, and economic ties between Africa and Asia integrate further, pangolin products are increasingly being shipped in from Africa (Challender and Hywood 2012); a trend that has been on the rise since around 2009 (Challender 2011). However, this phenomenon appears to have escalated in the past couple

of years, with more frequent seizures of pangolin shipments originating from Africa and often involving large quantities. Between 2000 and 2012, the weight of scales seized in a single incident ranged from 1 kg to 200 kg (Challender and Hywood 2012). These numbers now commonly range from 250 kg to 2000 kg (Gomez, et al. 2016b). As recently as 2016, two seizures involving shipments from Cameroon and Nigeria took place in Hong Kong, amounting to 4000 kg and 7300 kg of scales respectively; the largest recorded seizures of scales from Africa so far (Anon. 2016c, b).

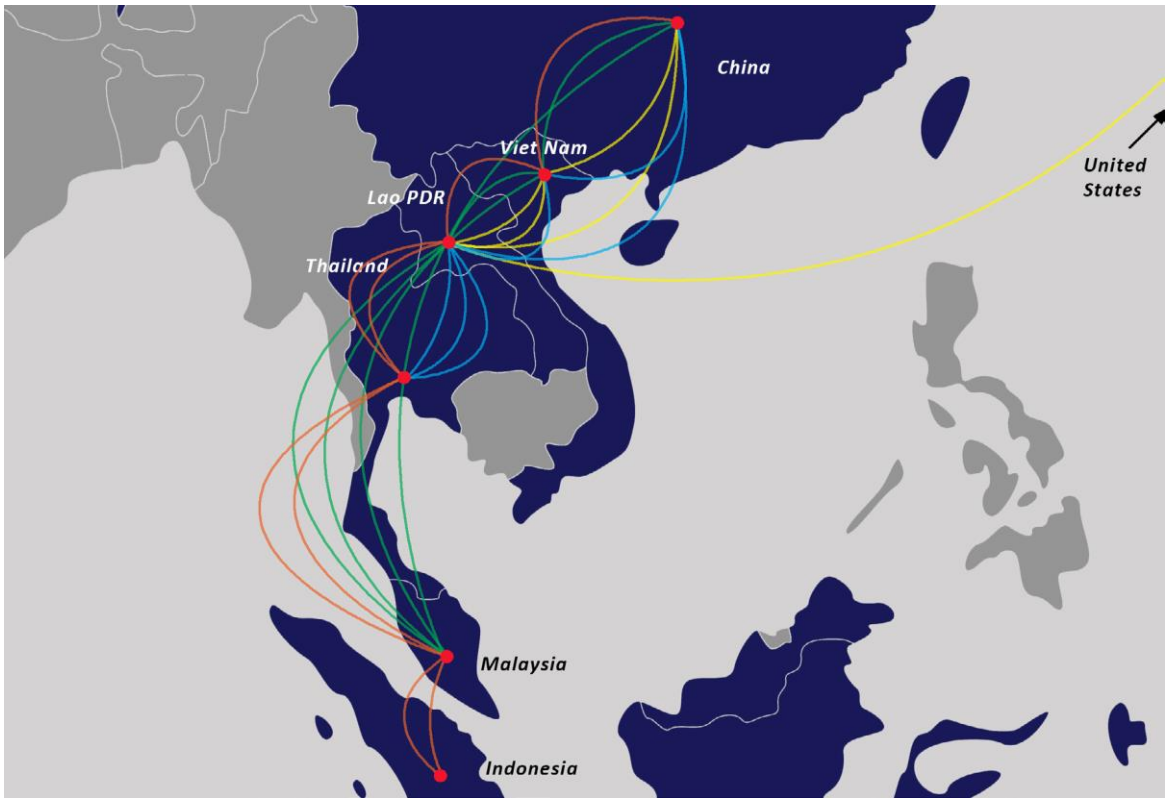

Figure A1.5: Pangolin trade routes in Asia, with each line representing an observed trade route, disregarding the frequency with which it was observed. Colours vary according to the reported country of origin (Orange = Indonesia; Green = Malaysia; Blue = Thailand; Yellow = Lao PDR).

A recent study has found the pangolin trade between Nigeria and China to be blooming, with several large seizures of pangolin scales and meat taking place between 2011 and 2015 (Gomez, et al. 2016b). This study also found that whenever shipments were not directly shipped from Nigeria to China, they were (to be) smuggled in through Lao PDR. These shipments were reportedly sent to Lao PDR either via Singapore, Thailand or France (**Figure A1.6**).

Shipments originating from Africa seized in Lao PDR only contained scales, and in previous research only scales and meat (Gomez, et al. 2016b). In fact, 83.2 % of all reports

of seized pangolin scales analysed in this study were of African origin. Trade in Asian pangolins on the other hand, consisted predominantly of live animals and "individuals" (whole animals for which it was unclear whether they were alive or dead). There may be several reasons for this. From a practical point of view, scales are more easily concealed than live animals and require less attention during extended travel, making them more suitable for the intercontinental trade. Additionally, scales may be a by-product of pangolin meat consumption in Africa (Pietersen, et al. 2014b), and thus scales may subsequently be transported to Asia and sold for higher profits than they would in Africa.

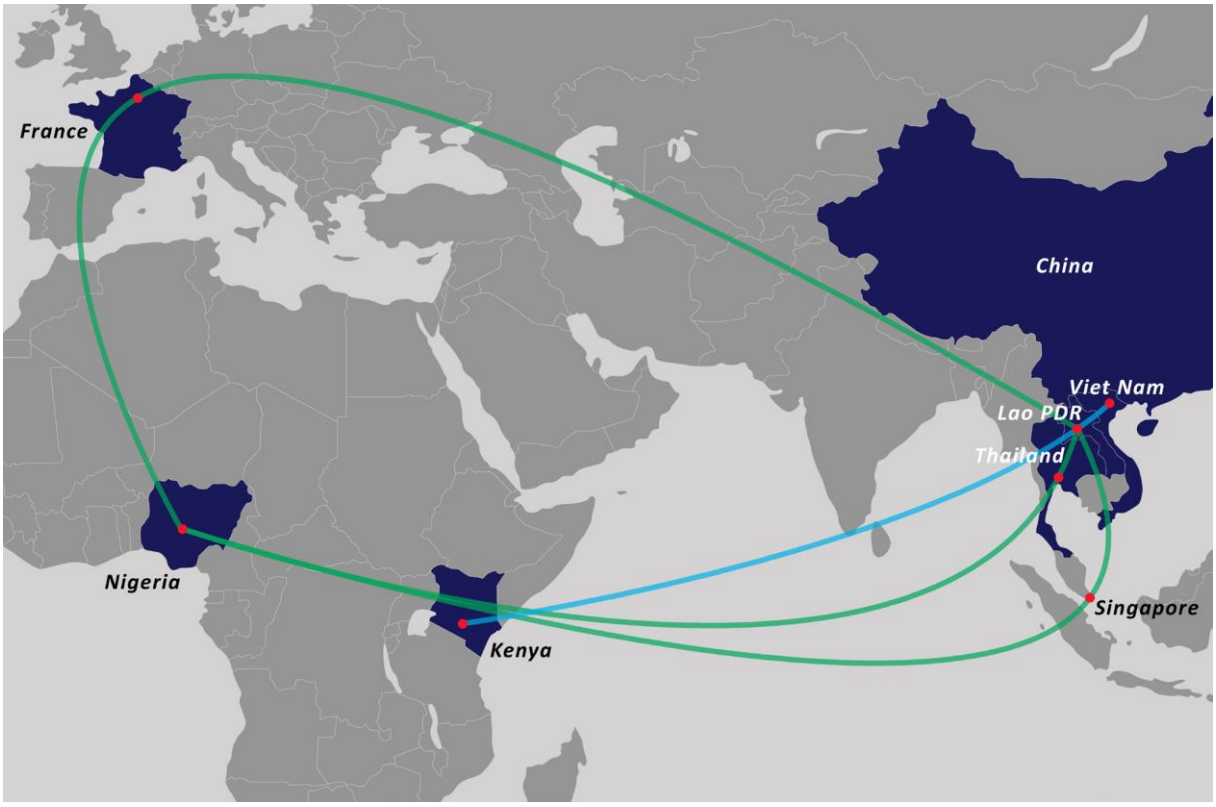

Figure A1.6: Pangolin trade routes between Africa and Asia, with each line representing a single record. One record was omitted from this map due to a lack of specificity regarding the country of origin ("Africa").

A1.5.3 Law enforcement

Lao PDR's porous borders and high levels of alleged corruption, have raised the country's profile as a major conduit for the trafficking of high value and highly threatened wildlife (EIA 2015; TRAFFIC 2015). Of the 43 reported pangolin seizures, only one took place in Lao PDR. This is a stark contrast to the large number of seizures that were conducted in both Thailand and Vietnam during the same period (involving shipments going to, or

coming from, Lao PDR). The lack of in-country seizure records from Lao PDR may be explained by a lack of reporting (of incidents to (inter-) national authorities) and by lack of enforcement effectiveness. The latter is confirmed by the fact that during the market surveys, pangolins scales were openly traded (alongside other illicit wildlife products, including rhino horn shavings, Helmeted Hornbill casques, tiger teeth, bear teeth, bile and claws, and large amounts of elephant ivory), without apparent fear of repercussion.

Similar findings were made by the CITES Secretariat during a recent mission to Lao PDR which was aimed at assessing the country's implementation of the provisions of the Convention to regulate and control the trade and use of CITES-listed species (CITES 2016b). Conclusions drawn from this visit included Lao PDR being targeted by organised crime groups to smuggle wildlife through its borders into other countries in Asia due to a combined lack of enforcement capacity and significant weaknesses and loopholes in national laws where wildlife trade is concerned (CITES 2016b).

A1.6 Conclusion

Lao PDR is situated in Southeast Asia, where it shares its porous borders with Cambodia, China, Myanmar, Thailand and Vietnam; all of which are countries persistently implicated in the illegal wildlife trade. However, while wildlife trade legislation, monitoring and law enforcement efforts have improved in neighbouring countries, it seems that Lao PDR is being exploited as a low-risk transport hub for illegal wildlife goods, including pangolins. Lao PDR's weak laws and ineffective enforcement allow pangolins from both Asian and African countries to be shipped through the country and into consumer countries such as China and Vietnam. Furthermore, it would appear that China has significant influence over trade activities within Lao PDR that is encouraging Chinese tourist/investors including the establishment of hotspots that perpetuate the illicit trade in wildlife, as is evident in Boten and the Golden Triangle SEZ.

Although protective national laws are in place for Lao PDR's native pangolin species, and the CITES zero quota for international trade should offer protection for all Asian species, it does not seem that these measures are being properly enforced. While all four African species are listed in Appendix II of CITES[13], there are no established export quotas in place

[13] Note that since the time of writing all pangolin species have been transferred to Appendix I

to regulate their international trade further, and poaching and trafficking continues to deplete wild populations. Globally, the illegal trade in African pangolins appears to be rapidly increasing. Whereas the frequency of pangolin seizures in Lao PDR has not increased over the past five years, the quantities that were seized in each incident have.

Improved law enforcement efforts in Lao PDR remain crucial to the effectiveness of CITES regulations, and therefore to the conservation of pangolins globally. Such improvement should include shutting down establishments like markets, shops and restaurants that sell illegal wildlife products; strengthening monitoring of illegal wildlife trade across Lao PDR's borders; and strengthening its national wildlife laws by incorporating stricter penalties.

Appendix 2

Scaly Nexus: Mapping Indonesian Pangolin Seizures (2010 – 2015)

Appendix 2. Scaly Nexus: Mapping Indonesian Pangolin Seizures (2010 – 2015)

The following report is included in this thesis as part of my contributions to further scientific studies. I am not the primary author of this report, but have contributed as a co-author. The original report can be found online on the TRAFFIC website (www.traffic.org) with the following citation:

Gomez, L., Leupen, B.T.C., Krishnasamy, K., and Heinrich, S. (2017). Scaly Nexus: Mapping Indonesian pangolin seizures (2010–2015) TRAFFIC, Southeast Asia Regional Office, Petaling Jaya, Selangor, Malaysia.

A2.1 Summary

Indonesia is home to one species of pangolin, the Sunda Pangolin *Manis javanica*, which can be found from Sumatra, Java and adjacent islands to Kalimantan. Currently listed as Critically Endangered on The IUCN Red List of Threatened Species™, this species is suspected to be in severe decline due to illegal trade. While little is known about the population of pangolins in Indonesia, it is likely that current trade and hunting levels are unsustainable. There is evidence of professional and industrial-scale hunting for the purposes of commercial international trade. This report provides an insight into the illegal trade of pangolins involving Indonesia by analysing seizure data between 2010 and 2015. The report discusses the country's role in the illicit trade of pangolins in the region and the impact it is likely to have on the conservation of the Sunda Pangolin.

Most of the seizures recorded took place in Indonesia (83%) and point to Sumatra being a hotspot in the so-called Sundaland connection – linking Indonesia, Malaysia and Singapore – with Medan in North Sumatra appearing to be a major collection site before export. The majority of the Indonesian seizures occurred in Sumatra (n = 55), followed by Java (n = 26) and Kalimantan (n = 11). In terms of estimated whole pangolins, however, Java and Sumatra appear equally involved in pangolin trafficking. The remaining records involved seizures in six other countries/territories, namely China (mainland China and Hong Kong), Lao PDR, Malaysia, the Philippines, the Unites States of America (US), and Vietnam. China, Malaysia and Vietnam were the top three locations most closely linked to Indonesia based on the number or frequency of seizure incidents. China and Vietnam were implicated

as destinations (involving an estimated 10 491 pangolins and 9852 pangolins respectively) while Malaysia emerged as the most prominent transit country in the movement of pangolins from Indonesia to end use destinations in East Asia. These seizure numbers may also be a reflection of (more) effective enforcement efforts in these locations. Only one record involving a shipment originating from outside of Indonesia was found in the country, which concerned a seizure of pangolin scales from Cameroon.

Very little is known about the Sunda Pangolin's population size in Indonesia. However, considering the large number of seizures and animals involved, and the fact that the average generation span of the Sunda Pangolin is seven years, pangolin populations in Indonesia are likely to be in decline as a result of illegal trade. Such decline is expected to continue unless immediate measures to counter this problem are put into place. With Chinese Pangolin *M. pentadactyla* populations all but depleted due to the illegal trade, other Asian pangolin populations, including the Sunda Pangolin in Indonesia may likely face a similar fate. The illegal international Asian pangolin trade is therefore of high and immediate concern. The IUCN Species Survival Commission (SSC) Pangolin Specialist Group, IUCN Asian Species Action Partnership (ASAP), and Wildlife Reserves Singapore (WRS), recently organised the Sunda Pangolin Regional Conservation Planning Workshop, between 28 –30 June 2017, to develop a more detailed, regional conservation strategy for the Sunda Pangolin that would guide investment in pangolin conservation and catalyse support for implementation of such strategies. Based on some of the key outcomes from the workshop discussions, it was revealed that saving pangolins from extinction will require engaging local communities in their conservation and addressing the demand for pangolin products, as well as strengthening domestic legislation and policy to combat the illegal wildlife trade. In light of this, TRAFFIC recommends the following:

Law enforcement

- Law enforcement capacity should be enhanced to improve proactive investigation into the international pangolin trade. Multi-agency collaboration, both at a local (provincial), national and international level, should be established and/or intensified to tackle the international and organised criminal networks involved in smuggling pangolins across Indonesia's borders. Knowledge and capacity of law enforcers should be enhanced, especially at important international wildlife trade hubs at land, sea and airports. Efforts to monitor and investigate this problem should be enhanced and increased at the hotspots identified by this study, particularly

within Sumatra and Kalimantan as source hotspots as well as the trade hotspots in Java, Kalimantan and Sumatra.

- Better cooperation and coordination between enforcement agencies, including Customs and police, is needed on the national and international levels. On an international level, such co-operation, especially between Indonesia and Malaysia, will be crucial in order to increase detection rates, disrupt the movement of pangolin shipments across international boundaries and dismantle organised wildlife crime syndicates. These are perhaps most needed to tackle trafficking between Sumatra and Peninsular Malaysia, as well as within Borneo, particularly between Kalimantan and Sarawak.
- Prosecutors and the judiciary should be made aware of the legal and environmental consequences of the illicit pangolin trade as part of a wider effort in prioritizing attention to wildlife crime. This is expected to contribute to increased and more successful prosecution rates and penalties for pangolin and other wildlife trafficking.
- To support global pangolin conservation efforts, Indonesia's revision of its wildlife legislation should list all eight pangolin species at the highest protection level. This will enable the country to effectively comply with CITES and ban all international pangolin trade.

Monitoring

- Conservation organisations and research institutions should continue monitoring and reporting the trafficking of pangolins in and out of Indonesia. This will aid in the effort to understand better and gauge levels of illegal trade and detect emerging trends (e.g., Indonesia's potential involvement as a transit country in the intercontinental trade of pangolins). This will help guide and shape enforcement interventions, conservation actions, decision making, and policies to overcome smuggling.
- Reporting to CITES by Indonesia, in adherence to the new annual illegal trade reporting requirements of CITES Notification 007 that was issued in February 2016, will complement global efforts to monitor and tackle the illegal international pangolin trade. The CITES Notification calls for reporting to the CITES Secretariat, which involves a comprehensive account of actions and outcomes of seizure and prosecution information. This level of reporting is needed to improve analysis of

the country's pangolin trade level and trends, which would feed towards improved law enforcement efforts.

Further research

- In Indonesia, a Sunda Pangolin population status overview is needed in order to establish national conservation threat levels and guide enforcement and prosecution reforms.
- Research into pangolin trade drivers and potential substitutes for pangolin products is needed not only in major destinations, such as China and Vietnam, but across the Southeast Asian region, where local consumption of pangolin products still occurs, albeit on a smaller scale. Such research will help us to understand trade dynamics better and would form the basis for future awareness-raising efforts.

Behaviour change

- By inducing behaviour change in consumption countries, the demand for pangolin products can be decreased. Best practice approaches to social behaviour change communications need to be explored and pursued. Such communications should include awareness raising campaigns and consumer education. Further behaviour change can be brought about by enhanced law enforcement efforts.
- In addition to behaviour change among consumers, there should be similar efforts to influence local communities and hunters involved in poaching and trading of pangolins. This may be achieved by educating them on the illegality of the trade and the importance of protecting pangolins.

A2.2 Introduction

Indonesia is among the most biodiverse countries in the world. Unfortunately, and notwithstanding management efforts to conserve this natural richness, the country has long been recognised as a significant illegal wildlife trade hub (Chng, et al. 2015; Nijman 2015; Auliya, et al. 2016). Traders use the country to source illegal wildlife products from key species, including tigers *Panthera tigris*, various primates, Sun Bears *Helarctos malayanus* and birds (Shepherd 2000; Shepherd and Magnus 2004; Nijman and Shepherd 2009; Schoppe 2009; Nijman 2010; Chng, et al. 2015; Nijman 2015; Auliya, et al. 2016; Yee 2019). Illicit trade in endangered floral and faunal species in, from, and to Indonesia is widespread and concerns both national and international trade chains. A recent report assessing wildlife crime in Indonesia indicates a growing pattern, with illegal trade increasingly involving organised criminal networks (USAID 2015). Among the myriad species of wildlife that are traded in and out of Indonesia are pangolins.

Analysis of seizure records between 1999 and 2017 show that a minimum of 192 567 pangolins were involved in illegal trade, based on 1557 seizure incidents globally and involving all species of pangolins (Challender and Waterman 2017). Increasing and persisting East Asian demand continues to put pressure on all eight existing pangolin species (Challender 2011; Challender and Hywood 2012; Nijman, et al. 2016; Xu, et al. 2016). The four Asian species in particular are considered to be in rapid decline (Challender 2011; Challender, et al. 2014c; Nijman, et al. 2016).

Indonesia is home to one species of pangolin, the Sunda Pangolin, which can be found from Sumatra, Java and adjacent Indonesian Islands to Kalimantan (Challender, et al. 2014c) (**Figure A2.1**). It has been protected in the country since 1931, dating back to the time of the Dutch administration, under the previous Wildlife Protection Ordinance No 266 (CITES, 2017), but illegal trade continues to occur at alarming levels. Indonesia's involvement in the international pangolin trade dates back to at least the early 20th century, with records of large shipments of scales from Java to China from as early as 1925 (Semiadi, et al. 2009; Nijman 2015). Between 1958 and 1964 there was documented trade of pangolin scales from Kalimantan on the island of Borneo to Hong Kong, amounting to an estimated 25 000 pangolins per year (Nijman 2015). During the 1990s, trade in pangolins out of Indonesia mostly involved skins which were used to make leather products such as bags, wallets and other accessories (Sopyan 2009). By the early 2000s, the skin trade was

replaced by the more profitable international trade in pangolin scales, which were coveted for use in Traditional Chinese Medicine. Since 2002, demand has increased not only for scales but also for pangolin meat and organs, the trade in which has continued unabated until today.

Figure A2.1: Sunda Pangolin distribution map (Source: IUCN Redlist™).

While little is known about the population status of the Sunda Pangolin in Indonesia, it is known that the species has an average generation span of seven years, making current trade and hunting levels of the species likely to be unsustainable (Challender, et al. 2014c). The Sunda Pangolin is currently listed as Critically Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, largely due to the threat trade poses, and is suspected to be in severe decline in Indonesia (Challender, et al. 2014c).

A 2.2.1 National Legislation

With at least five key legislations governing the use and trade of wildlife since 1990, Indonesia's national wildlife legislation relating to the protection and regulation on the harvest and trade of native species is generally adequate. However, the list of protected species requires reviewing and updating. At a national level, the Ministry of Environment and Forestry's Department of Forest Protection and Nature Conservation (KKH) is responsible for implementing the country's wildlife legislation. At a sub-national level, this responsibility falls on the Nature Conservation Agency (BKSDA). The Indonesian Institute of Sciences (LIPI) provides relevant scientific advice, for example with regards to setting quotas for harvest and export.

The Act of the Republic of Indonesia No. 5 of 1990 concerning conservation of living resources and their ecosystems, widely known as the Conservation Act (No. 5) 1990, is the principal legislation pertaining to the regulation of wildlife trade in Indonesia. Under this Act, species are categorised as "Protected" or "Unprotected" whereby species listed as Protected are classified as "Endangered" or "Rare". Chapter V Article 21 states that Protected species are not allowed to be caught, injured, killed, kept, possessed, cared for, transported, or traded whether alive or dead. Exceptions in this regard are permitted by the Government for the purposes of research, science and/or safeguarding a species. Violation of this Act can result in imprisonment for a maximum of five years and a fine of up to IDR 100 million (USD 7519). Chapter V also states that only Unprotected wildlife may be traded, and traders must submit trade records annually. All trade of plants and animals must be accompanied by legal documents.

That said, under Government Regulation No. 8, 1999 concerning the utilisation of wild plants and animals of this Act, the trade of a Protected species is permitted if the specimens are captive-bred. Captive-bred animals are subject to regulations under the Decree of the Ministry of Forestry, No.P.19/Ministry of Forestry-II/2005 concerning captive management of wild plant and animal species and Article 10 in Government Regulation No. 8, 1999, which defines that only second and subsequent generations of captive-bred Protected animals may be traded, and that all breeders must be registered with KKH (for exporters) and BKSDA (supplying to exporters but not exporting themselves). Currently, this is not permitted for pangolins.

Protected species are listed under Government Regulation No.7, 1999, Concerning the preservation of flora and fauna. This list has not been updated since it was first gazetted, and therefore does not include newly-recognised species and species that have since become of conservation concern. Sunda Pangolins are listed as a Protected species under this regulation, which technically means that all trade and harvest of wild-caught specimens is prohibited. The Indonesian Government is also in the midst of a revision of its wildlife protection legislations (Conservation Act (No.5) 1990 and Government Regulation No.7, 1999).

Under the Decree of the Minister of Forestry Number 447/Kpts-II/2003 concerning the administration directive of harvest, capture, and distribution of specimens of wild plant and animal species, a quota system regulates the collection and trade of unprotected animals. Harvest and export quotas are set by KKH annually for native species, except for Protected species or species listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which are prohibited from being harvested at all.

A2.2.2 CITES Legislation

Indonesia has been a Party to CITES since 1978. The Directorate of Biodiversity of the Ministry of Environment and Forestry functions as the national CITES Management Authority and is responsible for the implementation of CITES in Indonesia, while LIPI functions as the country's official Scientific Authority for CITES. Indonesia's CITES-implementing legislations however, specifically the Government Regulation No.7, 1999, has fundamental flaws in that it does not protect a vast number of non-native species and therefore effectively renders it meaningless when it concerns the trade of non-native species. In the year 2000, a zero annual CITES export quota was established for the four Asian pangolin species (CITES 2000b) but not for the African species. However, as of January 2017, all eight existing pangolin species were transferred from Appendix II to Appendix I of CITES, a decision that was adopted during the 17th Conference of the Parties (CoP) in Johannesburg, South Africa, in 2016. This effectively means that all international commercial trade in wild caught pangolins is prohibited.

A2.3 Methods

To characterise Indonesia's role in the international pangolin trade, a comprehensive seizure analysis was conducted. For this, pangolin seizure data for transactions involving Indonesia were collected for the period between 2010 and 2015. These data were extracted from various sources, including TRAFFIC publications, Customs, police, CITES, and media reports, grey literature and records from other non-governmental organisations (NGOs). It should be noted that non-English media reports were not specifically searched during the collation of the dataset, but were included when they were provided by a third party.

Only seizure data that involved Indonesia as a source, transit or destination country were included in the analysis. A "seizure country" was defined as the country where the seizure took place and could be either a source, transit or destination country. A "source country" was defined as the first known point of a trade route, a "transit country" was defined as a country that had functioned or was intended to function as both an importing and a re-exporting country in the trade route, and a "destination country" was defined as the last known or reported point of a trade route. For the purpose of this analysis the reported seizure data were assumed to be correct and complete; it is acknowledged, however, that seizure data are inherently influenced by a number of biases. The acquired seizure data were analysed for general trends relating to the commodity types being traded, and the countries involved during the research period. The analyses were conducted in the R software environment version 3.3.2 (R Core Team, 2016).

Apart from one incident where scales reportedly came from Africa, this analysis assumed that the pangolins involved belonged to the Sunda Pangolin given that the reported origin of the pangolin and/or parts was Indonesia. Where the weight of an animal was given, but no count, a minimum and a maximum figure of whole estimated animals of the Sunda Pangolin were calculated, following Gaubert (2011), i.e., 3–10 kg/animal. For scales it was assumed that the Sunda Pangolin would have 0.361 kg of scales per animal, following Zhou, et al. (2012).

In one incident where the quantity of specimens was described as "hundreds of dead pangolins", a minimum of 200 and a maximum of 999 pangolins was assumed. In three incidents where skins were reported but only a weight was given, it was assumed that the reported commodity was actually scales. In another incident where the number of scales

was reported as 146 pieces it was assumed that a minimum of one pangolin and a maximum of 146 pangolins were involved. In one incident where three "pax" of meat were reported, it was assumed that one to three pangolins were involved. In one incident where the seized scales originated from Africa, a minimum scale weight of the heaviest African pangolin (Giant Ground Pangolin *M. gigantea*) and the maximum scale weight of the lightest African pangolin (White-bellied Pangolin *M. tricupis*) (assuming scales make up 30% of a pangolins body weight and following Gaubert (2011) for a species body weight) were used to estimate the quantity of pangolins involved. In one incident where meat was reported and both a count and a weight were given, it was assumed that the count involved the number of dead pangolin bodies and was used as such to determine the number of pangolins involved.

In all incidents, the minimum and maximum estimated number of individual animals was calculated, and the average (rounded up to a whole animal) were used for subsequent analysis. In three incidents, the information provided was not sufficient to convert the quantity into whole estimated pangolins and they were therefore excluded from the analysis. In three other incidents only parts of the seized items could be converted due to insufficient information. These six included quantities of reported "tons of scales" in one incident, "legs" and "heads", "medicinals", and several kilogrammes of "body parts" in other incidents, and "meat" and a further "sack of scales".

Commodity types were consolidated into six categories for analysis, with the first three categories of "live", "dead" and "individuals" calculated as whole animals (**Table A2.1**).

Table A2.1: Commodity types used in the analysis

Commodity	Description
Live	Reported as live animals.
Dead	Reported as dead or frozen animals without further description of the state these animals were found; i.e., parts or whole, with or without scales, etc. Assumed to involve whole animals.
Individuals	Assumed to be whole animals that were seized but insufficient information reported to discern whether these involved live or dead specimens.
Meat	Usually reported by weight without further description on whether this involved whole dead/frozen specimens or body parts, etc.
Scales	Reported as scales.
Skins	Reported as skins.
Body Parts	Reported as body parts and assumed to involve any pangolin part excluding scales and skin.

Given the inconsistent manner in which seizures, enforcement action and effort are reported and recorded by the different countries, it is unlikely that this dataset is representative of the complete set of seizures involving Indonesia. Due to the inherently covert nature of the (international) illegal pangolin trade, its true extent is unlikely to be reflected by the reported seizure data alone. Seizure records are an indirect measure of trafficking levels, but the data are inherently biased. This is due to a number of factors, including varying levels of law enforcement in each country, different reporting and recording practices of both law enforcement and media, variability in NGO behaviour and advocacy, different levels of corruption, language biases etc. Therefore, more seizures in one country may not necessarily translate into higher wildlife trafficking levels in comparison to other countries. It is acknowledged that the above mentioned factors, among others, will ultimately influence the results of any seizure analysis, however, there is currently no comparable approach to gauge wildlife trafficking levels (but see Ingram, et al. (2017) for a different approach, using local scale hunting and market data).

A2.4 Results and Discussion

A total of 111 pangolin seizure records in which Indonesia was indicated as either a source country or a seizure country was found for the period between 2010 and 2015. These records involved live and dead pangolins, scales, meat and body parts. The number of seizures per year were generally constant throughout the research period (**Figure A2.2a**; estimate = 0.14, standard error (se) = 0.62, t = 0.23, p = 0.83), averaging around 18.5 (standard deviation (sd) = 2.4) (with a peak of 22 seizures in 2013). The trafficked volumes (i.e., estimated whole pangolins) fluctuated through time (**Figure A2.1b**; [log10] Estimate = -0.01, SE = 0.08, t = 0.101, p = 0.92). The total number of seizure records was estimated to involve about 35 632 seized pangolins over the six-year period (averaging 4421 (min = 2436, max = 10 857) pangolins per year), with the greatest quantities seized in 2011 (10 857 estimated whole pangolins) and 2013 (10 776 estimated whole pangolins).

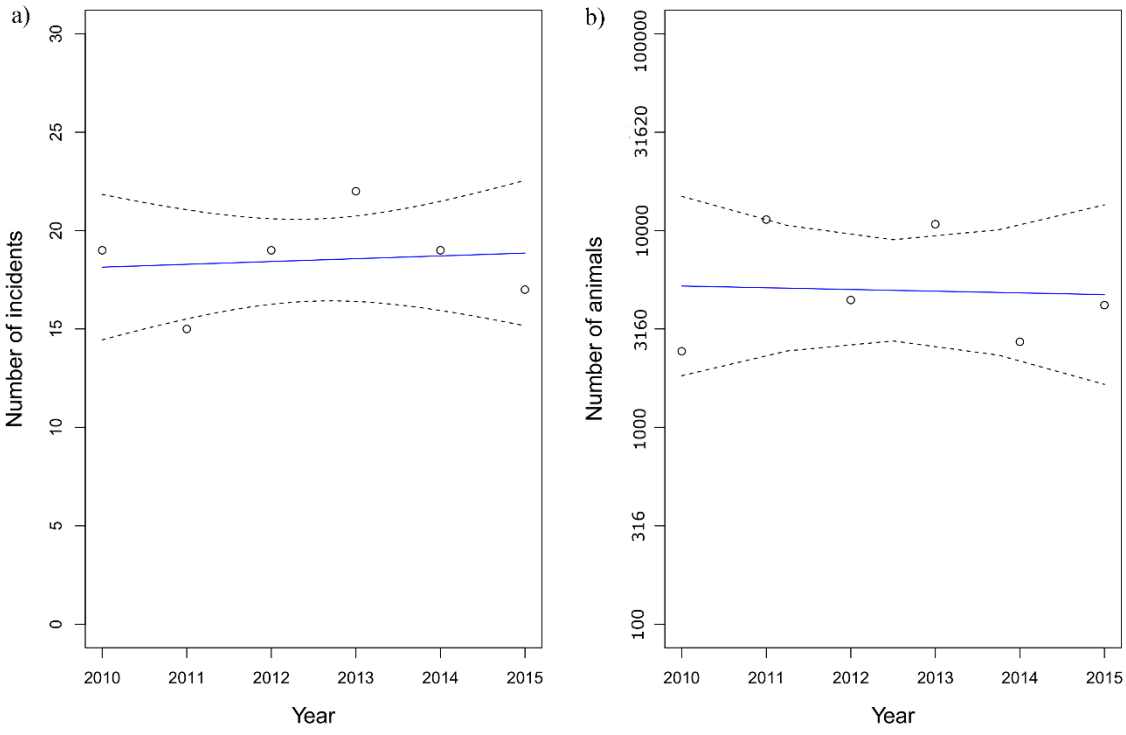

Figure A2.2: a) The number of pangolin seizure incidents (*Manis* spp.), and b) the estimated number of whole pangolins from 2010 – 2015 was used in a generalised linear model to create the fitted estimates (in blue) and 95% CI displayed in the dotted lines.

Most seized commodities (79%) involved dead pangolins in the form of bodies, meat, scales and skins which accounted for an estimated 27 960 whole pangolins (**Table A2.2**). Even though 37% of seizures involved at least some live animals, the total number of seized live pangolins was no more than 2884 (although this excludes "individuals" recorded which

may involve live or dead animals). Nevertheless, it should be noted that regardless of whether these animals were seized alive, not all of them will survive in captivity or will be able to be released back into the wild. The seized commodity that represented the highest volume of whole pangolins involved were scales.

Table A2.2: Seized quantities and estimated whole pangolins of trafficked pangolin commodities from 2010–2015.[14]

Commodity Seized	Number of Seizures[15]	Quantity	Whole Pangolins (Estimate)
Live	41	1540+6200 kg	2884
Dead	17	2681 + 23 566 kg	8389
Individuals	40	4788	4788
Meat	8	23 969.45 kg	5198
Scales	29	5218.57 kg + 146 pieces	14184
Skins	1	189	189

A2.4.1 Seizures in Indonesia

Of the 111 recorded seizures, the majority (83%) was found to have taken place in Indonesia (n = 92), while the remaining records, which involved seizures in six other locations (China, Lao PDR, Malaysia, Philippines, USA and Vietnam) (**Table A2.3**), implicated Indonesia as a source country. Of the 92 seizures occurring in Indonesia, most were found to have taken place in Sumatra (n = 55; followed by Java (n = 26) and Kalimantan (n = 11)) (**Table A2.4**). In one case the precise seizure location within Indonesia was unclear. Of the 19 seizures that occurred outside of Indonesia, at least eight were reportedly from Sumatra, while in the remaining 11 cases, the shipments were said to

[14] Note that quantities were not reported in all seizure incidents. These, as well as incidents that could not be converted, as described in the methodology, may not be reflected in the above table. Quantities are reported as a count of the commodity, unless otherwise marked (e.g., kg).
[15] Note that each seizure may involve more than one type of commodity seized

have originated from Indonesia, without any further details being given as to the specific place of origin. Only one record specifically indicated a source country other than Indonesia. This concerned a shipment of pangolin scales originating from Cameroon that was seized in Jakarta in January 2015.

Table A2.3: The number of seizure records linked to Indonesia per country and the associated number of whole estimated pangolins per seizure from 2010 – 2015. Displayed are also the number of incidents a country was involved in, regardless whether or not it was the country of seizure.

Country[16]	CM	CN	ID	LA	MY	PH	RU	SG	TH	US	VN
Number of Seizures	0	2	92	1	11	1	0	0	0	1	3
Whole Pangolins	0	6665	23305	81	1046	2167	0	0	0	0	2368
Number of Incidents[17]	1	14	111	2	22	1	1	4	3	1	7

Table A2.4: Total number of pangolin seizures from 2010 – 2015 in Indonesia – Java, Kalimantan and Sumatra.

Seizure Location	Whole Pangolins	Number of Seizures
Java	10 399	26
Kalimantan	2449	11
Sumatra	10 457	55
Total	23 305	92

[16] CM – Cameroon, CN – China (including mainland China and Hong Kong), LA – Lao PDR, MY – Malaysia, PH – Philippines, RU – Russian Federation, SG – Singapore, TH – Thailand, US – United States and VN – Vietnam

[17] implicated either as a source, transit or destination country.

Recorded seizures involved as few as one pangolin to as many as 6307 pangolins. There were at least 11 incidents where the seizures involved over 1000 estimated whole pangolins, seven of which occurred in Indonesia, i.e., Sumatra (3 seizures), Java (3 seizures) and Kalimantan (1 seizure). The largest of these Indonesian seizures, in terms of number of pangolins seized, was one of 5.9 tonnes of pangolin meat and 790 kg of scales (amounting to an estimated 3474 whole pangolins) at the Belawan International Container Terminal in Medan, Sumatra, which was reportedly headed for Vietnam. These were smuggled amongst several tonnes of snakehead fish *Channa spp*. and Asiatic Softshell Turtle *Amyda cartilaginea* meat. In terms of weight, the heaviest seizure was of a container with over 8500 kg of dead pangolins and close to 350 kg of pangolin scales (which was estimated to amount to 2812 whole pangolins), which occurred at the Tanjung Priok Port, Jakarta (Java). It is striking that even though the amount of seizures in Sumatra was approximately twice as high as in Java, the number of trafficked pangolins was approximately the same for both islands.

A2.4.2 Seizures outside Indonesia

Besides Indonesia, 10 other countries were found to have been involved in the pangolin trade with Indonesia (**Table A2.3**), serving either as source, transit or destination countries. The top three locations that have the closest ties with Indonesia, based on either estimated number of whole pangolins or frequency, are China, Vietnam and Malaysia. These are based either on reported seizure location (where Indonesia was named as a source), or where the locations were part of the trade chain in relation to where the seizure occurred or where a shipment was reportedly destined for.

China, although implicated in only 12 of the 111 seizure records, accounted for the largest volume of pangolins smuggled (these 12 seizures were estimated to involve 10 491 whole pangolins). It was found to serve only as a destination. Of the 12 seizures, only two occurred in China (one in mainland China and the other in Hong Kong) involving shipments originating from Indonesia. The total number of pangolins seized in these two incidents was estimated at 6665 largely due to one seizure of 232 boxes containing 2041 frozen pangolins and 1540 kg of pangolin scales (a total of 6307 estimated whole pangolins). Also seized were 11 boxes of python skins and 23 boxes of frozen tortoises. This was the largest seizure recorded for the study period, 2010 – 2015. Of the 12 incidents implicating China,

the most frequently seized commodity was pangolin scales (n = 7 incidents). In three incidents these scales were found in combination with live and/or dead pangolins.

Vietnam was linked to seven seizures involving Indonesia from 2010 – 2014; no seizures were reported to have occurred in 2015. These seven seizures combined accounted for the second highest total volume of pangolins seized (9852 animals). Three of these seizures occurred within the country (amounting to 2368 animals) and a further four seizure records implicated Vietnam as a destination country. The commodities seized included meat, scales and live pangolins, although the most abundant in terms of volume seized was meat, i.e., 18.1 tonnes from three seizures.

Malaysia emerged as the most prominent country implicated in the Indonesian pangolin seizure data, based on the frequency of reported incidents (a minimum of 22 cases involving a minimum of 3204 pangolins). There were 11 recorded seizures (involving 1046 animals) in Malaysia—all of which were seized on vessels by the marine police with the source of pangolin shipments reportedly from Indonesia. A further 11 seizures, which occurred in Indonesia (n = 10 seizures) and Lao PDR (n = 1 seizure) and accounted for a minimum of 2158 pangolins, involved shipments being transported to or through Malaysia. It is believed that the country largely functions as an export and transit hub through which Malaysian and Indonesian pangolins are shipped to end use destinations in Indochina and East Asia (Semiadi, et al. 2009; Sopyan 2009; Nijman, et al. 2016; Xu, et al. 2016). With demand coming predominantly from East Asian countries, shipments are likely to be transported through Malaysia. That said, this is a data gap that warrants further investigation. The seizures in Malaysia took place in three main States (Johor (n = 4), Melaka (n = 3) and Perak (n = 4)) on the west coast of Peninsular Malaysia and generally involved shipments of live pangolins (ranging between 15 and 100 pangolins in each shipment) by sea. Similarly, the seizure records implicating Malaysia as a destination and transit country mostly involved shipments of live pangolins (n = 11), a mix of both live and dead pangolins (n = 3; including scales, n = 1 seizures), or individuals (n = 3). Pangolin parts are known to be consumed in selected locations in the country, sourced by local hunters and served to exotic meat restaurants and therefore the country's role as a consumer requires further investigation (Pantel and Anak 2010; Yuen 2013; Chan 2017; TRAFFIC, unpublished data).

The Philippines was implicated in one large seizure which involved an estimated 2167 whole pangolins (10 000 kg pangolin meat), although in this case, the pangolins were only

discovered after a Chinese vessel ran aground in a coral reef within the Philippine Tubbataha National Marine Park, a UNESCO-designated World Heritage Site on Palawan Island (Cerojano 2013). According to the crewmen arrested, the pangolins were from Indonesia.

There was only one incident where the source of the seized shipment was reportedly an African country – 200 kg of pangolin scales from Cameroon were seized at the Soekarno Hatta International Airport in Jakarta in 2015. It is likely the scales were intended for a destination other than Indonesia as it primarily functions as a source of pangolins, rather than a consumer.

In at least 21 seizures, pangolins were confiscated along with other wildlife products and contraband. Other wildlife most frequently seized alongside pangolins included birds (live and parts; n = 9 seizures) and snakes (mostly pythons, live and skins; n = 6 seizures). Of the nine seizures that included birds, at least five involved hornbill casques, amounting to almost 500 pieces, although the bulk of this was mostly attributed to two seizures. In the first, authorities confiscated pangolin scales along with 229 pieces of Critically Endangered Helmeted Hornbill *Rhinoplax vigil* beaks and bear parts (44 bear claws and one canine) in Kalimantan, reportedly for a Taiwanese buyer (Anon. 2013b). The second incident involved the confiscation of 189 pangolin skins and 248 pieces of Helmeted Hornbill beaks in Jakarta, although these items were reportedly sourced from Kalimantan (Anon. 2013b, a). Authorities arrested four Chinese nationals who were heading to Hong Kong on a China Airline flight. These cases demonstrate that pangolin shipments from Southeast Asia are sometimes accompanied by other high-value wildlife commodities destined for the East Asian market.

As mentioned, seizure data are biased and the records are likely to represent only part of the illegal pangolin trade. Due to the trade's inherently covert nature and the possibility of insufficient or incomplete reporting, its true extent will remain unclear. Although the data found in this study may not present us with a complete picture, they are indicative of certain trade trends and dynamics.

A2.4.3 Indonesia as a source country

The number of seizures associated with Indonesia that were found to have taken place during the research period are indicative of the potentially important role the country plays in the international pangolin trade. Of the 111 seizure records for Indonesia over the study period, only 42 records included data on international trade routes (**Figure A2.3**).

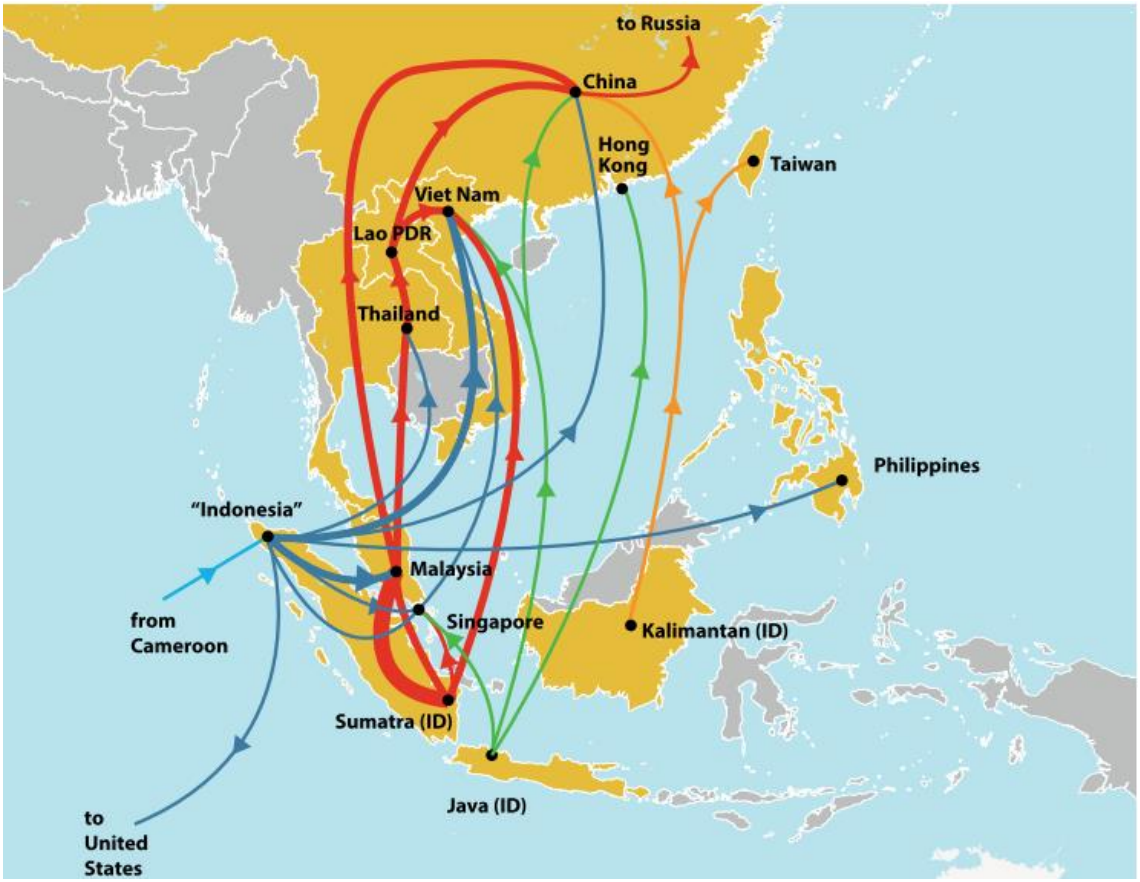

Figure A2.3. Pangolin trade routes involving Indonesia. The thickness of lines indicates number (frequency) of recorded shipments per route, with the thinnest lines representing one shipment. Blue lines mark shipments originating from "Indonesia" (unspecified location), red lines mark shipments originating from Sumatra, green lines mark shipments originating from Java, orange lines mark shipments originating from Kalimantan, light blue lines mark shipments originating from outside of Indonesia.

This dataset shows that, aside from one seizure record, all those reported by the seven countries in which seizures were made, were of shipments originating from Indonesia. This confirms that Indonesia functions mainly as an important source country. The data show that Indonesia has remained a key link in the black market trade of the Sunda Pangolin (see also (Shepherd 2009; Pantel and Anak 2010; Challender 2011).

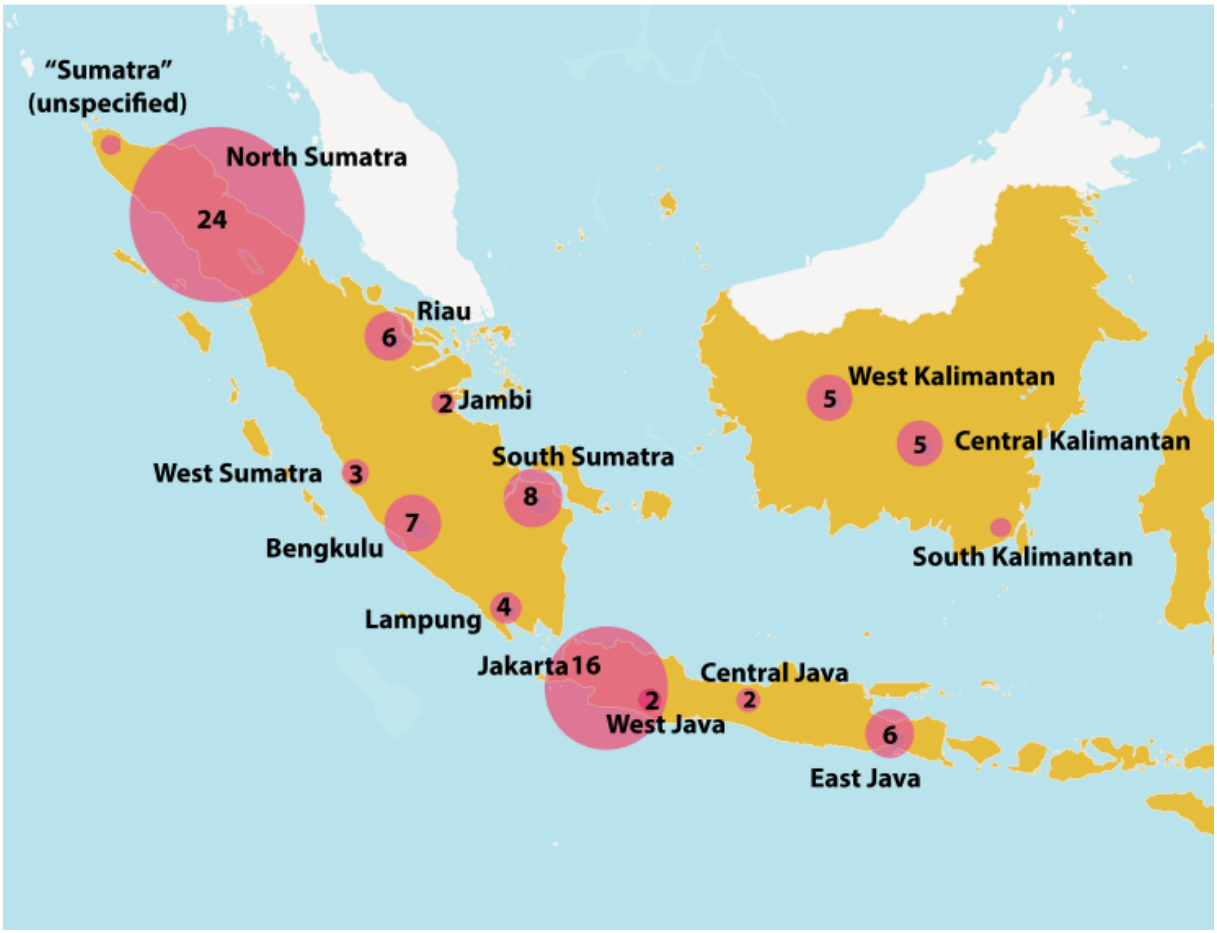

Figure A2.4: Seizure hotspots within Indonesia based on seizure data between 2010 and 2015. Numbers indicate the amount of seizures made during the research period, with those circles not containing a number representing a single seizure.

A2.4.4 Sumatra and the Sundaland connection

Sumatra appears to be home to the highest number of pangolin trade hotspots, with most trade passing through the North Sumatra province (**Figure A2.4**). The island's trade volumes can (at least partly) be explained by what can be called the "Sundaland connection". This refers to the strong trade links between Indonesia, Singapore and Malaysia and its role as a central distribution point. Due to its proximity to both Malaysia and Singapore, Sumatra appears to be the most important Indonesian island in the Sundaland connection. Of the incidents involving Malaysia (n = 22 seizures) and Singapore (n = 4 seizures), 19 were reported to be linked to Sumatra. Pangolin trade out of Sumatra was found to have Peninsular Malaysia as a (first) destination, with Medan in North Sumatra being a major collection site before export. Information from confidential sources single Medan out as such. Similar findings are reported by Takandjandji and Sawitri (2016) who report that pangolins from Aceh, North Sumatra and West Sumatra are exported

through Belawan Port, Medan, while pangolins from Riau Province and South Sumatra are exported through Palembang.

Information received by TRAFFIC over the years has yielded additional insight into this trade. In 2016, collectors in Curup, Bengkulu have been said to obtain around one to two pangolins from local hunters per day and sell them to middlemen in Medan (with the price of a live pangolin reportedly being around IDR 350 000 (USD 26) and the price of pangolin scales being around IDR 3 000 000 (USD 223) per kg). Similarly, collectors in Muara Bahan, Logas Subdistrict, Kuansing, Riau have been said to sell live pangolins, collected from local villages, to middlemen in Medan (and Padang) for around IDR 200 000 (USD 15) per kg. Another collector noted that Sijunjung, Kiliran Jao and Dharmasraya in West-Sumatra were notable locations targeted for the poaching of pangolins and other wildlife such as Helmeted Hornbills, stored in small numbers at a time (no more than two or three pangolins at a time) to minimise risk. The specimens are then transported overland to Medan, using couriers, although middlemen have been known to come pick up their shipments when these are larger than normal. From Medan, Peninsular Malaysia is easily reachable by boat and plane. According to Challender and Waterman (2017), interviews with poachers in 2012 revealed an average of 25–30 pangolins were collected a month in Indonesia. Outside the assessed period, between 2016 and June 2017, there have been at least a further 11 seizures in Sumatra, which reiterates the island's significance in this trade connection. The most recent incident occurred in June 2017, when a Malaysia-bound shipment of at least 225 pangolins (alive, dead and scales) was seized at the Belawan Port in Medan (Anon. 2017a).

In the international wildlife trade, Malaysia and Singapore have been known to function as gateways for some key illicit wildlife commodities that are being transported into the greater Southeast Asian (and eventually East Asian) region (Pantel and Chin 2009; Shepherd, et al. 2012; Milliken, et al. 2013, 2016). This also seems to be the case in the pangolin trade and is therefore a priority for law enforcement interventions. In 2015, Singapore intercepted 324 kg of African pangolin scales, along with 505 kg of ivory from Nigeria that was on its way to Lao PDR (Agri-food and Veterinary Authority of Singapore (AVA) and Singapore Customs 2015) Between May and June 2017, Malaysia similarly has intercepted close to 1.4 tonnes of African pangolin scales *en route* to China (TRAFFIC 2017).

A2.4.5 Java and Kalimantan

Pangolin shipments out of Java were almost always reportedly destined for Hong Kong (n = 5 seizures) or Vietnam (n = 1 seizure) and Singapore (n = 2) and smuggled by both air and sea. Additional information from outside the study period, included one incident in August 2016, in which 657 frozen pangolins were seized from a house in East Java, wrapped in plastic and stored in five large freezers. These pangolins were said to have been sourced from Sumatra and Borneo (Topsfield and Rosa 2017). It is assumed that, in cases like these, private premises function as collection centres, with the pangolins being packed and shipped out of the country once these locations have reached their storage limits (Sopyan 2009). Information collected by TRAFFIC over the years (2015 – 2017) indicates that collectors from Sijunjung in West Sumatra source pangolins from a number of locations (such as Bengkulu, Lampung, Aceh and Kalimantan) which are then sold to clients in Jakarta. According to Takandjandji and Sawitri (2016), hunting of pangolins in Java, based on interviews with 25 local hunters, are done by communities living around forested areas, both opportunistically (55%) as well as intentionally (23%) to supplement their income. Generally, the hunting of pangolins is co-ordinated by the collecting party and local traders.

While fewer seizure records were found for Kalimantan, the trade route between West Kalimantan and China has been thought to be of key importance in the international pangolin trade (Anon. 2016a). Pangolins are collected throughout the Bornean Island and smuggled via Jakarta or Sarawak, often mixed in with large shipments of legal products such as crops of various kinds (Anon. 2016a; Takandjandji and Sawitri 2016). The remoteness of most areas in Borneo, as well as the extensive shared border between Kalimantan and Sarawak, provides advantages to smugglers while inhibiting effective monitoring and control by relevant authorities. Some local communities, such as the Dayak in Kalimantan, are reportedly involved in the hunting of wild animals (TRAFFIC, unpublished data). While the bulk of such wildlife is used for their own subsistence, high value products like pangolins are reportedly sold to middlemen. One reported trade route involves poached pangolins being sent to a warehouse in Ketapang, West Kalimantan, from where they are transported to Entikong, West Kalimantan and then smuggled into Sarawak, Malaysia. Elsewhere, local people in Sambas were reportedly aware of a phone number to call if pangolin scales were obtained, though the destination of the scales were not known beyond that it was believed to serve “an export market” (TRAFFIC, unpublished data). In

2016, pangolin collectors were also reported to be operating out of Serimbu in the Landak district in West Kalimantan, where these pangolins were either consumed in the local villages or sold for around IDR 40 000 (USD 3). The involvement of middlemen in Entikong in the Sanggau district has also been reported, where scales were said to be transported across the border into Sarawak, concealed amongst crops, and sold to dealers in the border town of Tebedu, which is then shipped to China. Information on these trade routes operating within Borneo requires further investigation and verification.

A2.4.6 Intercontinental trade

With Asian pangolin populations dwindling, the intercontinental trade in African pangolins now appears to be on the rise (Challender and Hywood 2012; Challender, et al. 2016; Gomez, et al. 2016b; TRAFFIC 2017). In previous studies it was found that both European and Southeast Asian countries function as transit hubs in the intercontinental pangolin trade (Challender and Hywood 2012; Gomez, et al. 2016b; Chapter 3). While most of the seizure records indicate Indonesia as a source country, the country may also function as a transit hub in the intercontinental pangolin trade. Only one Indonesian seizure record, concerning a shipment of 200 kg of pangolin scales from Cameroon, supports this possibility. In previous studies into the intercontinental pangolin trade, the country has not been indicated as a transit hub (Challender and Hywood 2012; Gomez, et al. 2016b). The exact extent to which Indonesia should be seen as a re-exporting country of African pangolin species remains unclear but should be monitored and investigated further, considering that new trade routes are constantly evolving in the smuggling of illicit wildlife products (Chapter 3). In Chapter 3, it was shown that on average 27 new and previously undetected unique trade routes were formed each year in the international pangolin trade between 2010 and 2015. Further, this study identified Indonesia as one of the top 10 countries involved in illegal, international pangolin trade, based on the number of incidents it was implicated in, and regardless of the role it played, either as an origin, transit, or destination.

A2.4.7 Impacts of the international pangolin trade

The primary threat to the Asian pangolin species is illegal hunting and poaching for international trade that is largely driven by demand from East Asian markets. Between July

2000 and 2015, at least 153 434 trade records involving the Sunda and Chinese Pangolins have occurred (CITES, 2017). The precise impact of the international pangolin trade on Indonesian pangolin populations cannot be determined through seizure analysis alone. The inherent secretive nature of illegal trade means seizure data are unlikely to represent the full magnitude/scale of the trade and may reflect the variance in enforcement levels. Of the 35 632 pangolins seized between 2010 and 2015, only 2884 involved live animals (the remaining either involving dead specimens and/or parts), but given their low rate of survival under captive conditions, it is unlikely all these survived captivity or were able to be released back into the wild.

In a previous study it was found that between 2002 and 2008, 18 seizures were reported for Indonesia, involving an estimated total of 49 662 pangolins and averaging about 2759 pangolins per seizure (Semiadi, et al. 2009). The current study reports on 111 seizures (more than six times in comparison), involving an estimated 35 632 pangolins over a similar timespan, averaging about 321 pangolins per seizure. The smaller volume of pangolins per average seizure could, among other possible scenarios, potentially be an indication of a declining population. The smaller volumes per seizure may also be explained by the smugglers' attempts to avoid big losses in case of a seizure by spreading their valuable contraband over several smaller shipments. However, considering the high number of seized specimens found in this study (and in previous ones) and the fact that the average generation span of the Sunda Pangolin is seven years (Challender, et al. 2014c), populations are likely to shrink unless immediate countermeasures are put into place. Captive breeding of pangolins for commercial trade is not an option as pangolins are not suited to life in captivity considering their specialised behaviours, diet and high dependence on the natural environment (Hua, et al. 2015). With Chinese Pangolin populations depleted due to the illegal trade, other Asian pangolin populations, including the Sunda pangolin in Indonesia may likely face a similar fate. The illegal international Asian pangolin trade is therefore of high and immediate concern.

A2.5 Conclusions

Illegal international trade is the greatest threat to wild pangolins, which are already thought to be in severe decline. Indonesia clearly plays a significant role as a key source of pangolins in the international trade chain. With continuing high demand in China and

Vietnam, the Sunda Pangolin in Indonesia is facing certain demise as it is persistently harvested throughout the country to supply this demand. Despite the existence of sufficient wildlife laws to protect this native species, the illegal poaching of – and trade in – pangolins continues unhindered. However, the relatively large amount of seizures that have taken place here may also hint at improved enforcement efforts, particularly with the arrests of key players in the illegal pangolin trade disrupting trafficking networks (a minimum of 127 suspects were identified and/or arrested from the 111 incidents). Nevertheless, these efforts may be undermined by corruption and insufficient conviction rates, with convictions often involving low fines (a maximum of IDR 100 million (USD 7500). Urgent measures are needed in order to put a halt to the rampant pangolin trade from Indonesia. The IUCN Species Survival Commission (SSC) Pangolin Specialist Group, IUCN Asian Species Action Partnership (ASAP), and Wildlife Reserves Singapore (WRS) recently organised the Sunda Pangolin Regional Conservation Planning Workshop, 28 – 30 June 2017 in Singapore, to develop a more detailed, regional conservation strategy for the Sunda Pangolin that would guide investment in pangolin conservation and catalyse support for implementation of such strategies. Based on some of the key outcomes from the workshop discussions, it was revealed that saving pangolins from extinction will require engaging local communities in their conservation and addressing the demand for pangolin products, as well as strengthening domestic legislation and policy to combat the illegal wildlife trade.

Appendix 3

Supplementary Data

Appendix 3. Supplementary Data

Supplementary Material: Chapter 2

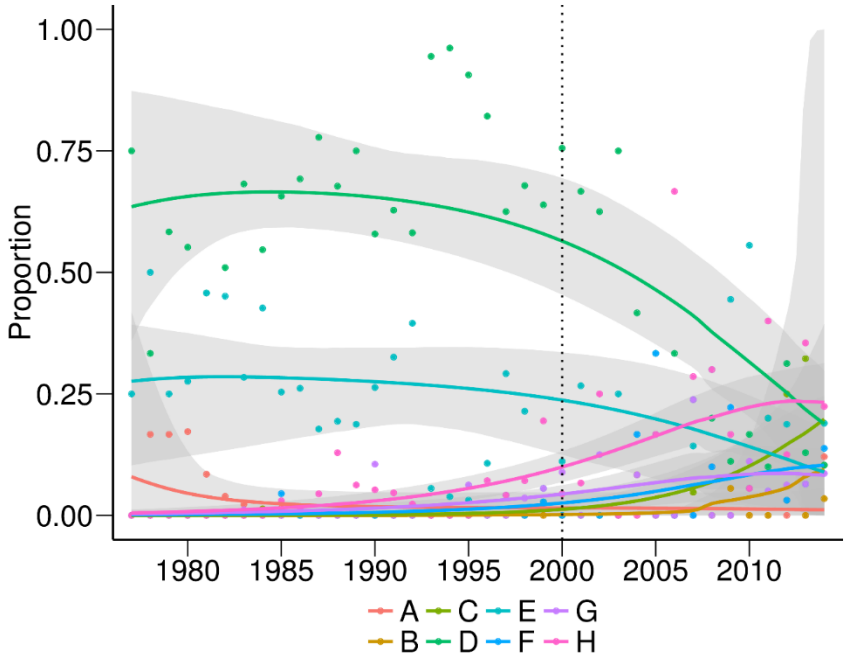

Figure S2.1. Estimated proportional abundances of pangolin species traded through time (average proportion ± 95% CI) from bootstrapped multinominal logit models. A = *Manis crassicaudata*, B = *Manis culionensis*, C = *Manis gigantea*, D = *Manis javanica*, E = *Manis pentadactyla*, F = *Manis temminckii*, G = *Manis tetradactyla*, H = *Manis tricuspis*.

Table S2.1. Country codes and corresponding country names that appear in the CITES data or are Range States (native countries), and are referenced in the analyses included in this paper. Also listed are the pangolin species native to each country.

Country Code	***Country Name***	***Native Species***
AE	United Arab Emirates (the)	
AO	Angola	*M. gigantea; M. temminckii; M. tetradactyla; M. tricuspis*
AT	Austria	
AU	Australia	
BD	Bangladesh	*M. crassicaudata; M. pentadactyla*
BE	Belgium	
BG	Bulgaria	
BI	Burundi	*M. gigantea; M. temminckii; M. tricuspis*
BJ	Benin	*M. tricuspis*
BN	Brunei Darussalam	*M. javanica*
BR	Brazil	
BT	Bhutan	*M. pentadactyla*
BW	Botswana	*M. temminckii*
CA	Canada	
CD	Congo (the Democratic Republic of the)	*M. gigantea; M. tetradactyla; M. tricuspis*
CF	Central African Republic (the)	*M. temminckii; M. tetradactyla; M. tricuspis*
CG	Congo	*M. gigantea; M. tetradactyla; M. tricuspis*
CH	Switzerland	
CI	Côte d'Ivoire	*M. gigantea; M. tetradactyla; M. tricuspis*
CM	Cameroon	*M. gigantea; M. tetradactyla; M. tricuspis*
CN	China	*M. pentadactyla*
CO	Colombia	

Country Code	**Country Name**	**Native Species**
CU	Cuba	
CZ	Czech Republic (the)	
DE	Germany	
DJ	Djibouti	
DK	Denmark	
ES	Spain	
ET	Ethiopia	*M. temminckii*
FJ	Fiji	
FR	France	
GA	Gabon	*M. gigantea; M. tetradactyla; M. tricuspis*
GB	United Kingdom (the)	
GE	Georgia	
GH	Ghana	*M. gigantea; M. tetradactyla; M. tricuspis*
GM	Gambia (the)	*M. gigantea*
GN	Guinea	*M. gigantea; M. tetradactyla; M. tricuspis*
GQ	Equatorial Guinea	*M. gigantea; M. tetradactyla; M. tricuspis*
GW	Guinea-Bissau	*M. gigantea; M. tricuspis*
GR	Greece	
HK	Hong Kong	*M. pentadactyla*
HU	Hungary	
ID	Indonesia	*M. javanica*
IN	India	*M. crassicaudata; M. pentadactyla*
IT	Italy	
JP	Japan	
KE	Kenya	*M. gigantea; M. temminckii; M. tricuspis*

Country Code	**Country Name**	**Native Species**
KH	Cambodia	*M. javanica*
KR	Korea (the Republic of)	
KW	Kuwait	
LA	Lao People's Democratic Republic (the)	*M. javanica; M. pentadactyla*
LK	Sri Lanka	*M. crassicaudata*
LR	Liberia	*M. gigantea; M. tetradactyla; M. tricuspis*
LU	Luxembourg	
MM	Myanmar	*M. javanica; M. pentadactyla*
MO	Macao	
MW	Malawi	*M. temminckii*
MX	Mexico	
MY	Malaysia	*M. javanica*
MZ	Mozambique	*M. temminckii*
NAM	Namibia	*M. temminckii*
NG	Nigeria	*M. tetradactyla; M. tricuspis*
NL	Netherlands (the)	
NO	Norway	
NP	Nepal	*M. crassicaudata; M. pentadactyla*
NZ	New Zealand	
OM	Oman	
PA	Panama	
PH	Philippines (the)	*M. culionensis*
PK	Pakistan	*M. crassicaudata*
PL	Poland	

Country Code	**Country Name**	**Native Species**
PT	Portugal	
QA	Qatar	
RU	Russian Federation (the)	
RW	Rwanda	*M. gigantea; M. temminckii; M. tricuspis*
SA	Saudi Arabia	
SE	Sweden	
SG	Singapore	*M. javanica*
SH	Saint Helena, Ascension and Tristan da Cunha	
SI	Slovenia	
SL	Sierra Leone	*M. gigantea; M. tetradactyla; M. tricuspis*
SN	Senegal	*M. gigantea*
SS	South Sudan	*M. gigantea; M. temminckii; M. tricuspis*
TD	Chad	*M. temminckii*
TG	Togo	*M. tricuspis*
TH	Thailand	*M. javanica; M. pentadactyla*
TO	Tonga	
TW	Taiwan (Province of China)	*M. pentadactyla*
TZ	Tanzania, United Republic of	*M. gigantea; M. temminckii; M. tricuspis*
UG	Uganda	*M. gigantea; M. temminckii; M. tricuspis*
US	United States (the)	
VN	Vietnam	*M. javanica; M. pentadactyla*
ZA	South Africa	*M. temminckii*
ZM	Zambia	*M. temminckii; M. tricuspis*
ZW	Zimbabwe	*M. temminckii*

Table S2.2. The number of incidents (and the number of whole pangolins involved) in the top ten country partnerships (exporter to importer). Also shown is whether or not the exporting country is a range state and the percentage that African and Asian species contribute to the number of incidents and number of whole pangolins (in parenthesis) for any one partnership, a) pre 2000 and b) post 2000. Refer to **Table S2.1** for corresponding country names associated with each country code in the partnerships.

a) Partnership	Incidents (whole animals)	African species (%)	Asian species (%)	Exporter range
MX - US	152 (46290)	0.66 (0.23)	81.58 (97.81)	Non-range
JP - US	115 (152638)	0 (0)	100 (100)	Non-range
US - MX	69 (41696)	0 (0)	100 (100)	Non-range
LA - US	56 (73118)	0 (0)	51.79 (99.09)	Asia
TH - US	52 (3114)	0 (0)	51.92 (66.80)	Asia
US - CA	51 (875)	0 (0)	88.24 (98.17)	Non-range
TW - US	38 (21249)	0 (0)	94.74 (99.84)	Asia
US - JP	32 (3575)	0 (0)	100 (100)	Non-range
IT - US	26 (4655)	0 (0)	100 (100)	Non-range
SG - US	23 (55981)	0 (0)	100 (100)	Asia

b) Partnership	Incidents (whole animals)	African species (%)	Asian species (%)	Exporter range
CN - US	37 (3747)	2.7 (1.01)	16.22 (10.38)	Asia
VN - US	32 (36718)	0 (0)	56.25 (96.96)	Asia
US - FR	25 (103)	44 (42.72)	56 (57.28)	Non-range
LA - US	24 (858)	0 (0)	20.83 (91.38)	Asia
MX - US	20 (277)	5 (37.91)	10 (2.89)	Non-range
TH - US	19 (507)	15.79 (35.70)	15.79 (0.99)	Asia
US - CA	16 (46)	43.75 (50)	56.25 (50)	Non-range
CM - US	13 (238)	53.85 (92.86)	0 (0)	Africa
SG - US	12 (215)	0 (0)	100 (100)	Asia
CN - NZ	9 (1970)	11.11 (0.05)	0 (0)	Asia

Supplementary Material: Chapter 3

Table S3.1: Number of pangolin (*Manis* spp.) seizure incidents that occurred in each country across international pangolin trafficking incidents (n = 539) from 2010 - 2015. Also shown is the relative percentage that each country played as either an origin, transit or destination, in the international trafficking routes.

Country/Territory	***Number of Seizures***	***Percentage***		
		Destination	**Origin**	**Transit**
US	127	100	0	0
China	113	73.4	25.7	0.9
Germany	37	13.2	0	86.9
Vietnam	35	31.1	56.7	12.2
Thailand	32	26.8	41.1	32.1
Belgium	30	16.1	0	83.9
Malaysia	24	30	60	10
Netherlands	24	92.3	0	7.7
India	23	6.7	93.3	0
Indonesia	21	2.5	97.5	0
France	14	40	6.7	53.3
Nepal	11	10.5	63.2	26.3
Hong Kong	8	26.3	64.9	8.8
Switzerland	8	100	0	0
Cameroon	3	0	100	0
Malta	3	100	0	0
Philippines	3	18.2	81.8	0
Uganda	3	0	67	33
Poland	2	100	0	0
Sri Lanka	2	0	100	0
Zimbabwe	2	100	0	0

Country/Territory	**Number of Seizures**	**Percentage**		
		Destination	**Origin**	**Transit**
Japan	1	100	0	0
Kenya	1	0	71.4	28.6
Lao PDR	1	25	31.8	43.2
Mali	1	100	0	0
Mozambique	1	0	100	0
Pakistan	1	0	100	0
Singapore	1	50	16.7	33.3
South Africa	1	0	66.7	33.3
Sweden	1	100	0	0
Taiwan	1	33.3	66.7	0
Tanzania	1	0	100	0
Togo	1	0	100	0
UK	1	100	0	0
Zambia	1	100	0	0
Angola	0	0	100	0
Bangladesh	0	0	0	100
Burundi	0	0	100	0
Cambodia	0	0	100	0
Canada	0	0	66.7	33.3
Central African Republic	0	0	100	0
Congo	0	0	100	0
Côte d'Ivoire	0	0	87.5	12.5
Democratic Republic of the Congo	0	0	100	0
Ethiopia	0	0	85.7	14.3

Country/Territory	**Number of Seizures**	**Percentage**		
		Destination	**Origin**	**Transit**
Equatorial Guinea	0	0	100	0
Ghana	0	50	0	50
Guinea	0	0	100	0
Italy	0	0	100	0
Liberia	0	0	87.5	12.5
Liechtenstein	0	0	100	0
Mexico	0	0	100	0
Morocco	0	0	0	100
Myanmar	0	19.4	55.6	25
Nigeria	0	0	97.6	2.4
Qatar	0	0	75	25
Russia	0	100	0	0
Saudi Arabia	0	0	0	100
Sierra Leone	0	0	100	0
Spain	0	0	50	50
Turkey	0	50	0	50
United Arab Emirates	0	0	75	25
Uruguay	0	100	0	0

Supplementary Material: Chapter 4

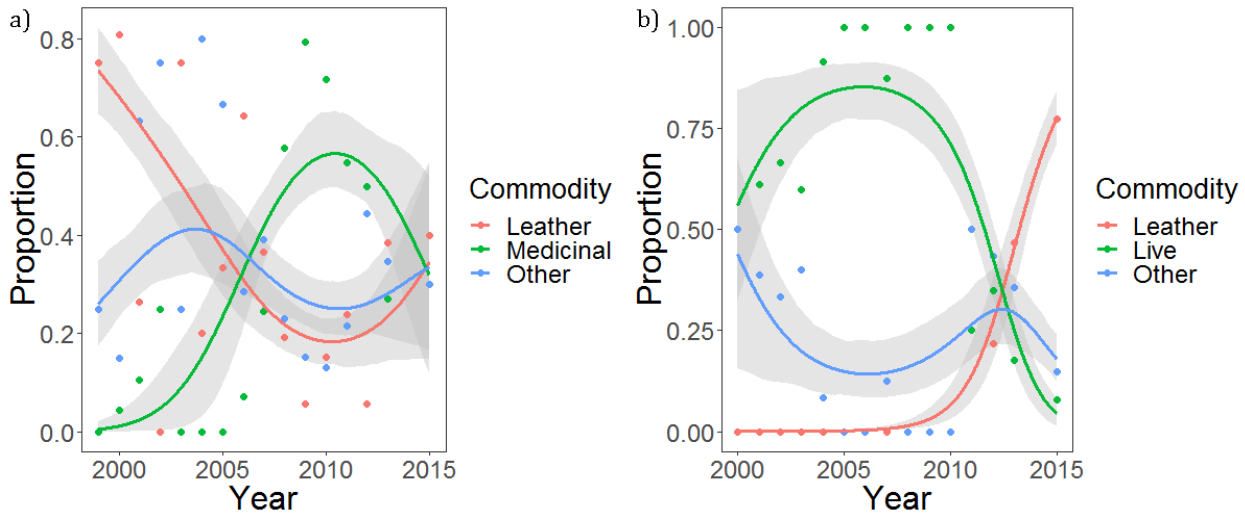

Figure S4.1: Change in the proportion of trade incidents from 1999 – 2015 reported in the LEMIS dataset of a) pangolins and b) arapaimas. The frequency of incidents was used in a logit regression model to create the fitted estimates and bootstrapped predictions were used to calculate 95% CI (shaded in grey). Note that the year 2014 is missing in both series.

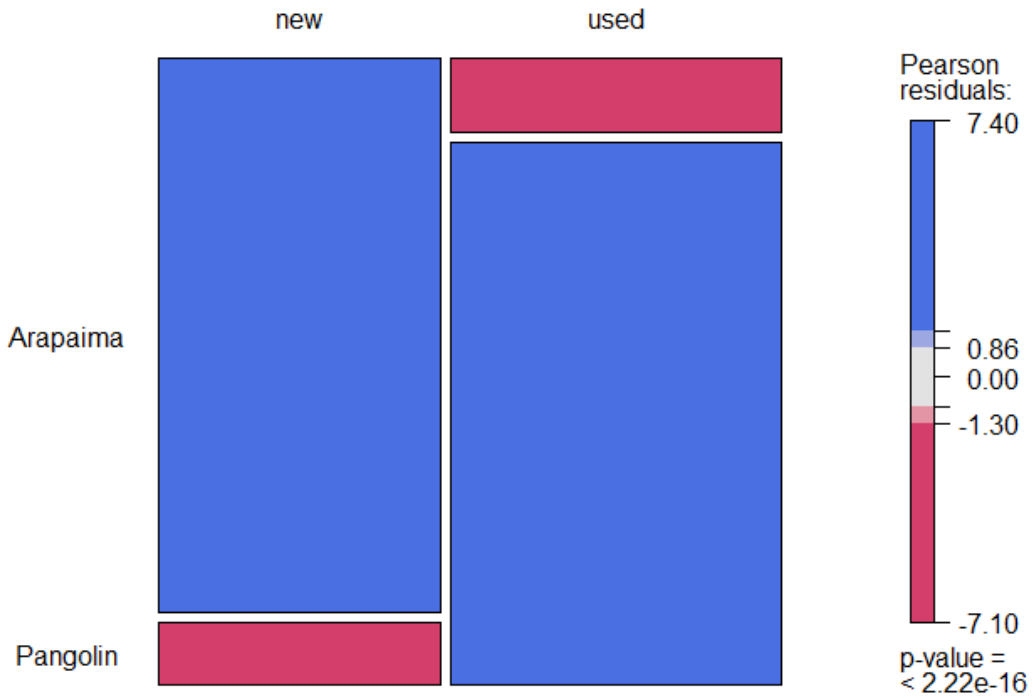

Figure S4.2: Mosaic plot of the deviation in conditional independence between leather products (being either genuine arapaima ('Arapaima') or genuine pangolin ('Pangolin')) and the condition of the leather products ('New' or 'Used'; n = 322), as advertised on the US eBay website between September 2017 and May 2018. The size of each cell is proportional to the observed cell frequency for each trait. Following Zeileis et al. (2007), the residual-based shading reflects the cell contribution to the Chi-square statistic: If the observed frequency is significantly greater than expected under independence the cells are shaded in blue, when the observed frequency is significantly less, the cells are shaded in red, as shown in the legend of the plot.

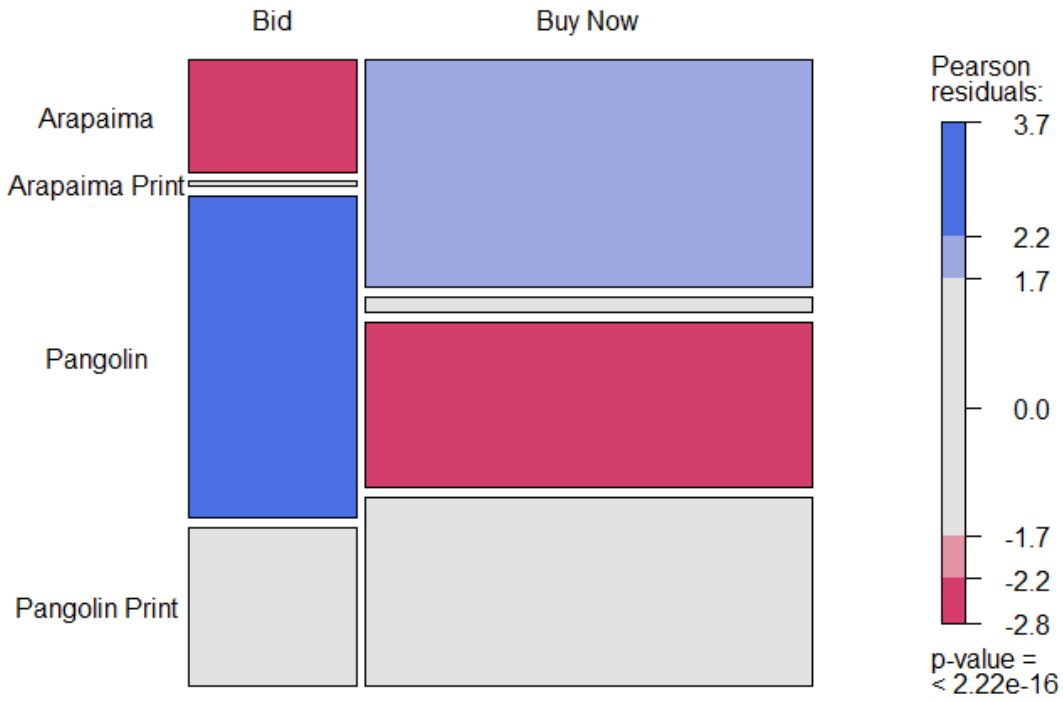

Figure S4.3: Mosaic plot of the deviation in conditional independence between the leather products advertised on the US eBay website from September 2017 to May 2018 (being either: i) Genuine arapaima ('Arapaima'); ii) Genuine pangolin ('Pangolin'); iii) Imitation pangolin leather ('Pangolin Print'); or iv) Imitation arapaima leather ('Arapaima Print')) and the auction type ('Bid' or 'Buy Now'; n = 469). The size of each cell is proportional to the observed cell frequency for each trait. Following Zeileis et al. (2007), the residual-based shading reflects the cell contribution to the Chi-square statistic: If the observed frequency is significantly greater than expected under independence the cells are shaded in blue, when the observed frequency is significantly less, the cells are shaded in red, as shown in the legend of the plot.

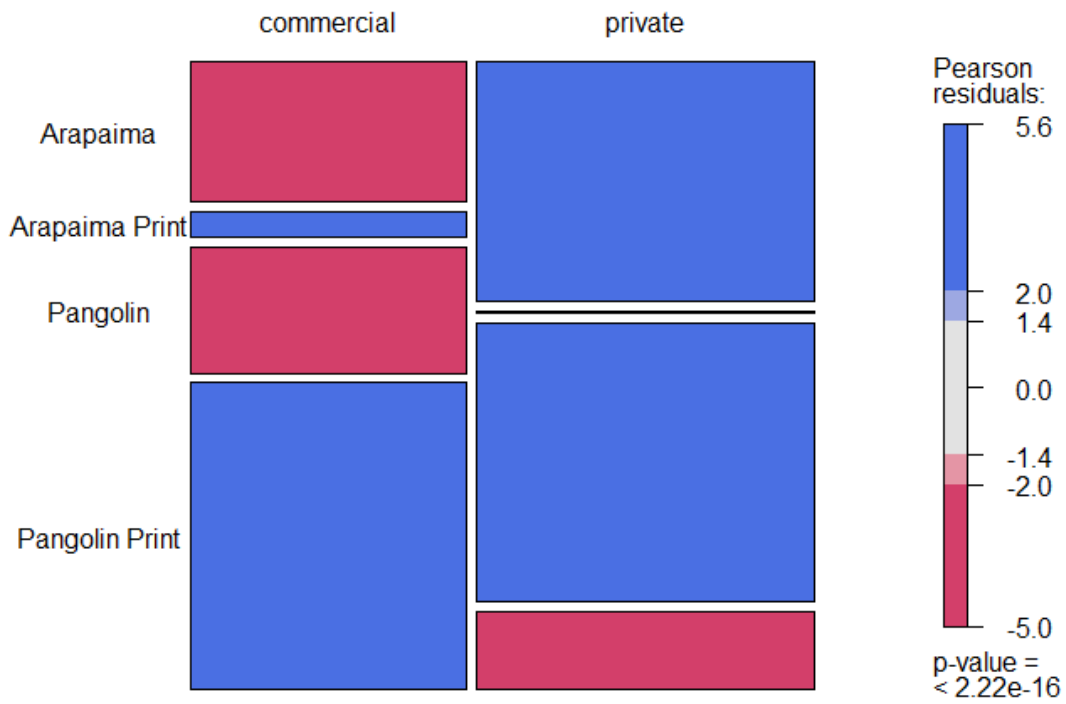

Figure S4.4: Mosaic plot of the deviation in conditional independence between the leather products advertised on the US eBay website from September 2017 to May 2018 (being either: i) Genuine arapaima ('Arapaima'); ii) Genuine pangolin ('Pangolin'); iii) Imitation pangolin leather ('Pangolin Print'); or iv) Imitation arapaima leather ('Arapaima Print')) and the status of the seller ('Private' or 'Commercial'; n = 473). The size of each cell is proportional to the observed cell frequency for each trait. Following Zeileis et al. (2007), the residual-based shading reflects the cell contribution to the Chi-square statistic: If the observed frequency is significantly greater than expected under independence the cells are shaded in blue, when the observed frequency is significantly less, the cells are shaded in red, as shown in the legend of the plot.

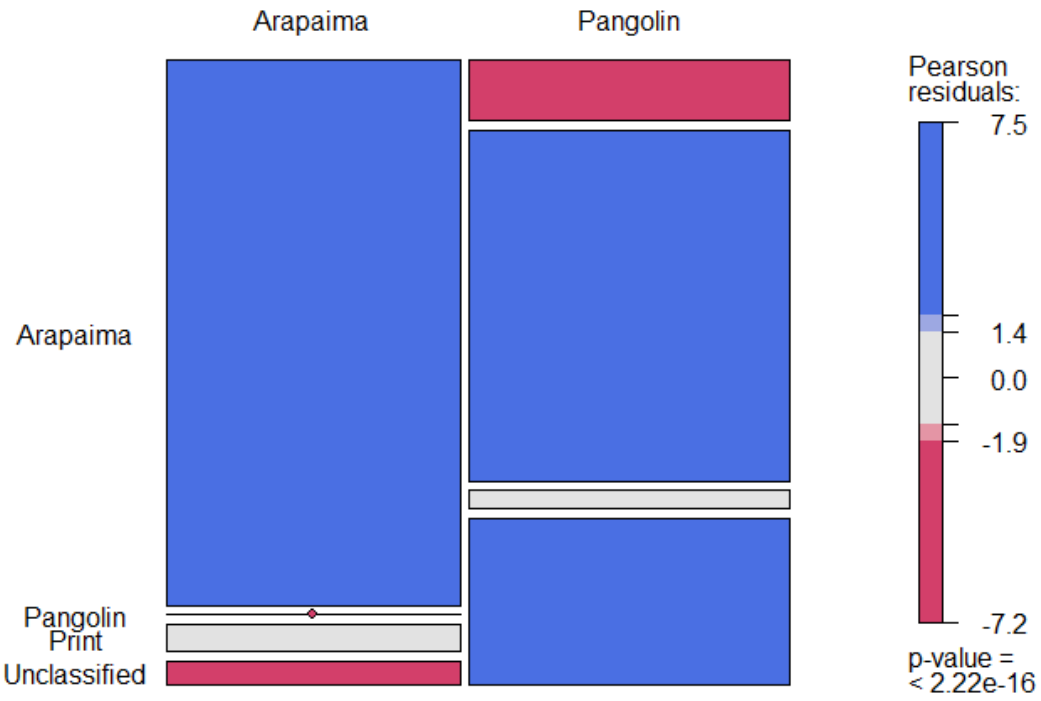

Figure S4.5: Mosaic plot of the deviation in conditional independence between the leather products advertised on the US eBay website from September 2017 to May 2018 (being advertised as either: i) Genuine arapaima ('Arapaima'); ii) Genuine pangolin ('Pangolin'); iii) Imitation leather of either pangolin or arapaima ('Print'); or iv) not being advertised as neither pangolin nor arapaima ('Unclassified')) and the true identity of the leather products, as classified based on the pictures provided in the advertisement (being either genuine arapaima ('Arapaima'), or genuine pangolin ('Pangolin'); n = 322, χ^2 = 228.19, df = 3, p < 0.001). The size of each cell is proportional to the observed cell frequency for each trait. Following Zeileis et al. (2007), the residual-based shading reflects the cell contribution to the Chi-square statistic: If the observed frequency is significantly greater than expected under independence the cells are shaded in blue, when the observed frequency is significantly less, the cells are shaded in red, as shown in the legend of the plot.

Supplementary Material: Chapter 6

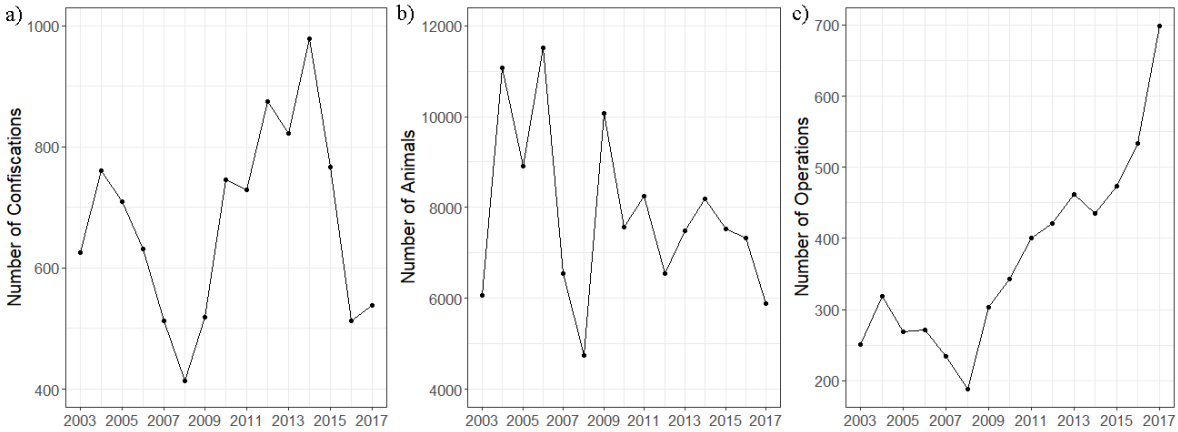

Figure S6.1: The total number of a) confiscations, and b) confiscated animals, from 2003 – 2017. Plotted is the raw data, as opposed to the residuals that are displayed in Figure 1.

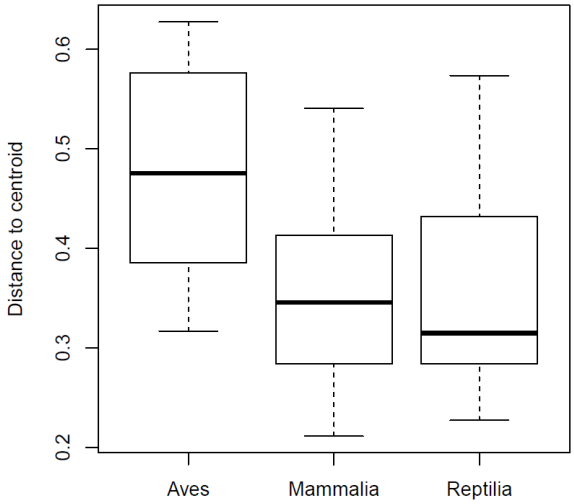

Figure S6.2: Boxplots of the temporal variation in beta diversity (i.e., dispersion) for bird, mammal, and reptile species, based on the species relative abundances in confiscations.

References

v) References

Agri-food and Veterinary Authority of Singapore (AVA) and Singapore Customs (2015). AVA and Singapore Customs seize shipment of illegal ivory and pangolin scales. http://www.ava.gov.sg/docs/default-source/defaultdocument-library/joint-media-release-by-ava-and-singapore-customs_17-dec-2015.pdf?sfvrsn=0. Viewed 4 June 2017.

Altherr, S. (2014). *Stolen Wildlife – Why the EU needs to tackle smuggling of nationally protected species.* Pro Wildlife, Munich (Germany).

Andersen, I. (2016). Seizure of huge African pangolin scale shipment points to worrying increase in trafficking http://www.iucn.org/news/seizure-huge-african-pangolin-scale-shipment-points-worrying-increase-trafficking. Viewed 24 June 2016.

Anderson, M. J. (2006). Distance-based tests for homogeneity of multivariate dispersions. *Biometrics.* **62**(1):245-253.

Anon. (2013a). Empat WN China ditangkap di Bandar Soetta. http://poskotanews.com/2013/01/04/empat-wn-china-ditangkap-di-bandara-soetta/. Viewed 2 August 217.

Anon. (2013b). Indonesia arrests 4 Chinese suspected of smuggling hornbill beaks, pangolins for medicines. http://www.foxnews.com/world/2013/01/07/indonesia-arrests-4-chinese-suspectedsmuggling-hornbill-beaks-pangolins-for.html. Viewed 2 August 2017.

Anon. (2015a). Zoll beschlagnahmt Schuppentier-Fleisch am Flughafen. https://www.muenchen.tv/zoll-beschlagnahmt-schuppentier-fleisch-am-flughafen-94755/. Viewed 24 April 2019.

Anon. (2015b). Zoll beschlagnahmt gefährliches Fleisch. https://www.abendzeitung-muenchen.de/inhalt.hauptzollamt-muenchen-zoll-beschlagnahmt-gefaehrliches-fleisch.26413225-9d84-4c2f-ac9d-7178a7441baa.html. Viewed 24 April 2019.

Anon. (2015c). China seizes 2674 smuggled pangolin carcasses. http://news.xinhuanet.com/english/2015-11/03/c_134776514.htm. Viewed 21 July 2016.

Anon. (2016a). Pangolin trade ring in Indonesian Borneo busted. https://www.malaysiakini.com/letters/360773#ixzz4QzJtjxBF. Viewed 8 August 2017.

Anon. (2016b). Largest Known Seizure of Pangolin Scales, It's Devastating. http://pangolinconservation.org/2016/07/19/largest-known-seizure-of-pangolin-scales-its-devastating/. Viewed 5 August 2016.

Anon. (2016c). Pangolin Seizure in Hong Kong Demonstrates Need for Stronger Protection for World's Most Trafficked Mammals. http://www.ifaw.org/united-states/news/pangolin-seizure-hong-kongdemonstrates-need-stronger-protection-world%E2%80%99s-most-trafficked-mammal. Viewed 5 August 2016.

Anon. (2017a). Indonesia seizes pangolins, scales worth $190,000. http://www.thestar.com.my/news/regional/2017/06/14/indonesia-seizes-pangolins-scales-worth-$190000/. Viewed 9 October 2017.

Anon. (2017b). Customs seizes more than 700 kg of pangolin scales worth RM9m. http://www.themalaymailonline.com/malaysia/article/customs-seizes-more-than-700kg-of-pangolin-scales-worth-rm9m. Viewed 15 June 2017.

Anon. (2019a). Singapore makes second huge seizure of pangolin scales in days. https://af.reuters.com/article/nigeriaNews/idAFL3N21S1UL. Viewed 24 April 2019.

Anon. (2019b). Hong Kong seizes record eight tonnes of pangolin scales. https://phys.org/news/2019-02-hong-kong-seizes-tonnes-pangolin.html. Viewed 24 April 2019.

ASEAN-WEN (2016). *ASEAN Handbook on Legal Cooperation to Combat Wildlife Crime*.

Ashwell, D. and Walston, N. (2008). An overview of the use and trade of plants and animals in traditional medicine systems in Cambodia. *TRAFFIC Southeast Asia, Greater Mekong Programme, Hanoi, Vietnam.* 112.

Asian Turtle Trade Working Group (2000). *Malayemys subtrijuga (errata version published in 2016).* The IUCN Red List of Threatened Species,

Auliya, M., Altherr, S., Ariano-Sanchez, D., Baard, E. H., Brown, C., Brown, R. M., Cantu, J.-C., Gentile, G., Gildenhuys, P., Henningheim, E., Hintzmann, J., Kanari, K., Krvavac, M., Lettink, M., Lippert, J., Luiselli, L., Nilson, G., Nguyen, T. Q., Nijman, V., Parham, J. F., Pasachnik, S. A., Pedrono, M., Rauhaus, A., Córdova, D. R., Sanchez, M.-E., Schepp, U., van Schingen, M., Schneeweiss, N., Segniagbeto, G. H., Somaweera, R., Sy, E. Y., Türkozan, O., Vinke, S., Vinke, T., Vyas, R., Williamson, S. and Ziegler, T. (2016). Trade in live reptiles, its impact on wild populations, and the role of the European market. *Biological Conservation.* **204**(Part A):103-119.

Baillie, J., Challender, D. W. S., Kaspal, P., Khatiwada, A., Mohapatra, R. and Nash, H. (2014). Manis crassicaudata. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12761A45221874.en. Viewed 20 June 2016.

Baselga, A. and Orme, C. D. L. (2012). betapart: an R package for the study of beta diversity. *Methods in Ecology and Evolution.* **3**(5):808-812.

Bennett, E. L. (2011). Another inconvenient truth: the failure of enforcement systems to save charismatic species. *Oryx.* **45**(4):476-479.

BfN (2014). *CITES Biennial Report 2013 - 2014 of the Federal Republic of Germany*. Federal Agency for Nature Conservation (BfN), Bonn (Germany).

BfN (2017). *CITES Biennial Report 2015 - 2017 of the Federal Republic of Germany*. Federal Agency for Nature Conservation (BfN), Bonn (Germany).

Bhattacharya, S. (2016). Slaughter of the songbirds. *Nature.* **529**(452 - 455.

Biggs, D., Cooney, R., Roe, D., Dublin, H. T., Allan, J. R., Challender, D. W. S. and Skinner, D. (2017). Developing a theory of change for a community-based response to illegal wildlife trade. *Conservation Biology.* **31**(1):5-12.

Blackburn, T., Scrivens, S., Heinrich, S. and Cassey, P. (2017). Patterns of selectivity in introductions of mammal species worldwide.

Blundell, A. G. and Mascia, M. B. (2005). Discrepancies in Reported Levels of International Wildlife Trade. *Conservation Biology.* **19**(6):2020-2025.

Boakye, M. K., Pietersen, D. W., Kotze, A., Dalton, D. L. and Jansen, R. (2014). Ethnomedicinal use of African pangolins by traditional medical practitioners in Sierra Leone. *Journal of ethnobiology and ethnomedicine.* **10**(76):

Bräutigam, A., Howes, J., Humphreys, T. and Hutton, J. (1994). Recent information on the status and utilization of African pangolins. *Traffic Bulletin.* **15**(1):15-22.

Broad, S. and Burgess, G. (2016). Synthetic Biology, Product Substitution and the Battle against Illegal Wildlife Trade. *Traffic Bulletin.* **28**(1):22-28.

Broad, S., Mulliken, T. and Roe, D. (2002). The Nature and Extent of Legal and Illegal Trade in Wildlife. In: Oldfield, S. (Ed.), *The trade in wildlife: regulation for conservation*. Taylor & Francis Group, New York (USA).

Brochet, A.-L., Van Den Bossche, W., Jbour, S., Ndang'Ang'A, P. K., Jones, V. R., Abdou, W. A. L. I., Al- Hmoud, A. R., Asswad, N. G., Atienza, J. C., Atrash, I., Barbara, N., Bensusan, K., Bino, T., Celada, C., Cherkaoui, S. I., Costa, J., Deceuninck, B., Etayeb, K. S., Feltrup-Azafzaf, C., Figelj, J., Gustin, M., Kmecl, P., Kocevski, V., Korbeti, M., KotroŠAn, D., Mula Laguna, J., Lattuada, M., LeitÃO, D., Lopes, P., LÓPez-JimÉNez, N., LuciĆ, V., Micol, T., Moali, A., Perlman, Y., Piludu, N., Portolou, D., Putilin, K., Quaintenne, G., Ramadan-Jaradi, G., RuŽIĆ, M., Sandor, A., Sarajli, N., SaveljiĆ, D., Sheldon, R. D., Shialis, T., Tsiopelas, N., Vargas, F., Thompson, C., Brunner, A., Grimmett, R. and Butchart, S. H. M. (2016). Preliminary

assessment of the scope and scale of illegal killing and taking of birds in the Mediterranean. *Bird Conservation International.* **26**(1):1-28.

Brooks, E. G. E., Roberton, S. I. and Bell, D. J. (2010). The conservation impact of commercial wildlife farming of porcupines in Vietnam. *Biological Conservation.* **143**(11):2808-2814.

Brooks, M. E., Kristensen, K., van Benthem, K. J., Magnusson, A., Berg, C. W., Nielsen, A., Skaug, H. J., Machler, M. and Bolker, B. M. (2017). glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. *The R journal.* **9**(2):378-400.

Brooks, S. E., Allison, E. H. and Reynolds, J. D. (2007). Vulnerability of Cambodian water snakes: Initial assessment of the impact of hunting at Tonle Sap Lake. *Biological Conservation.* **139**(3):401-414.

Broussard, G. (2017). Building an Effective Criminal Justice Response to Wildlife Trafficking: Experiences from the ASEAN Region. *Review of European, Comparative & International Environmental Law.* **26**(2):118-127.

Burgess, E. A., Stoner, S. S. and Foley, K.-E. (2014). *Brought to Bear: An Analysis of Seizures across Asia (2000-2011)*. TRAFFIC Southeast Asia, Petalin Jaya, Selangor (Malaysia).

Carrillo-Páez, C. C. (2018). Wildlife Trafficking by Parcel Service: A National Problem that Threatens Biodiversity. In: Arroyo-Quiroz, I. and Wyatt, T. (Ed.), *Green Crime in Mexico: A Collection of Case Studies*. 115-125. Palgrave Macmillan, Cham,

Castello, L. and Stewart, D. J. (2010). Assessing CITES non-detriment findings procedures for Arapaima in Brazil. *Journal of Applied Ichthyology.* **26**(1):49-56.

Castello, L., Arantes, C. C., Mcgrath, D. G., Stewart, D. J. and Sousa, F. S. D. (2015). Understanding fishing-induced extinctions in the Amazon. *AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS.* **25**(5):587-598.

Cavole, L. M., Arantes, C. C. and Castello, L. (2015). How illegal are tropical small-scale fisheries? An estimate for arapaima in the Amazon. *Fisheries Research.* **168**(Supplement C):1-5.

Chaber, A.-L., Allebone-Webb, S., Lignereux, Y., Cunningham, A. A. and Rowcliffe, M. J. (2010). The scale of illegal meat importation from Africa to Europe via Paris. *Conservation Letters.* **3**(5):317-321.

Challender, D. W. S. (2011). Asian pangolins: Increasing affluence driving hunting pressure. *Traffic Bulletin.* **23**(3):92-93.

Challender, D. W. S. and Hywood, L. (2012). African pangolins - Under increased pressure from poaching and intercontinental trade. *Traffic Bulletin.* **24**(2):53-55.

Challender, D. W. S. and MacMillan, D. C. (2014). Poaching is more than an Enforcement Problem. *Conservation Letters.* **7**(5):484-494.

Challender, D. W. S. and Waterman, C. (2017). Implementation of CITES Decisions 17.239 b) and 17.240 on Pangolins (Manis spp.).

Challender, D. W. S., Waterman, C. and Baillie, J. (2014a). *Scaling up pangolin conservation*. Zoological Society of London, London (UK).

Challender, D. W. S., Harrop, S. R. and MacMillan, D. C. (2015a). Towards informed and multi-faceted wildlife trade interventions. *Global Ecology and Conservation.* **3**(129-148.

Challender, D. W. S., Harrop, S. R. and MacMillan, D. C. (2015b). Understanding markets to conserve trade-threatened species in CITES. *Biological Conservation.* **187**(249-259.

Challender, D. W. S., Heinrich, S., Shepherd, C. R. and Katsis, L. K. D. (2019a). International trade and trafficking in pangolins, 1900-2019. In: Challender, D. W. S. and Nash, H. (Ed.), *Pangolins: Science, Society, and Conservation*. Elsevier,

Challender, D. W. S., Baillie, J., Ades, G., Kaspal, P., Chan, B., Khatiwada, A., Xu, L., Chin, S., KC, R., Nash, H. and Hsieh, H. (2014b). Manis pentadactyla. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12764A45222544.en. Viewed 20 June 2016.

Challender, D. W. S., Baillie, J., Waterman, C., Pietersen, D., Nash, H., Wicker, L., Parker, K., Thomson, P., Nguyen, T. V., Hywood, L. and Shepherd, C. R. (2016). On scaling up pangolin conservation. *Traffic Bulletin.* **28**(1):19-21.

Challender, D. W. S., Nguyen Van, T., Shepherd, C. R., Krishnasamy, K., Wang, A., Lee, B., , Panjang, E., Fletcher, L., Heng, S., Seah Han Ming, J., Olsson, A., Nguyen The Truong, A., Nguyen Van, Q. and Chung, Y. (2014c). Manis javanica. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12763A45222303.en. Viewed 20 June 2016.

Challender, D. W. S., t'Sas-Rolfes, M., Ades, G. W. J., Chin, J. S. C., Ching-Min Sun, N., Chong, J. l., Connelly, E., Hywood, L., Luz, S., Mohapatra, R. K., de Ornellas, P., Parker, K., Pietersen, D. W., Roberton, S. I., Semiadi, G., Shaw, D., Shepherd, C. R., Thomson, P., Wang, Y., Wicker, L., Wu, S. B. and Nash, H. C. (2019b). Evaluating the feasibility of pangolin farming and its potential conservation impact. *Global Ecology and Conservation.* **20**(e00714.

Chan, J. (2017). Illegal and exotic meat on Sabah's menu. http://www.themalaymailonline.com/malaysia/article/illegal-and-exotic-meats-on-sabahs-menus#V5tZJ78PMVWYzey6.97. Viewed 2 August 2017.

Chang, W., Cheng, J., Allaire, J., Xie, Y. and McPherson, J. (2016). Shiny: Web Application Framework for R. *R package version 0.13.2.*

Cheng, W., Xing, S. and Bonebrake, T. C. (2017). Recent Pangolin Seizures in China Reveal Priority Areas for Intervention. *Conservation Letters.* **10**(6):757-764.

China Biodiversity Conservation and Green Development Foundation (2016). *An overview of pangolin data: when will the over-exploitation of the pangolin end? Data analysis based on government information and suggestions for conservation*.

Chng, S. C. L., Eaton, J. A., Krishnasamy, K., Shepherd, C. R. and Nijman, V. (2015). In the market for extinction: an inventory of Jakarta's bird markets. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

CITES (1992). *Final Report of the CITES Animal Committee , AC 6-7: Manis*. CITES Animals Committee,

CITES (1994). *Notification to the Parties No. 788 - Annual Reports*. Geneva (Switzerland).

CITES (1997). Conf. 10.10 - Trade in elephant specimens In: (Ed.), *Tenth meeting of the Conference of the Parties*, Harare (Zimbabwe).

CITES (1999). Manis javanica. In: (Ed.), *Fifteenth meeting of the Animals Committee*, Antananarivo (Madagascar).

CITES (2000a). Consideration of Proposals for Amendment of Appendices I and II. In: (Ed.), *Eleventh Conference of Parties*, Gigiri (Kenya).

CITES (2000b). Amendments to Appendices I and II of the Convention In: (Ed.), *Eleventh meeting of the Conference of the Parties* Girigiri (Kenya).

CITES (2010). Ranching and trade in ranched specimens of species transferred from Appendix I to Appendix II. In: (Ed.), *Fifteenth meeting of the Conference of the Parties*, Doha (Qatar).

CITES (2013a). *A guide to using the CITES Trade Database*. United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), Cambridge (UK).

CITES (2013b). Decisions 16.41 and 16.42. In: (Ed.), *Sixteenth Meeting of the Conference of Parties*, Bangkok (Thailand).

CITES (2015). Report of the first pangolin range states meeting. In: (Ed.), Da Nang (Viet Nam).

CITES (2016a). Proposal 11 - Transfer Manis javanica and M. pentadactyla from CITES Appendix II to Appendix I. In: (Ed.), *Seventeenth meeting of the Conference of the Parties*, Johannesburg (South Africa).

CITES (2016b). SC67 Doc. 12.1. Application of Article XIII In Lao People's Democratic Republic. In: (Ed.), *CITES Sixty-seventh meeting of the Standing Committee*, Johannesburg (South Africa).

CITES (2016c). Notification 2016/063 - Amendments to Appendices I and II of the Convention. adopted by the Conference of the Parties at its 17th meeting, Johannesburg (South Africa), 24 September – 4 October 2016. Geneva (Switzerland).

CITES (2016d). List of proposals for amendment of Appendices I and II. In: (Ed.), *Seventeenth meeting of the Conference of the Parties*, Johannesburg (South Africa).

CITES (2016e). Notification to the parties No. 2016/007. New annual illegal trade report. Geneva (Switzerland).

CITES (2017a). *Guidelines for the preparation and submission of CITES annual reports*. Geneva (Switzerland).

CITES (2017b). Notification to the Parties No. 2017/035 -- Information on the status, trade and conservation of pangolin species. Geneva (Switzerland).

CITES (2018). National Legislation Project: Status of Legislative Progress for Implementing CITES. https://cites.org/eng/legislation/National_Legislation_Project. Viewed

Clark, L., Van Thai, N. and Phuong, T. Q. (2009). A long way from home: the health status of Asian pangolins confiscated from the illegal wildlife trade in Viet Nam. *Workshop on Trade and Conservation of Pangolins Native to South and Southeast Asia*, Singapore Zoo. 111.

Coggins, C. (2003). The tiger and the pangolin: nature, culture, and conservation in China. University of Hawaii Press, Honolulu (USA).

Coghlan, M. L., Maker, G., Crighton, E., Haile, J., Murray, D. C., White, N. E., Byard, R. W., Bellgard, M. I., Mullaney, I., Trengove, R., Allcock, R. J. N., Nash, C., Hoban, C., Jarrett, K., Edwards, R., Musgrave, I. F. and Bunce, M. (2015). Combined DNA, toxicological and heavy metal analyses provides an auditing toolkit to improve pharmacovigilance of traditional Chinese medicine (TCM). *Scientific Reports.* **5**(17475.

Conniff, R. (2013). Poaching Pangolins: An Obscure Creature Faces Uncertain Future. Yale Environment 360, http://e360.yale.edu/feature/poaching_pangolins_an_obscure_creature_faces_uncertain_future/2692/. Viewed 27 July 2016.

Cooney, R., Kasterine, A., MacMillan, D., Milledge, S. A., Nossal, K., Roe, D. and John't Sas-Rolfes, M. (2015). The trade in wildlife: a framework to improve biodiversity and livelihood outcomes. International Trade Centre,

Cortegano, C. A. A., de Godoy, L. C., Petenuci, M. E., Visentainer, J. V., Affonso, E. G. and Gonçalves, L. U. (2017). Nutritional and lipid profiles of the dorsal and ventral muscles of wild pirarucu. *Pesquisa Agropecuária Brasileira.* **52**(4):271-276.

Cota-Larson, R. (2017). *Pangolin Species Identification Guide: A Rapid Assessment Tool for Field and Desk.* USAID Wildlife Asia Activity, Bangkok (Thailand).

Courchamp, F., Angulo, E., Rivalan, P., Hall, R. J., Signoret, L., Bull, L. and Meinard, Y. (2006). Rarity Value and Species Extinction: The Anthropogenic Allee Effect. *PLOS Biology.* **4**(12):e415.

Csardi, G. and Nepusz, T. (2006). The igraph software package for complex network research. *International Journal of Complex Systems.*

D'Cruze, N. and Macdonald, D. W. (2016). A review of global trends in CITES live wildlife confiscations. *Nature Conservation.* **15**(47-63.

Di Lorenzo, P. (2018). usmap: US Maps Including Alaska and Hawaii. *R package version 0.3.0.*

Di Minin, E., Fink, C., Tenkanen, H. and Hiippala, T. (2018). Machine learning for tracking illegal wildlife trade on social media. *Nature Ecology & Evolution.*

Di Minin, E., Brooks, T. M., Toivonen, T., Butchart, S. H. M., Heikinheimo, V., Watson, J. E. M., Burgess, N. D., Challender, D. W. S., Goettsch, B., Jenkins, R. and Moilanen, A. (2019). Identifying global centers of unsustainable commercial harvesting of species. *Science Advances.* **5**(4):eaau2879.

Drury, R. (2009). Reducing urban demand for wild animals in Vietnam: examining the potential of wildlife farming as a conservation tool. *Conservation Letters.* **2**(6):263-270.

Drury, R. (2011). Hungry for success: urban consumer demand for wild animal products in Vietnam. *Conservation and Society.* **9**(3):247-257.

Duckworth, J. W., Salter, R. E. and Khounboline, K. (1999). Wildlife in Lao PDR: 1999 status report. IUCN, Wildlife Conservation Society, Centre for Protected Areas and Watershed Management, Vientiane (Lao PDR).

Duckworth, J. W., Batters, G., Belant, J. L., Bennett, E. L., Brunner, J., Burton, J., Challender, D. W. S., Cowling, V., Duplaix, N. and Harris, J. D. (2012). Why South-east Asia should be the

world's priority for averting imminent species extinctions, and a call to join a developing cross-institutional programme to tackle this urgent issue. *S.A.P.I.EN.S. Surveys and Perspectives Integrating Environment and Society.* **5**(2):77-95.

Dudley, J. P., Ginsberg, J. R., Plumptre, A. J., Hart, J. A. and Campos, L. C. (2002). Effects of war and civil strife on wildlife and wildlife habitats. *Conservation Biology.* **16**(2):319-329.

Duffin, C. J. (2013). Porcupine stones. *Pharm Hist (Lond).* **43**(1):13-22.

Dunning, J. B. J. (2008). CRC Handbook of Avian Body Masses. Taylor & Francis Group,

Eaton, J. A., Shepherd, C. R., Rheindt, F. E., Harris, J. B. C., Van Balen, S. B., Wilcove, D. S. and Collar, N. J. (2015). Trade-driven extinctions and near-extinctions of avian taxa in Sundaic Indonesia. *Forktail.* **31**(1-12.

EIA (2015). *Sin City - Illegal wildlife trade in Laos Golden Triangle special economic zone*. Environmental Investigation Agency (EIA), London (UK).

EIA (2018). *Taking Stock: An assessment of progress under the National Ivory Action Plan process*. Environmental Investigation Agency,

Ellis, R. (2005). Tiger bone & rhino horn: the destruction of wildlife for traditional Chinese medicine. Island Press, Washington (USA).

Emmett, D. (2009). Current conservation status of turtles in Cambodia. *Turtle Log.* **1**(

Engler, M. and Parry-Jones, R. (2007). *Opportunity or threat: The role of the European Union in global wildlife trade*. TRAFFIC Europe, Brussels (Belgium).

FAO (2012). *Cultured Aquatic Species Information Programme: Arapaima gigas*. Food and Agriculture Organization (FAO), Rome (Italy).

Foster, S., Wiswedel, S. and Vincent, A. (2016). Opportunities and challenges for analysis of wildlife trade using CITES data - seahorses as a case study. *AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS.* **26**(1):154-172.

Frank, E. G. and Wilcove, D. S. (2019). Long delays in banning trade in threatened species. *Science.* **363**(6428):686-688.

Gannon, M. (2014). Rare Pangolins May Be Eaten to Extinction, Conservationists Warn. http://www.livescience.com/47073-pangolins-may-be-eaten-to-extinction.html. Viewed 5 August 2016.

Gaubert, P. (2011). Family Manidae (Pangolins). In: Wilson, D. E. and Mittermeier, R. A. (Ed.), *Handbook of the Mammals of the World*. Chapter 2 - Hoofed Mammals: 82-103. Lynx Edicions, Barcelona (Spain).

Gaubert, P., Njiokou, F., Ngua, G., Afiademanyo, K., Dufour, S., Malekani, J., Bi, S. G., Tougard, C., Olayemi, A., Danquah, E., Djagoun, C. A., Kaleme, P., Mololo, C. N., Stanley, W., Luo, S. J. and Antunes, A. (2016). Phylogeography of the heavily poached African common pangolin (Pholidota, Manis tricuspis) reveals six cryptic lineages as traceable signatures of Pleistocene diversification. *Molecular Ecology.* **25**(23):5975-5993.

Gerson, H., Cudmore, B., Mandrak, N. E., Coote, L. D., Farr, K. and Baillargeon, G. (2008). Monitoring international wildlife trade with coded species data. *Conservation Biology.* **22**(1):4-7.

Gilbert, M., Sokha, C., Joyner, P. H., Thomson, R. L. and Poole, C. (2012). Characterizing the trade of wild birds for merit release in Phnom Penh, Cambodia and associated risks to health and ecology. *Biological Conservation.* **153**(10-16.

Gomez, L., Leupen, B. T. C. and Heinrich, S. (2016a). *Observations on the illegal pangolin trade in Lao PDR*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Gomez, L., Leupen, B. T. C. and Hwa, T. K. (2016b). The trade of African pangolins to Asia: A brief case study of pangolin shipments from Nigeria. *Traffic Bulletin.* **28**(1):3-5.

Gray, T., Milliken, T., Khem, V. and Gauntlett, S. (2017a). Cambodia's increasing role in the African ivory and rhinoceros horn trade. *Traffic Bulletin.* **29**(45-46.

Gray, T. N. E. and Prum, S. (2012). Leopard density in post-conflict landscape, Cambodia: Evidence from spatially explicit capture–recapture. *The Journal of Wildlife Management.* **76**(1):163-169.

Gray, T. N. E., Marx, N., Khem, V., Lague, D., Nijman, V. and Gauntlett, S. (2017b). Holistic management of live animals confiscated from illegal wildlife trade. *Journal of Applied Ecology.* **54**(3):726-730.

Gray, T. N. E., Hughes, A. C., Laurance, W. F., Long, B., Lynam, A. J., O'Kelly, H., Ripple, W. J., Seng, T., Scotson, L. and Wilkinson, N. M. (2018). The wildlife snaring crisis: an insidious and pervasive threat to biodiversity in Southeast Asia. *Biodiversity and conservation.* **27**(4):1031-1037.

Hallett, L. M., Jones, S. K., MacDonald, A. A. M., Jones, M. B., Flynn, D. F., Ripplinger, J., Slaughter, P., Gries, C. and Collins, S. L. (2016). codyn: an R package of community dynamics metrics. *Methods in Ecology and Evolution.* **7**(10):1146-1151.

Hallmann, K. and Griebeler, E. M. (2018). An exploration of differences in the scaling of life history traits with body mass within reptiles and between amniotes. *Ecology and evolution.* **8**(11):5480-5494.

Harrington, L., D'Cruze, N. and Macdonald, D. (2018). Rise to fame: Events, media activity and public interest in pangolins and pangolin trade, 2005-2016. 107-133.

Harrison, M., Roe, D., Baker, J., Mwedde, G., Travers, H., Plumptre, A., Rwetsiba, A. and Milner-Gulland, E. J. (2015). *Wildlife crime: a review of the evidence on drivers and impacts in Uganda*. IIED, London (UK).

Harrison, R. D., Sreekar, R., Brodie, J. F., Brook, S., Luskin, M., O'Kelly, H., Rao, M., Scheffers, B. and Velho, N. (2016). Impacts of hunting on tropical forests in Southeast Asia. *Conservation Biology.* **30**(5):972-981.

Harrisson, T. and Loh, C. Y. (1965). To scale a pangolin. *Sarawak Museum Journal.* **12**(25-26):415-418.

Hastie, J. and McCrea-Steele, T. (2014). *Wanted - Dead or Alive: Exposing Online Wildlife Trade*. International Fund for Animal Welfare (IFAW), London (UK).

Haysom, S. (2019). *In search of cyber-enabled discruption - Insights from the Digital Dangers project*. The Global Initiative Against Transnational Organized Crime, Geneva (Switzerland).

Heath, M. E. (1992a). Manis temminckii. *Mammalian Species.* 415):1-5.

Heath, M. E. (1992b). Manis pentadactyla. *The American Society of Mammalogists.* **414**(1-3.

Heath, M. E. and Hammel, H. T. (1986). Body temperature and rate of O2 consumption in Chinese pangolins. *American Journal of Physiology.* **250**(3):377-382.

Heath, M. E. and Vanderlip, S. L. (1988). Biology, husbandry, and veterinary care of captive Chinese pangolins (Manis pentadactyla). *Zoo biology.* **7**(4):293-312.

Heinrich, S., Wittmann, T. A., Prowse, T. A. A., Ross, J. V., Delean, S., Shepherd, C. R. and Cassey, P. (2016). Where did all the pangolins go? International CITES trade in pangolin species. *Global Ecology and Conservation.* **8**(241-253.

Hua, L., Gong, S., Wang, F., Li, W., Ge, Y., Li, X. and Hou, F. (2015). Captive breeding of pangolins: current status, problems and future prospects. *ZooKeys.* **507**(99-114.

Ingram, D. J., Cronin, D. T., Challender, D. W. S., Venditti, D. M. and Gonder, M. K. (2019). Characterising trafficking and trade of pangolins in the Gulf of Guinea. *Global Ecology and Conservation.* **17**(e00576.

Ingram, D. J., Coad, L., Abernethy, K. A., Maisels, F., Stokes, E. J., Bobo, K. S., Breuer, T., Gandiwa, E., Ghiurghi, A. and Greengrass, E. (2017). Assessing Africa-Wide Pangolin Exploitation by Scaling Local Data. *Conservation Letters.*

IUCN (2019). *The IUCN Red List of Threatened Species.* **Version 2019-2**(

Jacobs, R. L., McClure, P. J., Baker, B. W. and Espinoza, E. O. (2019). Myth debunked: Keratinous pangolin scales do not contain the analgesic tramadol. *Conservation Science and Practice.* **1**(9):

Janssen, J. and Blanken, L. J. (2016). *Going Dutch: An analysis of the import of live animals from Indonesia by the Netherlands*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Janssen, J. and Chng, S. C. L. (2018). Biological parameters used in setting captive-breeding quotas for Indonesia's breeding facilities. *Conservation Biology.* **32**(1):18-25.

Janssen, J. and de Silva, A. (2019). The presence of protected reptiles from Sri Lanka in international commercial trade. *Traffic Bulletin.* **31**(1):9 - 15.

Johnson, R. N., Wilson-Wilde, L. and Linacre, A. (2014). Current and future directions of DNA in wildlife forensic science. *Forensic Science International: Genetics.* **10**(1-11.

Jost, L. (2006). Entropy and diversity. *Oikos.* **113**(2):363-375.

Katuwal, H. B., Neupane, K. R., Adhikari, D. and Thapa, S. (2013). *Pangolins Trade, Ethnic Importance and its Conservation in Eastern Nepal*. Small Mammals Conservation and Research Foundation and WWF-Nepal, Kathmandu (Nepal).

Khatri-Chhetri, R., Wang, H.-C., Chen, C.-C., Shih, H.-C., Liao, H.-C., Sun, C.-M., Khatri-Chhetri, N., Wu, H.-Y. and Pei, K. J.-C. (2016). Surveillance of ticks and associated pathogens in free-ranging Formosan pangolins (Manis pentadactyla pentadactyla). *Ticks and Tick-borne Diseases.* **7**(6):1238-1244.

Khwaja, H., Buchan, C., Wearn, O. R., Bahaa-el-din, L., Bantlin, D., Bernard, H., Bitariho, R., Bohm, T., Borah, J., Brodie, J., Chutipong, W., Preez, B. d., Ebang-Mbele, A., Edwards, S., Fairet, E., Frechette, J. L., Garside, A., Gibson, L., Giordano, A., Veeraswami Gopi, G., Granados, A., Gubbi, S., Harich, F., Haurez, B., Havmøller, R. W., Helmy, O., Isbell, L. A., Jenks, K., Kalle, R., Kamjing, A., Khamcha, D., Kiebou-Opepa, C., Kinnaird, M., Kruger, C., Laudisoit, A., Lynam, A., Macdonald, S. E., Mathai, J., Sienne, J. M., Meier, A., Mills, D., Mohd-Azlan, J., Nakashima, Y., Nash, H. C., Ngoprasert, D., Nguyen, A., O'Brien, T., Olson, D., Orbell, C., Poulsen, J., Ramesh, T., Reeder, D., Reyna, R., Rich, L. N., Rode-Margono, J., Rovero, F., Sheil, D., Shirley, M. H., Stratford, K., Sukumal, N., Suwanrat, S., Tantipisanuh, N., Tilker, A., Van Berkel, T., Van der Weyde, L. K., Varney, M., Weise, F., Wiesel, I., Wilting, A., Wong, S. T., Waterman, C. and Challender, D. W. S. (2019). Pangolins in global camera trap data: Implications for ecological monitoring. *Global Ecology and Conservation.* **20**(e00769.

Kideghesho, J. R. (2016). Reversing the trend of wildlife crime in Tanzania: challenges and opportunities. *Biodiversity and conservation.* **25**(3):427-449.

Klaas, K., Sina, S. and Gerstetter, C. (2016). *Wildlife Crime in Germany*. European Parliament Policy Department A: Economic and Scientific Policy, Brussels (Belgium).

Krishnasamy, K. and Stoner, S. (2016). *Trading Faces: A Rapid Assessment on the use of Facebook to Trade Wildlife in Peninsular Malaysia*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Krishnasamy, K. and Shepherd, C. R. (2017). Seizure of African pangolin scales in Malaysia in 2017. *Traffic Bulletin.* **29**(2):52-54.

Lagrada, L., Schoppe, S. and Challender, D. (2014). Manis culionensis. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T136497A45223365.en. Viewed 20 June 2016.

LeCun, Y., Bengio, Y. and Hinton, G. (2015). Deep learning. *Nature.* **521**(7553):436-444.

Lee, J., Chng, S. and Eaton, J. (2016). Conservation strategy for Southeast Asian songbirds in trade. Recommendations from the first Asian Songbird Trade Crisis Summit 2015 held in Jurong Bird Park, Singapore, 27–29 September 2015. Wildlife Reserves Singapore. *TRAFFIC Southeast Asia.*

Lim, N. T. L. and Ng, P. K. L. (2008). Home range, activity cycle and natal den usage of a female Sunda pangolin Manis javanica (Mammalia: Pholidota) in Singapore. *Endangered Species Research.* **4**(233-240.

Lima Junior, D. P., Magalhães, A. L. B., Pelicice, F. M., Vitule, J. R. S., Azevedo-Santos, V. M., Orsi, M. L., Simberloff, D. and Agostinho, A. A. (2018). Aquaculture expansion in Brazilian freshwaters against the Aichi Biodiversity Targets. *Ambio.* **47**(4):427-440.

Loucks, C., Mascia, M. B., Maxwell, A., Huy, K., Duong, K., Chea, N., Long, B., Cox, N. and Seng, T. (2009). Wildlife decline in Cambodia, 1953–2005: exploring the legacy of armed conflict. *Conservation Letters.* **2**(2):82-92.

Lunde, D., Aplin, K. and Molur, S. (2016). *Hystrix brachyura (errata version published in 2017)*. The IUCN Red List of Threatened Species,

Lyons, J. A. and Natusch, D. J. D. (2011). Wildlife laundering through breeding farms: Illegal harvest, population declines and a means of regulating the trade of green pythons (Morelia viridis) from Indonesia. *Biological Conservation.* **144**(12):3073-3081.

MacGregor, J. (2006). *The Call Of The Wild: Captive Crocodilian Production And The Shaping Of Conservation Incentives*. TRAFFIC, Cambridge (UK).

MaMing, R., Zhang, T., Blank, D., Ding, P. and Zhao, X. (2012). Geese and ducks killed by poison and analysis of poaching cases in China. *Goose Bulletin.* **15**(2-11.

Martin, E. B. and Phipps, M. (1996). A review of the wild animal trade in Cambodia. *TRAFFIC Bulletin-Wildlife Trade Monitoring Unit.* **16**(45-60.

Maxwell, S. L., Fuller, R. A., Brooks, T. M. and Watson, J. E. (2016). Biodiversity: The ravages of guns, nets and bulldozers. *Nature.* **536**(7615):143-145.

McClenachan, L., Cooper, A. B. and Dulvy, N. K. (2016). Rethinking Trade-Driven Extinction Risk in Marine and Terrestrial Megafauna. *Current Biology.* **26**(12):1640-1646.

McNamara, J., Rowcliffe, M., Cowlishaw, G., Alexander, J. S., Ntiamoa-Baidu, Y., Brenya, A. and Milner-Gulland, E. J. (2016). Characterising Wildlife Trade Market Supply-Demand Dynamics. *PloS one.* **11**(9):e0162972.

McNeely, J. A. (2003). Conserving forest biodiversity in times of violent conflict. *Oryx.* **37**(2):142-152.

Meyer, D., Zeileis, A. and Hornik, K. (2017). vcd: Visualizing Categorical Data. R package version 1.4-4.

Milliken, T., Underwood, F. M., Burn, R. W. and Sangalakula, L. (2013). Doc. 53.2.2 (Rev. 1). Interpretation and implementation of the Convention - species trade and conservation: elephants. Monitoring of illegal trade in ivory and other elephant specimens. In: (Ed.), *16th Conference of the Parties*, Gland (Switzerland).

Milliken, T., Underwood, F. M., Burn, R. W. and Sangalakula, L. (2016). Doc. 57.6 (Rev. 1) - The Elephant Trade Information System (ETIS) and the illicit trade in ivory: A report to the 17th meeting of the Conference of the Parties to CITES. In: (Ed.), *CoP17*, Johannesburg (South Africa).

Mohapatra, R. K. and Panda, S. (2014). Husbandry, behaviour and conservation breeding of Indian pangolin. *Folia Zoologica.* **63**(2):73-80.

Mohapatra, R. K., Panda, S., Acharjyo, L. N., Nair, M. V. and Challender, D. W. S. (2015). A note on the illegal trade and use of pangolin body parts in India. *Traffic Bulletin.* **27**(1):33-40.

Moore, P., Prompinchompoo, C. and Beastall, C. A. (2016). *CITES Implementation in Thailand. A review of the legal regime governing the trade in great apes and gibbons and other CITES-listed species*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Mwale, M., Dalton, D. L., Jansen, R. and Kotze, A. (2016). *Scientific Forensic Report: Hong Kong Pangolin scale confiscation*. National Research Foundation and National Zoological Gardens, South Africa.

Nash, H. C., Wirdateti, Low, G. W., Choo, S. W., Chong, J. L., Semiadi, G., Hari, R., Sulaiman, M. H., Turvey, S. T., Evans, T. A. and Rheindt, F. E. (2018). Conservation genomics reveals possible illegal trade routes and admixture across pangolin lineages in Southeast Asia. *Conservation Genetics.* **19**(5):1083-1095.

Natusch, D. J. D. and Lyons, J. A. (2014). *Assessment of Python Breeding Farms Supplying the International High-end Leather Industry. A report under the 'Python Conservation Partnership' programme of research*. IUCN, Gland, Switzerland 56pp.

Natusch, D. J. D., Webb, G., Shine, R., Cooney, R., Roe, D., Waller, T., Archer, M., Fitzgerald, L., Siroski, P. and Shanker, K. (2019). Is banning exotic leather bad for reptiles? Crossroads Blog, https://www.iucn.org/crossroads-blog/201903/banning-exotic-leather-bad-reptiles. Viewed 08.April 2019.

Nellemann, C., Henriksen, R., Kreilhuber, A., Stewart, D., Kotsovou, M., Raxter, P., Mrema, E. and Barrat, S. (2016). *The Rise of Environmental Crime - A Growing Threat to Natural Resources, Peace, Development and Security. A UNEP-INTERPOL Rapid Response Assessment.* United Nations Environment Programme and RHIPTO Rapid Response, Norwegian Center for Global Analyses.

Newton, P., Nguyen, T. V., Roberton, S. and Bell, D. (2008). Pangolins in peril: using local hunters knowledge to conserve elusive species in Vietnam. *Endangered Species Research.* **6**(41-53.

Nijman, V. (2010). An overview of international wildlife trade from Southeast Asia. *Biodiversity and conservation.* **19**(4):1101-1114.

Nijman, V. (2015). Pangolin Seizures Data Reported in the Indonesian Media. *Traffic Bulletin.* **27**(2):44-46.

Nijman, V. and Shepherd, C. R. (2009). *Wildlife trade from ASEAN to the EU: issues with the trade in captive-bred reptiles from Indonesia*. TRAFFIC Europe Report for the European Commission, Brussels (Belgium).

Nijman, V. and Shepherd, C. R. (2011). The role of Thailand in the international trade in CITES-listed live reptiles and amphibians. *PloS one.* **6**(3):e17825.

Nijman, V. and Shepherd, C. R. (2012). The role of Lao PDR in the ivory trade. *Traffic Bulletin.* **24**(1):35-40.

Nijman, V. and Shepherd, C. R. (2015a). Ongoing trade in illegally-sourced tortoises and freshwater turtles highlights the need for legal reform in Thailand. *Natural History Bulletin of the Siam Society.* **61**(1):3-6.

Nijman, V. and Shepherd, C. (2015b). Adding up the numbers: an investigation into commercial breeding of Tokay Geckos in Indonesia. *TRAFFIC Southeast Asia, Petaling Jaya, Malaysia.*

Nijman, V., Shepherd, C. R. and Sanders, K. L. (2012). Over-exploitation and illegal trade of reptiles in Indonesia. *The Herpetological Journal.* **22**(2):83-89.

Nijman, V., Zhang, M. X. and Shepherd, C. R. (2016). Pangolin trade in the Mong La wildlife market and the role of Myanmar in the smuggling of pangolins into China. *Global Ecology and Conservation.* **5**(118-126.

Nooren, H. and Claridge, G. (2001). Wildlife trade in Laos: the end of the game. IUCN,

Pantel, S. and Chin, S. Y. (2009). Proceedings of the Workshop on Trade and Conservation of Pangolins Native to South and Southeast Asia. Singapore Zoo.

Pantel, S. and Anak, N. A. (2010). *A preliminary assessment of Sunda Pangolin trade in Sabah*. TRAFFIC Southeast Asia, Petaling Jaya (Malaysia).

Pearce, F. (2003). Rhino rescue plan decimates Asian antelopes. https://www.newscientist.com/article/dn3376-rhino-rescue-plan-decimates-asian-antelopes/. Viewed 25.09 2019.

Phanthavong, B. (2008). Pangolin conservation in Lao PDR. In: Pantel, S. and Chin, S. Y. (Ed.), *Proceedings of the workshop on trade and conservation of pangolins native to South and Southeast Asia*, Singapore Zoo. 56-58.

Phelps, J. and Webb, E. L. (2015). "Invisible" wildlife trades: Southeast Asia's undocumented illegal trade in wild ornamental plants. *Biological Conservation.* **186**(296-305.

Phelps, J., Webb, E. L., Bickford, D., Nijman, V. and Sodhi, N. S. (2010). Boosting CITES. *Science.* **330**(6012):1752-1753.

Phelps, J., Shepherd, C. R., Reeve, R., Niissalo, M. A. and Webb, E. L. (2014). No Easy Alternatives to Conservation Enforcement: Response to Challender and Macmillan. *Conservation Letters.* **7**(5):495-496.

Pietersen, D., Waterman, C., Hywood, L., Rankin, P. and Soewu, D. (2014a). Smutsia temminckii. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12765A45222717.en. Viewed 20 June 2016.

Pietersen, D. W., McKechnie, A. E. and Jansen, R. (2014b). A review of the anthropogenic threats faced by Temminck's ground pangolin, Smutsia temminckii, in southern Africa. *South African Journal of Wildlife Research.* **44**(2):167-178.

Regueira, R. F. S. and Bernard, E. (2012). Wildlife sinks: Quantifying the impact of illegal bird trade in street markets in Brazil. *Biological Conservation.* **149**(1):16-22.

Rhodin, A. G. J., Stanford, C. B., Dijk, P. P. v., Eisemberg, C., Luiselli, L., Mittermeier, R. A., Hudson, R., Horne, B. D., Goode, E. V., Kuchling, G., Walde, A., Baard, E. H. W., Berry, K. H., Bertolero, A., Blanck, T. E. G., Bour, R., Buhlmann, K. A., Cayot, L. J., Collett, S., Currylow, A., Das, I., Diagne, T., Ennen, J. R., Forero-Medina, G., Frankel, M. G., Fritz, U., García, G., Gibbons, J. W., Gibbons, P. M., Shiping, G., Guntoro, J., Hofmeyr, M. D., Iverson, J. B., Kiester, A. R., Lau, M., Lawson, D. P., Lovich, J. E., Moll, E. O., Páez, V. P., Palomo-Ramos, R., Platt, K., Platt, S. G., Pritchard, P. C. H., Quinn, H. R., Rahman, S. C., Randrianjafizanaka, S. T., Schaffer, J., Selman, W., Shaffer, H. B., Sharma, D. S. K., Haitao, S., Singh, S., Spencer, R., Stannard, K., Sutcliffe, S., Thomson, S. and Vogt, R. C. (2018). Global Conservation Status of Turtles and Tortoises (Order Testudines). *Chelonian Conservation and Biology.* **17**(2):135-161.

Rhyne, A. L., Tlusty, M. F., Schofield, P. J., Kaufman, L., Morris, J. A., Jr. and Bruckner, A. W. (2012). Revealing the Appetite of the Marine Aquarium Fish Trade: The Volume and Biodiversity of Fish Imported into the United States. *PloS one.* **7**(5):e35808.

Rivalan, P., Delmas, V., Angulo, E., Bull, L. S., Hall, R. J., Courchamp, F., Rosser, A. M. and Leader-Williams, N. (2007). Can bans stimulate wildlife trade? *Nature.* **447**(7144):529-530.

Roe, D. (2008). *Trading nature - A Report, with Case Studies, on the Contribution of Wildlife Trade Management to Sustainable Livelihoods and the Millennium Development Goals.* TRAFFIC International and WWF International, Cambridge (UK).

Romagosa, C. (2014). Patterns of Live Vertrebrate Importation into the United States: Analysis of an Invasion Pathway. In: Keller, R. P., Cadotte, M. W. and Sandiford, G. (Ed.), *Invasive Species in a Globalized World: Ecological, Social, and Legal Perspectives on Policy*. 115-146. University of Chicago Press, USA.

Rosen, G. E. and Smith, K. F. (2010). Summarizing the evidence on the international trade in illegal wildlife. *EcoHealth.* **7**(1):24-32.

Roth, H. H. and Merz, G. (1997). Wildlife resources: a global account of economic use. Springer, Berlin (Germany).

Rowcliffe, M. J., Milner-Gulland, E. J. and Cowlishaw, G. (2005). Do bushmeat consumers have other fish to fry? *Trends in Ecology & Evolution.* **20**(6):274-276.

Runhovde, S. R. (2015). Seizures of inconvenience? Policy, discretion and accidental discoveries in policing the illegal wildlife trade at the Norwegian border. *Crime, Law and Social Change.* **64**(2):177-192.

Schoppe, S. (2009). *Status, trade dynamics and management of the Southeast Asian Box Turtle in Indonesia*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Schweikhard, J., Kasper, K., Ebert, C. L., Lehmann, M., Erbe, P. and Ziegler, T. (2019). Investigations into the illegal wildlife trade in central Lao PDR. *Traffic Bulletin.* **31**(1):19 - 25.

Semiadi, G., Darnaedi, D. and Arief, A. J. (2009). Sunda Pangolin Manis javanica conservation in Indonesia: status and problems. In: Pantel, S. and Chin, J. S. (Ed.), *Proceedings of the workshop on trade and conservation of pangolins native to South and Southeast Asia*, Singapore Zoo.

Shairp, R., Verissimo, D., Fraser, I., Challender, D. and MacMillan, D. (2016). Understanding Urban Demand for Wild Meat in Vietnam: Implications for Conservation Actions. *PloS one.* **11**(1):e0134787.

Shepherd, C. R. (2000). Export of live freshwater turtles and tortoises from North Sumatra and Riau, Indonesia: a case study. *Chelonian Research Monographs.* **2**(112-119.

Shepherd, C. R. (2009). Overview of pangolin trade in Southeast Asia. In: Pantel, S. and Chin, S. Y. (Ed.), *Proceedings of the Workshop on Trade and Conservation of Pangolins Native to South and Southeast Asia*, Singapore Zoo. 6-9.

Shepherd, C. R. (2010). Illegal primate trade in Indonesia exemplified by surveys carried out over a decade in North Sumatra. *Endangered Species Research.* **11**(3):201-205.

Shepherd, C. R. and Magnus, N. (2004). *Nowhere to hide: The trade in Sumatran Tiger*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Shepherd, C. R., Stengel, C. J. and Nijman, V. (2012). *The export and re-export of CITES-listed birds from the Solomon Islands*. TRAFFIC Southeast Asia, Petaling Jaya, Selangor (Malaysia).

Shepherd, C. R., Shepherd, L. and Foley, K.-E. (2013). Straw-headed Bulbul Pycnonotus zeylanicus: legal protection and enforcement action in Malaysia. *BirdingAsia.* **19**(92-94.

Shepherd, C. R., Connelly, E., Hywood, L. and Cassey, P. (2016). Taking a stand against illegal wildlife trade: the Zimbabwean approach to pangolin conservation. *Oryx.* **51**(2):280-285.

Sinovas, P., Price, B., King, E., Hinsley, A. and Pavitt, A. (2017). *Wildlife trade in the Amazon countries: an analysis of trade in CITES listed species*. Technical report prepared for the Amazon Regional Program (BMZ, DGIS, GIZ). UN Environment World Conservation Monitoring Centre, Cambridge (UK).

Smith, K. F., Behrens, M., Schloegel, L. M., Marano, N., Burgiel, S. and Daszak, P. (2009). Reducing the Risks of the Wildlife Trade. *Science.* **324**(5927):594-595.

Sodeinde, O. A. and Adedipe, S. R. (1994). Pangolins in south-west Nigeria – current status and prognosis. *Oryx.* **28**(1):43-50.

Sodhi, N. S., Koh, L. P., Brook, B. W. and Ng, P. K. (2004). Southeast Asian biodiversity: an impending disaster. *Trends in Ecology & Evolution.* **19**(12):654-660.

Sodhi, N. S., Posa, M. R. C., Lee, T. M., Bickford, D., Koh, L. P. and Brook, B. W. (2010). The state and conservation of Southeast Asian biodiversity. *Biodiversity and conservation.* **19**(2):317-328.

Soewu, D. A. and Sodeinde, O. A. (2015). Utilization of pangolins in Africa: Fuelling factors, diversity of uses and sustainability. *International Journal of Biodiversity and Conservation.* **7**(1):1-10.

Sopyan, E. (2009). Malayan Pangolin Manis javanica trade in Sumatra, Indonesia. In: Pantel, S. and Chin, S. Y. (Ed.), *Proceedings of the workshop on trade and conservation of pangolins native to South and Southeast Asia*, Singapore Zoo.

Starr, C., Nekaris, K., Streicher, U. and Leung, L. (2010). Traditional use of slow lorises Nycticebus bengalensis and N. pygmaeus in Cambodia: an impediment to their conservation. *Endangered Species Research.* **12**(1):17-23.

Stefani, M. M. A., Rosa, P. S., Costa, M. B., Schetinni, A. P. M., Manhaes, I., Pontes, M. A. A., Costa, P., Fachin, L. R. V., Batista, I., Virmond, M., Pereira, E., Penna, M. L. F. and Penna, G. O. (2019). Leprosy survey among rural communities and wild armadillos from Amazonas state, Northern Brazil. *PloS one.* **14**(1):e0209491.

Stuart, B., Nguyen, T. Q., Thy, N., Grismer, L., Chan-Ard, T., Iskandar, D., Golynsky, E. and Lau, M. W. N. (2012). *Python bivittatus*. IUCN, http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T193451A2237271.en.

Stuart, B. L. (2004). The harvest and trade of reptiles at U Minh Thuong National Park, southern Viet Nam. *Traffic Bulletin.* **20**(1):25-34.

Su, S., Cassey, P. and Blackburn, T. M. (2014). Patterns of non-randomness in the composition and characteristics of the Taiwanese bird trade. *Biological Invasions.* **16**(12):2563-2575.

Takandjandji, M. and Sawitri, R. (2016). Penangkapan dan perdagangan trenggiling jawa (Manis javanica Desmarest, 1822) di Indonesia. *Jurnal Analisis Kebijakan Kehutanan.* **13**(2):85-101.

Tensen, L. (2016). Under what circumstances can wildlife farming benefit species conservation? *Global Ecology and Conservation.* **6**(286-298.

Thapa, P. (2014). An Overview of Chinese Pangolin (Manis pentadactyla): Its General Biology, Status, Distribution and Conservation Threats in Nepal. *The Initiation.* **5**(164-170.

Thomson, J. (2008). *Captive breeding of selected taxa in Cambodia and Viet Nam: A reference manual for farm operators and CITES authorities*. TRAFFIC, Greater Mekong Programme, Hanoi, Vietnam.

TRAFFIC (2014). *Bulletin Seizures and Prosecutions: Vol. 16 No. 3 (March 1997) to Vol. 26 No. 2 (October 2014)*.

TRAFFIC (2015). Wildlife seizures in 2014 highlighting Lao PDR's role in trafficking. http://www.traffic.org/home/2015/1/6/wildlife-seizures-in-2014-highlight-lao-pdrs-role-in-traffic.html. Viewed 4 July 2016.

TRAFFIC (2017). Malaysia makes third pangolin scale seizure in a month. https://www.traffic.org/news/malaysia-makes-third-major-pangolin-scale-seizure-in-a-month/. Viewed 5 June 2017.

Truman, R. (2005). Leprosy in wild armadillos. *Leprosy Review.* **76**(3):198-208.

Twining-Ward, L., Li, W., Bhammar, H. and Wright, E. (2018). *Supporting sustainable livelihoods through wildlife tourism*. World Bank,

Ueland, M., Ewart, K., Troobnikoff, A. N., Frankham, G., Johnson, R. N. and Forbes, S. L. (2016). A rapid chemical odour profiling method for the identification of rhinoceros horns. *Forensic Science International.* **266**(99-102.

Ullmann, T., Veríssimo, D. and Challender, D. W. S. (2019). Evaluating the application of scale frequency to estimate the size of pangolin scale seizures. *Global Ecology and Conservation.* **20**(e00776.

Underwood, F. M., Burn, R. W. and Milliken, T. (2013). Dissecting the Illegal Ivory Trade: An Analysis of Ivory Seizures Data. *PloS one.* **8**(10):e76539.

UNEP-WCMC (2014). Checklist of CITES species. http://checklist.cites.org/. Viewed 15 November 218.

UNODC (2016). *World Wildlife Crime Report - Trafficking in protected species*. United Nations Office on Drugs and Crime (UNODC),

UNODC (2017). *Criminal justice response to wildlife crime in Malaysia - A rapid assessment*. United Nations Office on Drugs and Crime (UNODC),

USAID (2015). *Wildlife crime in Indonesia: A rapid assessment of the current knowledge, trends and priority actions.* U.S. Agency for International Development (USAID), Washington D.C. (USA).

Utermohlen, M. and Baine, P. (2017). *Flying Under the Radar - Wildlife Trafficking in the Air Transport Sector*. C4ads,

Vallianos, C. (2016). *Pangolins on the brink*. WildAid, San Francisco (US).

Van Thai, N., Clark, L. and Quang Phuong, T. (2014). *Sunda Pangolin Husbandry Guidelines*. Carnivore & Pangolin Conservation Program,

Venables, W. N. and Ripley, B. D. (2002). Modern Applied Statistics with S. Springer, New York.

Wallen, K. E. and Daut, E. (2018). The challenge and opportunity of behaviour change methods and frameworks to reduce demand for illegal wildlife. *Nature Conservation.* **26**(55-75.

Wasser, S. K., Mailand, C., Booth, R., Mutayoba, B., Kisamo, E., Clark, B. and Stephens, M. (2007). Using DNA to track the origin of the largest ivory seizure since the 1989 trade ban. *Proceedings of the National Academy of Sciences.* **104**(10):4228-4233.

Wasser, S. K., Brown, L., Mailand, C., Mondol, S., Clark, W., Laurie, C. and Weir, B. S. (2015). Genetic assignment of large seizures of elephant ivory reveals Africa's major poaching hotspots. *Science.* **349**(6243):84-87.

Waterman, C., Pietersen, D., Soewu, D., Hywood, L. and Rankin, P. (2014a). Phataginus tricuspis. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12767A45223135.en. Viewed 20 June 2016.

Waterman, C., Pietersen, D., Soewu, D., Hywood, L. and Rankin, P. (2014b). Phataginus tetradactyla. The IUCN Red List of Threatened Species 2014,

http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12766A45222929.en. Viewed 20 June 2016.

Waterman, C., Pietersen, D., Hywood, L., Rankin, P. and Soewu, D. (2014c). Smutsia gigantea. The IUCN Red List of Threatened Species 2014, http://dx.doi.org/10.2305/IUCN.UK.2014-2.RLTS.T12762A45222061.en. Viewed 20 June 2016.

Williams, V. L., Newton, D., Loveridge, A. and Macdonald, D. (2015). *Bones of Contention: An assessment of the South African trade in African Lion Panthera leo bones and other body parts*. TRAFFIC, Cambridge, UK & WildCRU, Oxford (UK).

Williams, V. L., Loveridge, A. J., Newton, D. J. and Macdonald, D. W. (2017). A roaring trade? The legal trade in Panthera leo bones from Africa to East-Southeast Asia. *PloS one.* **12**(10):e0185996.

Wilson, A. E. (1994). Husbandry of pangolins Manis spp. *International Zoo Yearbook.* **33**(1):248-251.

Wilson, A. E., Mittermeier, R. A. and Rylands, A. B. (2013). Handbook of the Mammals of the World. Lynx Edicions in assosciation with Conservation International and IUCN, Barcelona (Spain).

Wingard, J. and Pascual, M. (2018). *Catch me if you can: Legal challenges to illicit wildlife trafficking over the internet*. The Global Initiative Against Transnational Organized Crime, Geneva (Switzerland).

Wood, S. N. (2011). Fast stable restricted maximum likelihood and marginal likelihood estimation of semiparametric generalized linear models. *Journal of the Royal Statistical Society: Series B (Statistical Methodology).* **73**(1):3-36.

World Conservation Monitoring Centre (1996). Arapaima gigas. http://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T1991A9110195.en. Viewed 10 November 2017.

Wu, S., Liu, N., Zhang, Y. and Ma, G. (2004). Assessment of threatened status of Chinese Pangolin (Manis pentadactyla). *Chinese Journal of Applied and Environmental Biology.* **10**(4):456-461.

WWF (2016). *Ranger Perceptions Africa*. World Wide Fund for Nature (WWF),

Wyatt, T. (2011). The illegal trade of raptors in the Russian Federation. *Contemporary Justice Review.* **14**(2):103-123.

Wyatt, T. (2013). Wildlife trafficking: A deconstruction of the crime, the victims, and the offenders. *Critical Criminological Perspectives.* Palgrave Macmillan,

Xiao, Y., Guan, J. and Xu, L. (2017). *Wildlife Cybercrime in China - E-commerce and social media monitoring in 2016*. TRAFFIC Briefing Paper,

Xu, L., Guan, J., Lau, W. and Xiao, Y. (2016). *TRAFFIC Briefing: An Overview of Pangolin Trade in China*. TRAFFIC,

Yang, C. W., Chen, S., Chang, C. Y., Lin, M. F., Block, E., Lorentsen, R., Chin, J. S. and Dierenfeld, E. S. (2007). History and dietary husbandry of pangolins in captivity. *Zoo biology.* **26**(3):223-230.

Yee, A. (2019). Nowhere to hide. *Science.* **363**(6432):1142-1143.

Yew, P. N., Goh, B. H., Lim, Y. Y. and Lee, W. L. (2018). Gastrointestinal Bezoar Stones: Current Knowledge and Future Perspective on the Potential of Plant-Derived Phytobezoar in Cancer Treatment. In: Akhtar, M. S. and Swamy, M. K. (Ed.), *Anticancer Plants: Natural Products and Biotechnological Implements: Volume 2*. 19-39. Springer Singapore, Singapore.

Yu, J., Jiang, F., Peng, J., Yin, X. and Ma, X. (2015). The First Birth and Survival of Cub in Captivity of Critically Endangered Malayan Pangolin (Manis javanica). *Agricultural Science & Technology.* **16**(10):2322-2323.

Yuen, M. K. (2013). Outlet in hot water over exotic menu. http://www.thestar.com.my/news/nation/2013/08/22/outlet-in-hot-water-over-exotic-menu-restaurant-serves-bears-foot-and-tapirs-nose/. Viewed 2 August 2017.

Zeileis, A., Meyer, D. and Hornik, K. (2007). Residual-based shadings for visualizing (conditional) independence. *Journal of Computational and Graphical Statistics.* **16**(3):507-525.

Zhang, H., Miller, M. P., Yang, F., Chan, H. K., Gaubert, P., Ades, G. and Fischer, G. A. (2015). Molecular tracing of confiscated pangolin scales for conservation and illegal trade monitoring in Southeast Asia. *Global Ecology and Conservation.* **4**(414-422.

Zhang, M., Gouveia, A., Qin, T., Quan, R. and Nijman, V. (2017). Illegal pangolin trade in northernmost Myanmar and its links to India and China. *Global Ecology and Conservation.* **10**(23-31.

Zhang, Y. (2009). Conservation and Trade Control of Pangolins in China. In: Pantel, S. and Chin, S. Y. (Ed.), *Proceedings of the workshop on trade and conservation of pangolins native to South and Southeast Asia*,

Zhou, Z. M., Zhao, H., Zhang, Z. X., Wang, Z. H. and Wang, H. (2012). Allometry of scales in Chinese pangolins (Manis pentadactyla) and Malayan pangolins (Manis javanica) and application in judicial expertise. *Dongwuxue Yanjiu.* **33**(3):271-275.

Ziegler, S., Merker, S., Streit, B., Boner, M. and Jacob, D. E. (2016). Towards understanding isotope variability in elephant ivory to establish isotopic profiling and source-area determination. *Biological Conservation.* **197**(154-163.

Ziegler, S., Giesen, K., Van Schingen, M., Rauhaus, A. and Ziegler, T. (2018). Testing the Applicability of 15N Isotopic Marker in Skin Tissue to Distinguish Between Captive and Wild Monitor Lizards. *Biawak.* **12**(2):73-83.