Wildlife Trade in the Digital Age: The Role of the Internet in Monitoring the Trade in Wild Plants and Animals in Thailand

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Abstract

The legal and illegal trade in wildlife is a multi-dollar industry that has detrimental impacts on species biodiversity, especially exacerbated in the 21st century as a result of increased globalisation and Internet accessibility. In this thesis, I aim to develop the understanding of wildlife trade in the digital age by examining the role of the Internet in monitoring trade in wild plants and animals in Thailand.

The first chapter focuses on using open-sourced legal trade of wildlife using the decadal trade data of reptiles and amphibians from the CITES trade database. I demonstrate that while the volume of traded reptiles and amphibians are constantly growing for a vibrant exotic pet and most likely leather market, there also an increasing trend for captive-bred individuals.

Subsequently, I demonstrate the shift from traditional markets to online platforms by evaluating the trade in birds of prey and owls. I found that there though there is a drastic shift in volume of birds for sale in markets as recorded in surveys conducted since the 1960s compared to online markets today, there was no clear statistical difference in species composition. It is also notable that the sales most likely illicit as they are mostly of native birds.

The third chapter focuses on Facebook as a key platform and examines factors that influence price in a virtual market trade of primates and carnivores. I find a combination of illegal and legal animals for sale. Price and availability are not always explained in predicted ways, i.e. illegal native animals are cheaper than legal non-native animals. These relationships imply that there are degrees of 'perceived or realised' rarity associated as a key selling point and these values influence demand and prices.

The final content chapter uses open-sourced seizure data through media news reports to monitor the rosewood trade. I found that the rosewood trade is geographically dispersed throughout Thailand, with most of the trade movement intended towards international markets. There was a decrease in rosewood seizure activity over the six-year period from 2013 to 2019. This chapter crucially demonstrates the ability to gather information to map out seizure hotspots, as well as illustrate *modus operandi* and trade pathways of timber moving in and out of Thailand.

Despite progresses made, current domestic and international policies are still insufficient, even after the 2019 legislative reform. Social media is central in the modern-day wildlife trade: as a trade platform, a monitoring tool, and if utilised correctly, an awareness tool. The outcomes in this thesis provide opportunities for policy change at local, domestic and international levels with interventions targeting law enforcement.

Acknowledgements & Authors Declaration

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To Bangtan Sonyeondan – *my epiphany, my zero o'clock*: 'In the middle of the road, in the moment you want to give up, shout even louder: so what?'

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Abbreviations

AAE	Anthropogenic Allee Effect
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DNP	Department of National Parks, Wildlife and Plant Conservation
WARPA	Wild Animal Reservation and Protection Act, B.E. 2535 (1992)
IUCN	International Union for Conservation of Nature
IUCN Red List	IUCN Red List of Threatened Species
UNODC	United Nations Office on Drugs and Crime
UNEP-WCMC	UN Environment Programme World Conservation Monitoring Centre

Relevant Thai Environmental Laws

Directly relevant laws cited in this study:

- Wild Animal Reservation and Protection Act, B.E. 2535 (1992)
- Wild Animal Reservation and Protection Act, B.E. 2562 (2019)
- Forest Act, B.E. 2484 (1981)
- Forest Act B.E. 2562 (2019)
- National Park Act, B.E. 2504 (1961)
- National Park Act, B.E. 2562 (2019)

Other laws related to import-export, possession, breeding and trade of wildlife:

- Animal Epidemic Act, B.E. 2558 (2015)
- Cruelty Prevention and Welfare of Animals Act, B.E. 2557 (2014)
- Promotion and Conservation of National Environmental Quality Act, B.E. 2535 (1992)
- Public Health Act, B.E. 2535 (1992)
- Commercial Registration Act, B.E.2499 (1956)

Other laws related to logging, transport, trade of timber:

- Community Forest Act, B.E. 2562 (2019)
- Chain Saws Act, B.E. 2545 (2002)
- Factory Act, B.E. 2535 (1992)

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Chapter 1: General Introduction

1.1 Global wildlife trade

Wildlife trade refers to the sale and exchange of wild animal and plant resources, their parts and their derivatives, including for commercial and subsistence use (Smith et al. 2009; Phelps et al. 2014; Inskipp and Wells 2019). The global wildlife trade is a multibillion-dollar industry (Blundell and Mascia 2005; Wyler and Sheikh 2013). Wildlife is consumed at a multitude of scales from domestic to international levels. Markets comprise of multiple species, and a single species can also be traded for multiple reasons and serve many purposes (van Uhm and Moreto 2017; UNODC 2020). It caters to an array of industries, including food, skins and furs, medicine, cosmetics, pets, textiles, timber, ornaments or objects with cultural or investment value (Reeve 2002; Broad et al. 2003; Smith et al. 2009; Challender et al. 2015a). Global wildlife trade reportedly impacts one in five species, affecting at least 5,500 species of birds, mammals, reptiles and amphibians (Scheffers et al. 2019).

In 2009, the legal global plant and wildlife market, including timber and fisheries, was estimated at US$ 323 billion (Cooney et al. 2015). While significant portions of wildlife trade indeed strive to be adequately regulated, and in some cases even achieve a suitable level of sustainability, the proportion of unregulated exploitation or overharvesting still imposes significant threats to a broad range of species (Milner-Gulland and Bennett 2003). While the volume and value of international wildlife trade are continually expanding (Roe 2008), records on the volume of legal trade depend on the level of reporting by national governments and agencies. This makes it difficult to estimate the exact values of legal wildlife trade accurately; systematic records of the illegal wildlife trade are even harder to get by (Broad et al. 2003).

Wildlife trade leads to potential species biodiversity decline, contributing to changes in ecological communities (Buchart et al. 2010; Dutton et al. 2013; Joppa et al. 2016). Other impacts include potential zoonotic consequences from invasive pathogens and species that may threaten agriculture, livestock and public health on local, regional and global scales (Pavlin et al. 2009; Travis et al. 2011). Welfare issues revolving around the capture, breeding and general handling, especially in illegal circumstances, are also issues raising concern (Baker et al. 2013). Direct impacts on human livelihood and economy are also consequences of legal and illegal wildlife trade (Chambers and Conway 1991), especially impacting and exploiting poverty-based communities (van Uhm and Moreto 2017). Finally, potential impacts on national security issues driven from organized crime, terrorism and corruption are also consequences threatening social stability in many communities (Lawson and Vines 2014; Van Uhm 2018).

Over time, the number of peer-reviewed publications published related to wildlife trade has increased. In a review of studies within Web of Science, focusing on peer-reviewed papers between 1990 to 2019, a total of 2,025 publications were reported on 'wildlife trade' (Figure 1a) and 189 publications were reported on 'illegal wildlife trade' (Figure 1b). The number of studies for both topics increased exponentially over time. Another literature review which examined related to illegal wildlife trade within Web of Science between 1995 to 2019 showed biases of taxa, where only 10% of studies addressed trade in plants (Margulies et al. 2019). In another search for 'CITES' also shows an increase in studies related to the Convention. Though the approach of literary search is limited in nature, it represents vital patterns within the spike of interest and popularity in the topic of the illegal wildlife trade and its regulations, amidst the explicit taxonomic biases that remain.

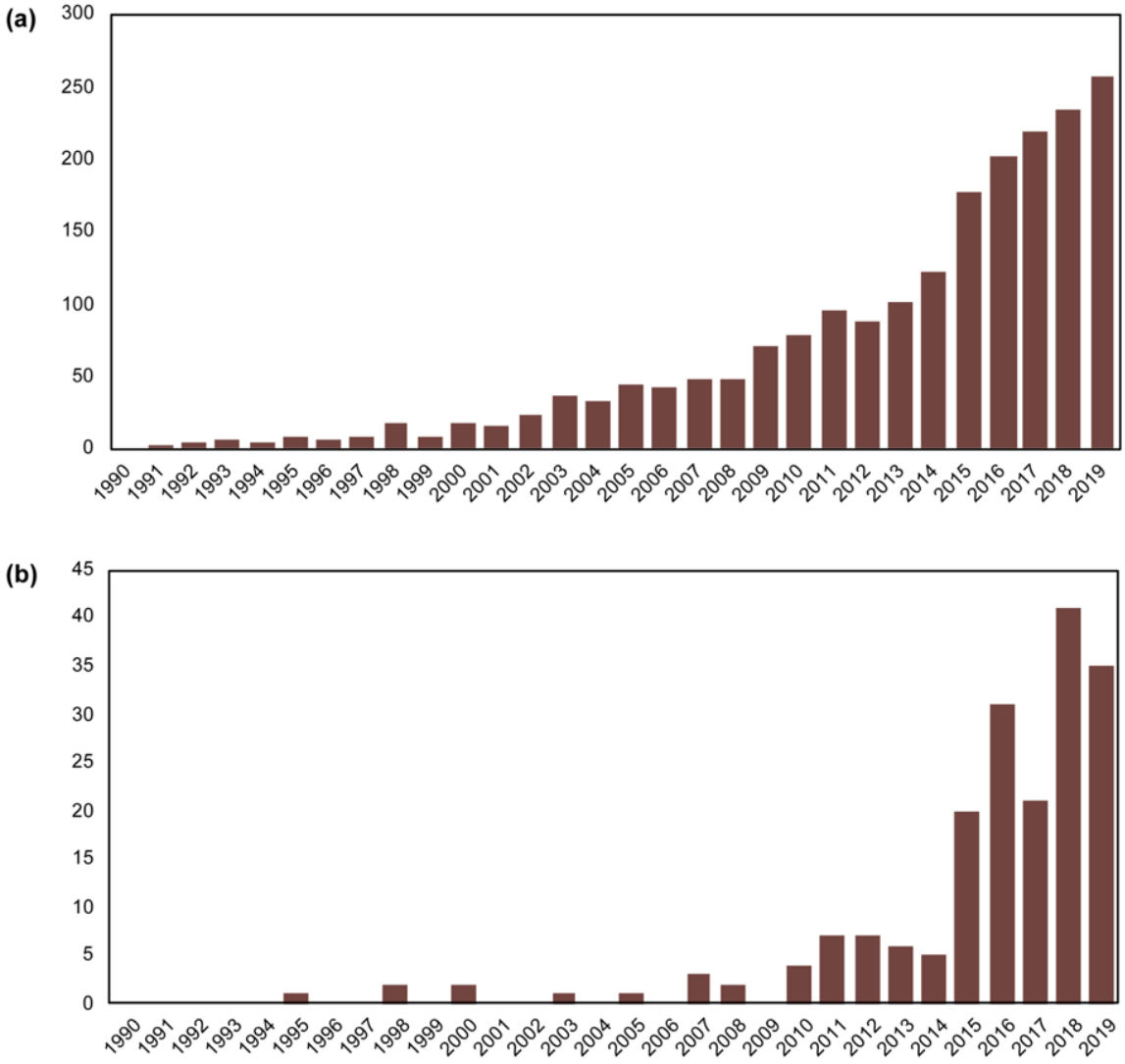

Figure 1. The number of published peer-reviewed studies on (a) 'wildlife trade' and (b) 'illegal wildlife trade' from 1990 to 2019 on the Web of Science.

1.2 Illegal wildlife trade

Operating in parallel to the legal trade is the illegal trade which is also one of the main driving forces driving many species into extinction (Warchol 2004; van Uhm and Wong 2019). Illegal trade may occur domestically and internationally. Wildlife or wildlife products may be acquired (captured, poached or logged), traded, transported (smuggling), or possessed illegally (Wyler and Sheikh 2008; Wyatt 2009). The relationship between legal and illegal trade is nuanced and not always straight forward (Tittensor et al. 2020). There are instances where the distinction between licit and illicit activity is fairly clear; for some cases, wildlife markets may be completely illegal, for example, the trade in rhino horn that has no international and legal permission for trade (UNODC 2020). While other cases, often legal channels are used to feed into the illegal trade (Felbab-Brown 2011), such as the trade of rosewoods and European eels (*Anguilla* spp.) that items of illegal origin is legitimised and sold to a larger pool of consumers (UNODC 2020). Or in the case of ivory trade where legal trade both masks growing illegal trade and stimulates poaching and stockpiling of ivory (t' Sas-Rolfes et al. 2014).

The economic value of the illegal trade is reported at a range from US$ 7 to 23 billion (Scheffers et al. 2019). The enormous value makes the illegal wildlife trade one of the largest illicit businesses, among human trafficking, and the trade of arms and drugs (Barber-Meyer 2010; Nellemann et al. 2016). The growth and increased complexity of the illegal wildlife trade is a globally recognised, with increased attention given by INTERPOL and UN Office on Drugs and Crime (UNODC). Due to the unlawful nature, the values and volume of trade are underreported and underestimated and thus trade is often unsustainable and unregulated (Duckworth et al. 2012). It is even said that any attempt to 'describe international wildlife trade must, unfortunately, begin with the recognition that this cannot be done with any accuracy' (Broad et al. 2003). The greatest challenge remains in the methods, where it is difficult to quantitatively study the illegal wildlife trade, including, its systems and networks (Keane et al. 2008; von Lampe 2012).

In a review of the global illegal wildlife trade, Rosen and Smith (2010) produced a summary on international illegal wildlife trade that compiled 12 years of seizure data from 1996 to 2008, based on information collected by TRAFFIC, the wildlife trade monitoring network. The researchers reported various wildlife products and derivatives including ivory, tiger skins, live reptiles, and other endangered wildlife and wildlife products (Rosen and Smith 2010). Among the key findings, the authors pinpointed Southeast Asia as a hot spot for trade and emerging diseases. The observed patterns revealed a flow of illegal wildlife trade from developing to developed nations, where wildlife in poorer countries in the regions of Africa and Southeast Asia are more targeted (Duffy 2010; Roe et al. 2002; Rosen and Smith 2010; UNODC 2016).

Furthermore, a decadal analysis conducted by Van Uhm (2016), found that over 20,000 wildlife seizures confiscated in the European Union specifically was concentrated from Africa and Southeast Asia. The market for the illegal wildlife trade has accelerated as consequences of globalisation in terms of improved transport and communication methods (Van Uhm 2016). This is evident for a wide range of reasons for consumption, ranging from illegal logging (Klienschmidt et al. 2016), hunting (Bennett et al. 2002), and for the pet trade (Sajeva et al. 2013; Lavorgna 2015). More recently, an updated review of global wildlife crimes revealed over 6,000 species seized and from wildlife seizure incidents from 1999 to 2018 showed taxonomic composition led by 23% mammals and 21% reptiles, followed by corals, plants, birds and fish (UNODC 2020).

Southeast Asia is one of the world's global biodiversity hotspots (Myers et al. 2000). Among other threats to biodiversity, including logging and land-agriculture conversion, wildlife trade is one of the leading causes to biodiversity decline (Sodhi et al. 2004). With its geographical proximity and global connectivity, the region is a critical player in the broader picture of international wildlife trade and transit (Nijman and Shepherd 2011). The role of corruption in the region is also prevalent (van Uhm and Moreto 2017). In examining the trade of CITES-listed species in the region, Nijman (2010) reported that records of illegal or undeclared international trade could be significantly larger than the official reported export values. In the region, trade threatens species or taxa from cats (Oswell 2011; Nijman et al. 2019a; Nijman et al. 2019b), bears (Foley et al. 2011), elephants and ivory (Nijman and Shepherd 2012), seahorses (Foster et al. 2019), birds (Harris et al. 2017) and turtles (Nijman and Shepherd 2007).

1.3 Regulatory bodies

The largest international agency that governs global wildlife trade is the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). Ratified by 183 countries, CITES is the most important legal cooperation to monitor and regulate the trade of plants and animals through a system of licenses. As of 2019, over 35,800 species are listed in CITES (Anonymous 2019a). The aim is to ensure international trade in wild animal and plant species do not threaten the survival, thereby reduce the threats associated with over-harvesting of imperilled species. CITES records offer the most comprehensive collection in wildlife trade. However, much of the data are dependent on the will and quality of reporting from individual country parties reporting (UNODC 2013). The data obtained can potentially be used for the analysis of existing trade, to make informed decisions for sustainability, such as setting trade quotas, implementing trade suspensions and highlighting areas requiring of further research and monitoring (Nijman and Shepherd 2011; Phelps et al. 2010). Official trade data can be used further to guide enforcement strategies (i.e. designating protected areas), to inform threat assessments (i.e. IUCN Red List, CITES listing, domestic protection listing).

International commercial trade of wildlife is classified under one of three Appendices. CITES Appendix I refers to species where trade seriously increases the likelihood of extinction, and therefore, the trade is allowed under strict circumstances. Specifically, certificates are required from both importing, exporting, and re-exporting parties. Species in Appendix II are defined as species that are not directly threatened but that are vulnerable to extinction due to overexploitation, or species that are very similar in appearance to ones that are in need for trade regulation. Regulation of the trade is therefore essential, as they may be imminent threats. As a result, trade is subjected to stricter regulation and speculation, and commercial trade requires non-detriment findings and export permits. CITES Appendix III species are species where individual countries of origin have put restrictions in place for their international trade. For CITES II and III listed species, import permits are not required, but only export permits are required. Signatory countries incorporate CITES guidelines into national laws through checking permits. It is also utilised with national laws, differing between countries and territories, which may strengthen regulation of CITES-listed species after import (Sung and Fong 2018). It is the national government's responsibility to collect data on international trade, set domestic harvest quotas and to conduct Non-Detriment Findings studies to identify cases where international trade is allowed without causing a detriment to wild populations (Phelps and Webb 2015; Rosser and Haywood 2002). Reliability and credibility of trade data are dependent on the will of the reporting parties.

In addition to CITES, there are also regional regulatory bodies that operate in a similar nature to record and monitor trade data. At the international level, examples include the World Customs Organisation's (WCO) Customs Enforcement Network (CEN) and World Wildlife Seizure database (World Wise), a developing initiative led by the UNODC. Regional multilateral bodies operating on wildlife, such as the European Union (EU)'s EU Trade in Wildlife Information Exchange (EUTWIX; www.eutwix.org), the Association of Southeast Asian Nations Wildlife Enforcement Network (ASEAN-WEN; http://www.asean-wen.org), the Lusaka Agreement Task Force (lusakaagreement.org), and the Wildlife Enforcement Monitoring Systems (WEMS) Initiative (http://wems-initiative.org/) have also been enacted to support governments in tools to monitor and regulate wildlife trade.

As such challenges associated with official trade data, there is also a growing number of third-party monitoring for research efforts (Phelps et al. 2010; Phelps and Webb 2015). Data can be collected and presented through independent investigations which document and report trade on a multitude of species, especially broadening to novel trades which may not be widely recognised (Phelps and Webb 2015). Another source is through non-governmental agencies. TRAFFIC, a wildlife trafficking network is one of the organisations with the broadest range of cases (www.traffic.org/bulletin) reporting in trends and seizures. Recently, the approach to incorporate alternative strategies is also

being implemented to improve trade monitoring efforts. Examples include using harvest and trade modelling techniques to monitor removal rates (Keane et al. 2008), analysis of seizure trade data (Underwood et al. 2013) and using mark-recapture techniques (Baker et al. 2007).

1.4 Trade dynamics and the Anthropogenic Allee Effect

The market for wildlife trade is driven by similar mechanics to any illicit trade where lessons can be gained from policies, patterns and nuances of other illegal systems (Phelps et al. 2016). The primary motivating factor for trade is economical, but this exists at different scales from domestic to international (Blundell and Mascia 2005; Nijman 2010). However, considering the literature, there have been taxonomic biases that focus on a narrow selection of charismatic species (Donaldson et al. 2016) and animals over plants (Phelps and Webb 2015; Balding and Williams 2016). As a result, trade in many ecologically vital species are overlooked (Laird et al. 2010; Nijman et al. 2012).

Despite the limitations, analyses can be carried out to examine the dynamics of trade of species where data are available. A variety of factors may influence the demand and price of wildlife, many of which are factors associated with rarity (Lyons and Natusch 2013), life-history traits (Hinsley et al. 2015), origin (Dutton et al. 2011), and conservation and trade regulation status (Courchamp et al. 2006). One of the theories used to explain the trade dynamics of rare or threatened wildlife is the Anthropogenic Allee Effect (AAE). The AAE is founded on the premise of a standard economic model of value (or scarcity value) that is used as a theory to explain supply and demand (Joosten 2012). Under the economic model assumption, over time, the costs to harvesting or acquiring ever rarer individuals will be so high that there will be no demand for it, and therefore, prevent a species' from becoming extinct (Courchamp et al. 2006).

The difference of AAE with the standard economic model is that the theoretical framework suggests that exaggerated 'value' placed on individuals and species disproportionately leads to their exploitation (Figure 2). Individuals become even rarer and more desirable to buyers and populations (Hall et al. 2008; Tella and Hiraldo, 2014). Despite higher search and harvest costs, this unique price-rarity relationship generates a financial incentive to harvest the last remaining individuals (Holden and McDonald-Madden 2017). The economic-biological feedback loop ultimately leads a populations to fall below a 'critical Allee threshold' that will ultimately result with extinction (Courchamp et al. 2006; Branch et al. 2013). It should also be noted that the AAE model is applied to open-access, unregulated exploitation, and where supply and demand are driven by market forces (Courchamp et al. 2006; Harris et al. 2013).

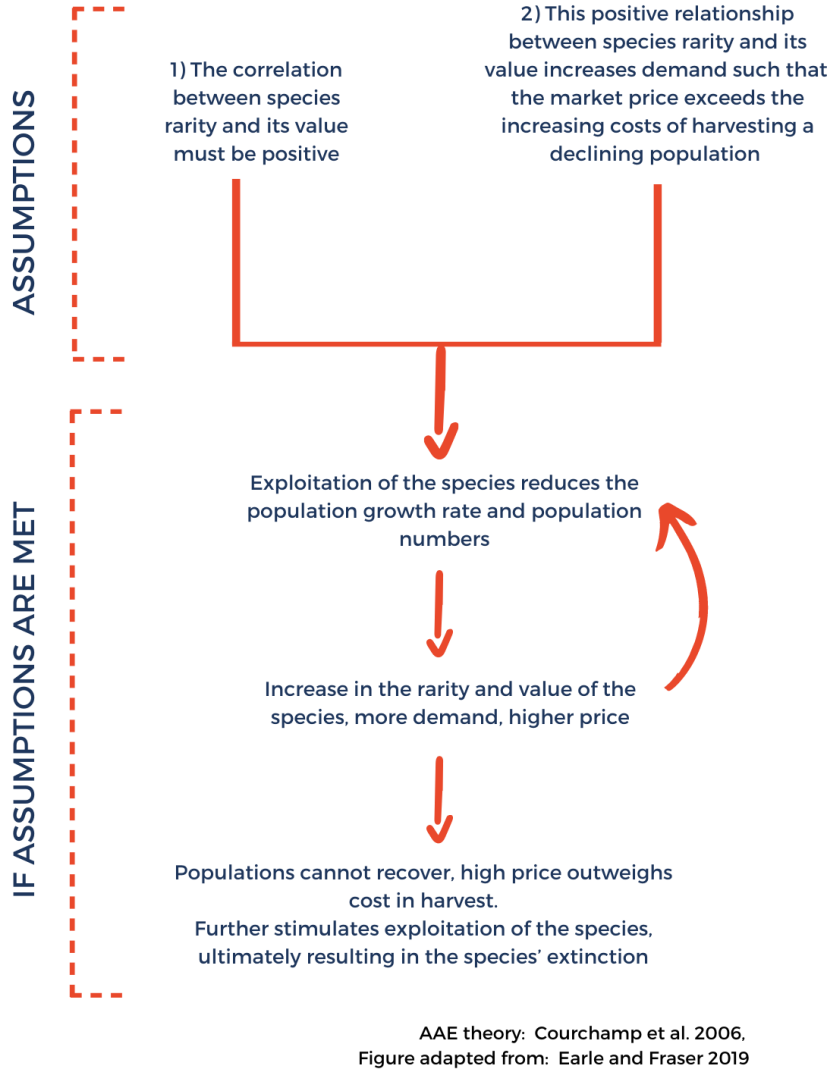

Figure 2. The Anthropogenic Allee Effect framework based on Courchamp et al. 2006 and adapted from Earle and Fraser 2019.

Furthermore, as species are exploited more and population sizes reduce, the consequences of AAE are even more exemplified in a cyclical manner where populations cannot recover at the rate it is harvested or removed. To support their proposed theory, Courchamp et al. (2006) presented mathematical models with empirical examples to illustrate how values attributed to rarity precipitates the extinction of rare species using examples of human activity including trophy hunting, exotic pet keeping, collections, luxury food items and ecotourism. Targeted species are not limited to those rare, threatened or emblematic species, but also include those with a 'perceived' or imposed rarity for whatever reasoning (Lyons and Natusch 2013). The imposed rarity can lead to an exaggerated 'value' for the species (Gault et al. 2008).

Multiple Allee effects can also occur when there are two or more Allee effects occurring simultaneously in a population (Berec and Courchamp 2007). Berec and Couchamp(2007) offered the example of white abalone (*Haliotis sorenseni*) that face an AAE as a result of overexploitation as consideration of a luxury item while smaller populations also have reduced fecundity and fertilization efficiency (Hobday et al. 2001). Desert bighorn sheep (*Ovis canadensis)* is valued for its rarity in the trophy hunting industry, while smaller remaining populations face increased risk from predation due to smaller group sizes (Mooring et al. 2004; Courchamp et al. 2006).

Research conducted on the Anthropogenic Allee Effect has been primarily theoretical (Courchamp et al. 2006; Holden and McDonald-Madden 2017); a smaller number of peer-reviewed studies have examined applied aspects of the theory to wildlife trade and consumption (Lyons and Natusch 2013; Purcell et al. 2014). A few publications have shown that demand for rare species is still maintained even at inflated market prices (Gault et al. 2008). Although the majority of studies outcomes favoured the Anthropogenic Allee Effect, the theory is dependent on other factors beyond rarity alone (Krishna 2019). This includes population dynamics, market preferences, and specific factors along the supply chain, which varies according to wildlife species and products. Understanding the factors which influence consumers' choices in wildlife trade can be beneficial to help identify measures to reduce demand for and regulate the trade of species of conservation concern (Hinsley et al. 2015).

In a literature review of the studies related to Anthropogenic Allee Effect (Table 1), 23 out of 40 studies that specifically mention the theory explored the Anthropogenic Allee Effect, whether in theory or analysis. Of this, eight primarily focused on the theoretical framework, 14 applied the Anthropogenic Allee Effect theory to different real-life case studies that ranged from trophy hunting, expensive seafood items, ecotourism, exotic pets or products and zoo viewing. Of the application papers, 15 papers demonstrated support for the theory. Further research into the direct effects of the AAE and extended consequences of interactions with other Allee effects are for the conservation and management of threatened or exploited populations (Berec and Courchamp 2007).

Table 1. An overview of 24 peer-reviewed studies related to the Anthropogenic Allee Effect from 2006 to 2020, the theory was either incorporated as a theoretical model or applied in a case study.

No.	Study	Topic
1	Courchamp F, Angulo E, Rivalan P, Hall RJ, Signoret L, Bull L, Meinard Y. (2006) Rarity value and species extinction: The Anthropogenic Allee Effect *PloS Biology* 4(12): e415.	Theoretical model
2	Berec L, Courchamp F. (2007) Multiple Allee effects and population management. *Trends in Ecology & Evolution* 22:185-191	Applied – In support of the theory
3	Hall RJ, Milner-Gulland EJ, Courchamp F. (2008) Endangering the endangered: the effects of perceived rarity on species exploitation. *Conservation Letters* 1(2):75 – 81.	Theoretical model / Applied
4	Gault A, Meinard Y, Courchamp F. (2008) Consumers' taste for rarity drives sturgeons to extinction *Conservation Letters* 1: 199–207	Theoretical model / Applied, Data: Luxury seafood
5	Angulo E, Deves AL, James MS, Courchamp F. (2009) Fatal attraction: rare species in the spotlight. *Proceedings of the Royal Society B: Biological Sciences* 276(1660):1331-7.	Applied – In support of the theory, Data: Zoos
6	Angulo E, Courchamp F. (2009) Rare species are valued big time. *PLoS One* 4(4): e5215.	Applied – In support of the theory, Data: Internet survey
7	Johnson PJ, Kansky R, Loveridge AJ, Macdonald DW. (2010) Size, rarity and charisma: Valuing African wildlife trophies. *PLoS ONE* 5(9): e12866.	Applied – In support of the theory, Data: Trophy hunting
8	Prescott GW, Johnson PJ, Liveridge AJ, MacDonald DW. (2011) Does change in IUCN status affect demand for African bovid trophies? *Animal Conservation* 15(3) 15(3): 248-252.	Applied – In support of the theory, Data: Trophy hunting
9	Palazy L, Bonenfant C, Gaillard JM, Courchamp F. (2011) Rarity, trophy hunting and ungulates. *Animal Conservation* 15: 4-11.	Applied – In support of the theory, Data: Trophy hunting
10	Palazy L, Bonenfant C, Gaillard JM, Courchamp F. (2011) Cat dilemma: too rare to escape trophy hunting? *PLoS One* 6(7): e22424.	Applied – In support of the theory, Data: Trophy hunting

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No.	Study	Topic
11	Defeo O, Castilla JC. (2012) Governance and governability of coastal shellfisheries in Latin America and the Caribbean: multi-scale emerging models and effects of globalization and climate change *Current Opinion in Environmental Sustainability* 4: 344-350.	Applied – In support of the theory, Data: Fisheries
12	Joosten R. (2012) Strong and weak rarity value in Small Fish Wars. *Dynamic Games and Applications* 6: 97–111	Theoretical model
13	Tournant P, Joseph L, Goka K, Courchamp F. (2012) The rarity and overexploitation paradox: stag beetle collections in Japan *Biodiversity and Conservation* 21: 1425–1440.	Applied – In support of the theory, Data: Pet collector
14	Harris RB, Cooney R, Leader-Williams N. (2013) Application of the Anthropogenic Allee Effect model to trophy hunting as a conservation tool. *Conservation Biology* 27: 945-951.	Applied – Not in support the theory Data: Hunting
15	Lyons JA, Natusch DJD. (2013) Effects of consumer preferences for rarity on the harvest of wild populations within a species. *Ecological Economics* 93; 278-283.	Applied – In support of the theory, Data: Pet collector
16	Purcell SW, Polidoro BA, Hamel J-F, Gamboa RU, Mercier A. (2014) The cost of being valuable: predictors of extinction risk in marine invertebrates exploited as luxury seafood. *Proceedings of the Royal Society - Biological Sciences.* 281(1781): 20133296.	Applied – In support of the theory, Data: Luxury seafood
17	Huang J-P. (2014) Modeling the effects of anthropogenic exploitation and climate change on an endemic stag beetle, *Lucanus miwai* (Lucanidae), of Taiwan. *Journal of Asia-Pacific Entomology* 17: 423-429.	Theoretical model
18	Leclerc C, Bellard C, Luque GM, Courchamp F. (2015) Overcoming extinction: understanding processes of recovery of the Tibetan antelope *Ecosphere* 6(9).	Applied – Some evidence in support of the theory, Data: Trophy hunting
19	Verma M. (2016) Modeling the effect of rarity value on the exploitation of a wildlife species subjected to the Allee Effect. *Natural Resource Modeling* 29: 3.	Theoretical model

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No.	Study	Topic
20	Holden MH, McDonald-Madden E. (2016) High prices for rare species can drive large populations extinct: The anthropogenic Allee effect revisited. *Journal of Theoretical Biology* 429: 170-180.	Theoretical model
21	Guttery MR, Messmer TA, Brunson MW, Robinson JD, Dahlgren DK. (2016) Declining populations of greater sage-grouse: hunter motivations when numbers are low *Animal Conservation* 19: 1.	Applied – Not in support of the theory Data: Hunting
22	Nijman V, Ardiansyah A, Bergin D, Birot H, Brown E, Laggeng A, Morcatty T, Spaan D, Siriwat P, Imron MA, Nekaris KAI. (2018) Dynamics of illegal wildlife trade in Indonesian markets over two decades, illustrated by trade in Sunda Leopard Cats. *Biodiversity* 20(1):1-14.	Yes – some support of the theory
23	Krishna VV, Darras K, Grass I, Mulyani YA, Prawiradilaga DM, Tscharntke T, Qaim M. (2019) Wildlife trade and consumer preference for species rarity: an examination of caged-bird markets in Sumatra. *Environment and Development Economics* 24: 339-360.	Theoretical model
24	Toomes A, Stringham OC, Mitchell L, Ross JV, Cassey P. (2020) Australia's wish list of exotic pets: biosecurity and conservation implications of desired alien and illegal pet species. *NeoBiota* 60:43-59.	Applied – exotic pets - some support of theory

1.5 The Internet as a vehicle for wildlife trade

As the world is becoming more globalised, wildlife trade has similarly expanded and grown in the same manner (Nijman 2010). One of the ways in which market wildlife trade has changed in the past decade has been due to the Internet (Lavorgna 2014). The commercialisation and globalisation of the Internet and the integral role in which it plays in our daily lives has contributed to the increase and rise in demand for exotic wildlife both internationally and domestically (Lavorgna 2015).

Previously, wildlife trade studies were conducted based on visiting physical markets (Nijman and Shepherd 2007; Regueira and Bernard 2012). Recent studies showed that the Internet is increasingly being used for trading various types of wildlife illegally. Traditional direct e-commerce platforms such as Amazon and eBay were first recognised as the platforms used including elephant ivory (Yeo et al. 2017), mammals (Harrison et al. 2016), primates (Bergin et al. 2017), cacti (Sajeva et al. 2013;

Vaglica et al. 2017) and various other wildlife species (Wu 2007). With the evolution of Internet platforms, social media platforms have been recognised as the current avenue in which wildlife are being traded. Social media platforms, not directly intended as a marketplace but evolved to become a market place in its expansion. Trade was recorded for many species, for example, in the trade of birds (Alves et al. 2013; Iqbal 2016), snakes (Jensen et al. 2018), and orchids species (Hinsley et al. 2015). This growth of the Internet in parallel to wildlife trade has created a 'hybrid market', characterised by the combination of the structures of traditional offline socio-economic opportunities with the novel opportunities that the Internet provides (Lavorgna 2014). The shift towards online trading has come with its challenges in management. Online platforms arguably offer more obscure trading platforms (Sung and Fong 2018). Understanding the scale of the Internet works in parallel with the understanding of trade dynamics (Sajeva et al. 2013), especially for heavily traded and harvested groups of wildlife (Yeo et al. 2017; Lavorgna et al. 2018).

1.6 Gaps in wildlife trade data

There are current gaps in wildlife trade data limited to species traded and geographically biased studies. Research in the past has highlighted the need for further research prioritising conservation studies in the region of Southeast Asia (Duckworth et al. 2012; de Silva 2016; Hughes 2017; Coleman et al. 2019). Even though physical markets have primarily been the central platform where wildlife has been traded, it is undeniable to state that there has been a shift towards online trade platforms in the past decade.

In a recent review of the conservation priorities in the region of Southeast Asia, a key area of research that is currently lacking is related to 'online trade'. Specifically, on establishing and understanding the extent of online illegal wildlife trade involving Southeast Asian flora and fauna species (Coleman et al. 2019). Authors of the study also asked what methods and approaches were effective in obtaining reliable data on illegal wildlife trade, highlighting that there has always been an underlying limitation in data collection. Furthermore, another research question the authors raised related to mapping and quantification the trade, as well as what was the effectiveness of legal and social interventions in minimising the online and offline illegal wildlife trade. I used these questions as guidelines to this research study and endeavour to form a more robust understanding of how we use and consume wildlife in the digital age in Thailand.

1.7 Study motivation and research approach

This motivation behind pursuing this PhD is recognising the changing ways in how wildlife is being traded in the digital age of the Internet. In recognising the increasing threat that the Internet and ease of connectivity have imposed on biodiversity, there is also usefulness in the volume and depth of data

available. In many cases, wildlife trade is not recorded, and there is a lack in reporting of the scope and scale of trade. Using Thailand as a case study, the aims of this study is to provide a baseline of how the Internet can be used to better understand wildlife trade.

This study addresses the trade in several taxa of wildlife, including plants and animals. The approach is to highlight separate perspective and tools in which we can look at the Internet. Importantly, this study also focuses on publicly available data. In many ways, we highlight what is readily available in the digital-verse. While this study is geographically concentrated, this makes specific policy recommendations for conservation and hopes to draw broader observations about the regulation and management of wildlife trade in the region.

1.8 Research objectives

This study is structured in five data chapters (chapter 3 to chapter 6). The data chapters provide individual case studies used to fundamentally display the role of the Internet in the legal and illegal wildlife trade. This includes, what species are being traded, how are they being traded, who the key drivers or consumers are, what are the trade dynamics and what influences the availability and prices offered. A research objective within each chapter is to highlight themes in regulation and enforcement, including an evaluation of domestic and international laws and treaties. Table 2 provides a breakdown of chapters with brief details.

Table 2. An overview of the chapters presented in this thesis, including the theoretical topics studied, laws examined, sources of data used, and associated publications or presentations during the duration of my PhD from 2016 to 2020.

Chapter	Details	
Chapter 2: Methods	Theoretical topic	Methodology: Provides an overview of the research methodology, including a brief overview of Thailand, the country on which I focussed, traditional methods used to gather data on wildlife trade ranging from sourcing information from databases, conducting market and online surveys, and using open-source data. I also introduce analytic methods that I used in the thesis, such as primary statistical tests and Generalised Linear Models applied.
Chapter 3:	Theoretical topic	This chapter examines legal wildlife trade using the CITES trade database with a case study of reptiles and amphibian species trade
	Laws examined	Wildlife Preservation and Protection Act (WARPA), CITES
	Data source(s)	CITES Trade database
	Published / Presented	N/A
	Aim / hypotheses	• I analyse the imported trade in CITES-listed reptiles and amphibians in Thailand from 2008 to 2018 to examine what is being traded in the past decade, where it is coming from and how it is sourced. • This chapter concludes with a comparative reflective approach in how Thailand's role in the global reptile and amphibian trade have changed, and if there have been any changes in terms of volume, source and conservation statuses of imported wildlife from the previous decade. I make direct comparisons to the findings reported from 1998 to 2007 by Nijman and Shepherd (2011). When comparing both decades, I hypothesize that: 1. Overall the volume of commercial trade will increase 2. The proportion of captive-bred individuals will increase 3. The proportion of threatened species (Critically Endangered, Endangered and Vulnerable) will decrease. 4. There will be a decline of imports from non-CITES parties.

(**Table 2** continued on the next page, 1/4)

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Chapter	Details	
Chapter 4:	Theoretical topic	The first exotic pet chapter compares the market and online wildlife trade using birds of prey and owls as a study species.
	Laws examined	WARPA, CITES
	Data source(s)	Market survey (physical and online markets), Facebook data
	Published / Presented	Digital media and the modern-day pet trade: a test of the 'Harry Potter effect. 2019. *Endangered Species Research* Wildlife trade shifts from brick-and-mortar markets to virtual marketplaces; A case-study of birds of prey trade In Thailand. (2020) In review, *Journal of Asia-Pacific Biodiversity*
	Hypotheses	• For the online trade of raptors and owls, I analyse price data in two steps to examine factors and variables that may explain price. • For each of the taxa found traded online, I expect that there will be typical market drivers and factors that can significantly explain the price. • In the second part, I directly make comparisons between the findings of the physical markets (literature review) and online markets. I compare the variability of species reported as well as the volume of each species. • In this part for both raptors and owls, I expect that there will be a decrease in the volume and species composition of individuals offered for sale in markets, and an increase in online markets. I also expect that the factors that explain availability in both markets and online platforms should be the same.

(**Table 1** continued on the next page, 2/4)

(**Table 2** continued from the previous page, 3/4)

Chapter	Details	
Chapter 5:	Theoretical topic	This second exotic pet chapter examines the online trade on Facebook and compares findings for two animal taxa: primates and carnivores.
	Laws examined	WARPA, CITES
	Data source(s)	Market survey (physical and online markets), Facebook data
	Published / Presented	Illegal pet trade on social media as an emerging impediment to the conservation of Asian otters species. (2018) *Journal of Asia-Pacific Biodiversity* The role of the Anthropogenic Allee Effect in the exotic pet trade on Facebook in Thailand. (2019) *Journal for Nature Conservation* / Presented partial findings at the European Federation of Primatology 2019 and the Primate Society of Great Britain (2019)
	Hypotheses	I aim to characterise the online trade by examining species composition, volume and its conservation status, identify legal and illegality of trade and identify factors that may influence price dynamics. I predict the following patterns: • Availability may influence price, where species that are more commonly offered will be cheaper on average. • Body mass may correlate with price, where it is expected that larger animals are more expensive. • Non-native alien species will be expected to be more expensive when compared to native local species • Species protected under the WARPA law will be less available and offered at higher prices. • Non-CITES listed species and CITES Appendix II species are legally tradable in Thailand, and be more available and offered at lower prices. • Species classified as more threatened will not be as available and also offered at higher prices. • There will be no difference in offering prices between primates and carnivores.

(**Table 2** continued on the next page, 3/4)

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Chapter	Details	
Chapter 6:	Theoretical topic	Uses seizure data obtained through public online news reports to better understand the wildlife trade activity.
	Laws examined	Forestry Laws
	Data source(s)	Media reports from online sources
	Published / Presented	Using online media-sourced seizure data to assess the illegal wildlife trade in Siamese rosewood. (2017) *Environmental Conservation.* Online media seizure reports: a tool to monitor CITES implementation in regulating the international rosewood trade. (2018) *Forest Policy and Economics.* / Presented at the Meeting of the Association of Tropical Biology and Conservation (2018) and at the Wildlife Trade Symposium (2019).
	Hypotheses	The purpose of this chapter is to use online media-sourced seizure reports to investigate the trade of Siamese rosewood in Thailand quantitatively. Seizure data were first collected from national news agencies in the period from January 2013 to December 2019. • Analyses were conducted to test spatial and temporal patterns associated with seizures, using the number of seizures and the number of logs seized per year and for each species. • Temporally, I test to see if there were any changes in the number of seizures and number of logs seized over time • To explore spatial patterns, I use a χ^2 test to see regional correlations with the number of seizures. • Generalised Linear Model, economic, geographic and ecological factors were included to predict seizures and key active hotspots in the rosewood trade in Thailand. • Qualitative analysis on *modus operandi*, pathways and suspect details
Chapter 7: Discussion	Theoretical topic	Chapter 7 provides a conclusion of a discussion of the main findings, discusses the changes made to Thailand's wildlife laws, and evaluates the process of researching the methods used to study wildlife trade. It also wraps up the themes and the implications, while proposing recommendations for future steps.

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Chapter 2: Methods

2.1 Introduction

Wildlife trade occurs at a multitude of levels, from local, regional to global levels. It also consists of a legal and an illegal component. As such, there are several approaches to study and record wildlife trade. In this chapter, I first set the background in regards to terminology and definitions referred to during the rest of the thesis. Subsequently, I provide a background on the key study location, Thailand, and provide a review of the current body of literature related to both the legal and illegal wildlife trade. I also present relevant domestic legislation as it pertains to wildlife trade in Thailand. Finally, I introduce the various methods that have previously been conducted for studying and monitoring the legal and illegal trade of wildlife. Finally, I highlight the multiple aspects of the methods I have chosen to use in the following data chapters.

Wildlife trade is the sales or exchanges of wild animal and plant resources by people (Broad et al. 2003). In this context, legality is referenced in accordance with the domestic laws or international regulations such as CITES, wherein a country may be a party to. The illegal wildlife trade is one of the components of wildlife trade, targeting thousands of terrestrial, marine, plants, fungi species worldwide. Here illegal wildlife trade is defined to include both fauna and flora species. 'Wildlife crime' may refer to the action of taking, trading, possessing, obtaining or consuming illegal wildlife (UNODC 2016).

Considering the immense volumes of information available on the Internet, one must be considerate about choosing what content to collect, as well as critical on the sources of data. Wildlife trade is characterised in multiple stages involving products, actors, network structures. Actors, in this case, may refer to people who post things for sale, or in seizure reports, the suspects involved in the cases. Recognising that while the term 'actor' may be used to describe people in different stages of the supply chain, we may not be able to determine precisely at which stage these actors belong (Phelps et al. 2016).

2.2 Study country

McNeely et al. (2009) identified Asia as a biological challenge where a myriad of plant and animal species will be threatened with endangerment as the region pushes on for rapid economic development and population growth while facing trade in endangered species of plant and animals (Nijman 2010). Historically, the region of Southeast Asia is on record as one of the critical hubs of the legal and illegal trade of wildlife where the transfer of goods within this region is also porous and poorly regulated (Scheffers et al. 2019; Grieser-Johns and Thomson 2005). Much of previous

literature on the wildlife trade has been focused on the impact on high-profile charismatic species, such as tigers (*Panthera tigris*), elephants, and rhinoceroses (Bennett 2011; Doak 2014). However, more and more research is being dedicated to study the impact of trade to a broader range of taxa within the region, commonly perceived as 'traditional' pets, i.e. birds (Harris et al. 2017) or freshwater turtles and tortoises (Nijman and Shepherd 2007; Morgan and Chng 2017).

The ten countries within the region of Southeast Asia operate under a multilateral body called 'the Association of South-East Asian Nations' (ASEAN) (Figure 3). The ASEAN coalition was established in 1967. It formed a roadmap for regional economic development, while also has agendas to deal with many of the environmental issues that the nations share in common, to have effective environmental governance and sustainable development in the region (Koh and Karim 2012). Southeast Asia's role in the illegal wildlife trade has been recognised as one of the region's priorities, with aims to share intelligence, review weak laws and coordinate enforcement action (Koh and Karim 2012).

Figure 3. Map of the Association of South-East Asian Nations (ASEAN) region that consists of 10 nations, showing the position of Thailand as one of its central countries.

2.2.1 Thailand

One of the countries in Southeast Asia is the Kingdom of Thailand. Geographically, Thailand shares land borders with Cambodia, Laos, Malaysia and Myanmar. Furthermore, though a direct border is not shared with either China or Vietnam, both countries have territories that lie within 100 km of Thailand. Thailand has a population of 69 million (2019), with a population growth rate of 0.29% (Anonymous 2018a). Within the context of the region, Thailand ranks as 2nd in GDP in its economic value, estimated at US$ 455 billion, following Indonesia (Anonymous 2019b). The GDP growth rate has been and is projected to remain stable (Anonymous 2018b). The Thai currency is Thai Baht and is ranked as the 10th most frequently used currency in the world (Anonymous 2018c). Issues of financial inequality are also predominant in the nation. According to the Credit Suisse Global Wealth Databook, Thailand was reported the world's third most unequal nation in 2018, following Russia and India (Anonymous 2018d). The distribution of wealth is such that that the top 1% of the population controls almost two-thirds of the entire country's wealth (Anonymous 2018e).

According to the UNESCO Institute for Statistics, in 2019, Thailand's literacy rate was 91% (Anonymous 2019c). The number of Internet users has also been steadily increasing. The National Broadcasting and Telecommunications Commissions reports that in 2013, it was estimated that there were around 26 million Internet users in Thailand, while in 2018 it was estimated to be 48 million users, or 69% of the population (Anonymous 2019d). In 2017, it was reported that nearly 94% of Internet users accessed the Internet through their mobile phones; while a decreasing proportion (from 50% to 45.4%) used the Internet via desktop computers (Anonymous 2019e). Social media plays a significant role in Thai society. The main instant messaging app used is LINE application, with 41 million users (Anonymous 2019e). In comparison, there are 49 million accounts of Facebook in Thailand, ranking the country 8th globally in terms of Facebook users (Anonymous 2019e). The volume of Facebook users runs closely to the volume of Internet users. However, despite all the connectivity, according to the worldwide Press Freedom Index, Thailand's ranking had been in steady decline since 2014, from 130 out of 180 countries to 140 in 2018, and ranked as 'Not Free' according to the 'Freedom on the Net' for the past five years (Anonymous 2019f).

Since 2014, Thailand has been governed under a military government that established a National Council for Peace and Order (NCPO). The country had its first elections following the 2014 *coup d'état* in 2019, and the same primarily military-based government was put in power. Even though the new government implemented a new constitution that went into effect on the 6th of April 2017, much of the laws that gave power to NCPO remained in operation. The government implemented a new National Strategy from 2018 to 2037 comprising of a strategy for 'environmental-friendly development', and a National Economic and Social Development Plan that includes the 'Thailand 4.0' (Anonymous 2018f). The goal of the former plan is to 'sustainable development of the country

under the principle of good governance', while the latter aims to transform Thailand into an unprecedented high-valued and technology-based economy, highlighting critical terms of increased cross-border connectivity, technological innovation and research, sustainable development (Anonymous 2018g; Pucharoen 2019) . There are also plans to reform wildlife and forest laws.

E-commerce is also growing to be a vital trade platform in Thailand. The Electronic Transactions Development Agency (ETDA) reported consistent growth of small-to-medium enterprise growing up to 46% from 2016. Over 200,000 enterprises were registered on traditional -e-commerce platforms in Thailand, which included, Shopee, Lazada and JD.com. In comparison, 300,000 more registered enterprises were listed as traders who used Line (social media messenger app), Instagram and Facebook (EDTA 2018).

2.2.2 Wildlife trade in Thailand

Thailand has always stood out for its outstanding role as a hub for wildlife trade consistently over time (Ee 1974; UNODC 2017; Table 3). In 2019, the illegal wildlife trade in Thailand was estimated to be worth up to US$ 2.2 billion (or 70 billion Thai Baht; Anonymous 2019g). In particular, wildlife and derivatives from elephants and tigers to seahorses (Oswell 2010; Kuo et al. 2018), the growing demand for exotic and rare pets (Todd 2011; Nijman and Shepherd 2011; Nijman and Shepherd 2015), bird trade (Round 1990, McClure and Chaiyaphun 1971) as well as trade in collectable orchids (McMahan and Walter 1989; Phelps and Webb 2015).

Table 3. Key wildlife trade studies in Thailand since the 1970s to the present day (2019).

Year	Studies
1970s	Ee PL (1974) Wildlife trade in Thailand *Intern Zoo Yearbook* 14(1): 23-28. McClure HE, Chaiyaphun S. (1971) The sale of birds at the Bangkok 'Sunday market' Thailand. *Nat Hist Bull Siam Soc*. 24: 41–78.
1980s	McMahan LR, Walter KS. (1989) The international orchid trade. Audubon Wildlife Report 1988/1989
1990s	Round PD. (1990) Bangkok Bird Club survey of the bird and mammal trade in the Bangkok weekend market. *Nat Hist Bull Siam Soc*. 38: 1-43 Srikosamatara S, Siripholdej B, Suteethorn V. (1992). Wildlife trade in Lao P.D.R. and between Lao P.D.R. and Thailand. *Nat. Hist. Bull. Siam Soc.* 40:1-47. Baird IG (1993) Wildlife trade between the southern Lao PDR provinces of Champasak, Sekong, and Attapeu and Thailand, Cambodia and Vietnam. TRAFFIC Southeast Asia, Field report NO. 3, Kuala Lumpur.

(**Table 3** continued on the next page, 1/2)

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Year	Studies
1990s	Robinson MF. (1994) Observation on the wildlife trade at the daily market in Chiang Khan, northeast Thailand. *Nat Hist Bull Siam Soc.* 42: 3-21. Srikosamatara S, Suteethorn V. (1994) Wildlife conservation along the Thai-Lao border. - *Nat Hist Bull Siam Soc.* 42:321 Handley P. (1991) The crass menagerie: Thailand leads the world in illicit wildlife trade. *Far Eastern Economic Review.* 151(30)
2000s	Nijman V, Shepherd C.R. (2007). Trade in non-native, CITES-listed, wildlife in Asia, as exemplified by the trade in freshwater turtles and tortoises (Chelonidae) in Thailand. *Contributions to Zoology* 76: 207-211. Stiles D. (2009) The elephant and ivory trade in Thailand TRAFFIC Southeast Asia, Petaling Jaya, Selangor, Malaysia
2010-2019	Todd M. (2011) Trade in Madagascar's reptiles and amphibians in Thailand. Petaling Jaya: TRAFFIC Southeast Asia Nijman V, Shepherd CR. (2010) The role of Asia in the global trade in CITES II-listed poison arrow frogs: hopping from Kazakhstan to Lebanon to Thailand and beyond. *Biodiversity and Conservation* 19: 1963–1970. Oswell AH. (2010) The Big Cat Trade in Myanmar and Thailand. TRAFFIC, Southeast Asia. Grey S. (2012) Conservation difficulties for Hylobates lar: white-handed gibbons and Thailand's illegal pet trade. *Consortium: Journal of Cross-Disciplinary Inquiry* 45–59. Nijman V, Shepherd CR. (2011) The role of Thailand in the international trade in CITES-listed live reptiles and amphibians. *PLoS ONE* 6: e17825 Environmental Investigation Agency. (2012) Rosewood Robbery: The Case for Thailand to List Rosewood on CITES. London: EIA Underwood FM, Burn RW, Milliken T. (2013) Dissecting the Illegal Ivory Trade: An Analysis of Ivory Seizures Data. *PLoS ONE DOI: 10.1371/journal.pone.0076539.* Nijman V, Shepherd CR. (2015) Analysis of a decade of trade of tortoises and freshwater turtles in Bangkok, Thailand. *Biological Conservation* 24: 309–318. Kuo TC, Laksanawimol P, Aylesworth L, Foster SJ, Vincent ACJ. (2018) Changes in the trade of bycatch species corresponding to CITES regulations: the case of dried seahorse trade in Thailand. *Biodiversity and Conservation* 27:3447–3468.

Within the past decade, there has been a significant volume of studies conducted on the illegal wildlife trade in Thailand. In the past, the impact of the research on wildlife trade has had a relatively small impact directly on the policy in regulating illegal wildlife trade in Thailand due to the cultural and language discrepancies that stem from the fact that the large portion of the research is authored by non-Thais. To some credit of enforcement agencies, studies and reports that receive a high level of international media coverage, often if related to the general public image of the country or has tourism implications, do trigger a subsequent action though this may be in the form of a market enforcement check or a publicised seizure.

In the decade between 2007 to 2018, there have been over 50 studies on wildlife trade in Thailand produced by researchers in academia and private, non-governmental agency sectors. Market surveys were predominantly the tool used to collect data from traditional brick-and-mortar markets, namely one, in particular, the Chatuchak Weekend Market, also known as JJ Market (Figure 4). Chatuchak Market comprises of shopping zones selling a variety of products catered to both domestic and tourist clientele, reaching a consumer base of over 200,000 visitors every weekend (https://www.chatuchakmarket.org).

One of the trade zones is dedicated to the sale of living animals, including dogs, cats, birds, among other animals (Chng and Eaton 2016). Historically, market surveys in Chatuchak Market date back to the 1960s by ornithologists observing the bird trade (McClure and Chaiyaphun 1971; Round 1990). Most of the studies in Chatuchak Market in the recent period have been focused on the reptile and amphibian trade (Nijman and Shepherd 2007, Shepherd and Nijman 2008, Nijman and Shepherd 2011, Todd 2011, Chng 2014; Nijman and Shepherd 2015), and a growing number of studies on the bird trade (Chng and Eaton 2016). Chatuchak Market is considered the main location in Bangkok, where there is the legal and illegal trade of CITES-listed species (UNODC 2017).

Figure 4. Photographs of Chatuchak Market on a typical weekend taken by myself. Different types of shops are found, including (a) permanent shop selling imported tortoises and birds (b) a person visiting a temporary shop holding a squirrel (c) overview market where the vendor on the left in selling puppies opposite a pet equipment shop.

In addition to studies from Chatuchak Market, illegal wildlife trade has also been reported in other species and locations. This includes trade of orchid (Phelps 2013), elephant and ivory products (Doak 2014); seahorse trade (Kuo et al. 2018; Foster et al. 2016), and more generally, reports on seizures of mammals such as big cats and otters (Oswell 2010; Siriwat and Nijman 2018a; Siriwat et al. 2019; Gomez et al. 2019). Other potential areas previously mentioned for wildlife trade and transactions in other NGO reports are also highlighted here, for example, Chatuchak 2 in Minburi and Sanam Luang 2, a large marketplace famous for plants and animals, located in old Bangkok area (Figure 5).

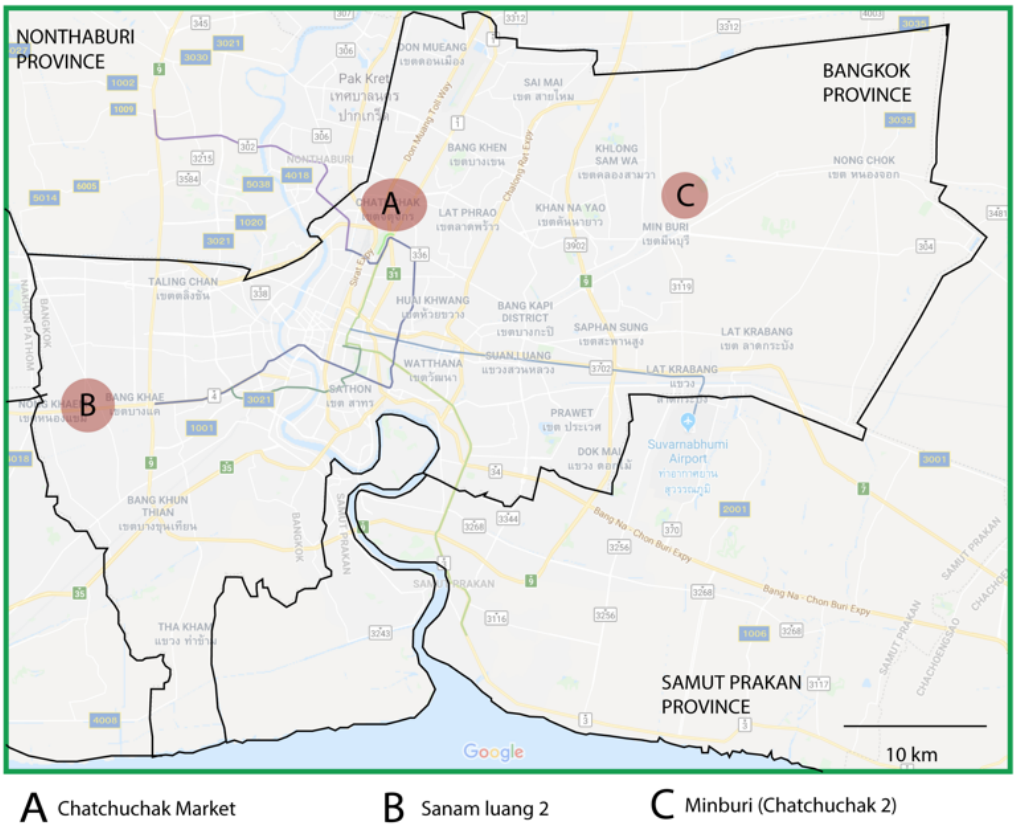

Figure 5. A map of trading markets in Bangkok and surrounding areas that are known for wildlife trade based on previous literature conducted since the 1960s. The main area is Chatuchak Market, while Sanam Luang 2 and Chatuchak 2 are smaller markets which have been mentioned.

Apart from Bangkok, wildlife trade has also been examined along with Thailand's borders towns between the Thai-Lao border (Srikosamatara and Suteethorn 1994; Robinson 1994), between Thai-Lao-Cambodian border region (Baird 1993), between Thai-Myanmar border (Shepherd 2001) and the Golden Triangle between Thailand, Myanmar and Laos (WWF 2017). Border towns are trade hotspots where smugglers converge to trade. Enforcement authorities also consistently report wildlife seizures throughout all major border towns in Thailand. Along the Thailand and Myanmar border, there have been studies that monitored wildlife, including ivory and wild cats (Shepherd and Nijman 2008; 2014; Nijman and Shepherd 2015; Min 2018). The northeast border between Thailand and Laos

PDR has also been highlighted in the orchid trade (Phelps et al. 2010), and rosewoods smuggling route (Siriwat and Nijman 2018b; Siriwat and Nijman 2018c).

One of the main reasons for wildlife consumption in Thailand is for the pets and entertainment industry. Thailand is one of the few places around the world that has a unique intersection of the tourism industry and wildlife. This overlap has led to the occurrence of a photo prop trade, found in licensed businesses but also freelance operators. Wildlife ranging from tigers, monkeys, raptors and iguana species are offered at tourist locations to be taken as a prop in a selfie (Grey 2012; Osterberg and Nekaris 2015; Hasanah 2018). In the tourist town of Phuket in the south of Thailand, slow lorises are commonly seen to be offered at hotels, resorts, beaches, and bars for a price of 100 to 500 Thai Baht (Osterberg and Nekaris 2015). Often, smaller, young animals are chosen as props, used in conditions unsuitable for their biological lifestyle, and many cannot be reintroduced back into the wild due to government regulation (Osterberg and Nekaris 2015).

2.2.3 Thailand wildlife laws

Up until November 2019, wild animal species in Thailand were protected under the Wild Animal Reservation and Protection Act (WARPA), B.E. 2535 (1992). WARPA controls the hunting, trade, possession, import-export and commercial breeding of 1296 native species of animals (Van Dijk and Plasuwan 2000). Thailand also became a signatory to CITES in 1983 and is rated in category 1 of the CITES National Legislation Project, meaning that its laws generally meets the requirements to implement CITES (Nijman and Shepherd 2011). However, there are many issues regarding the congruency of domestic laws and CITES were highlighted, especially with regards the limited out-dated protected species list that has yet to be updated since 1992 (Nijman and Shepherd 2011; Moore et al. 2016). Mainly, under the 1992 law, there are only provisions to regulate trade of CITES-listed species specifically at the border during import and export, and no provisions to regulate the breeding and trade domestically within the country.

The WARPA laws regulated wildlife belonging to three specific categories which were ‘wild animals’, ‘preserved wild animals’ and ‘protected wild animals’. This definition did not include all the fauna species listed by CITES, and the WARPA only protected half of all the CITES-listed taxa and 12 non-native CITES-listed species such as the African elephants (*Loxodonta africana* and *L. cyclotis*; Moore et al. 2016). As only the import and export of exotic species listed under the WARPA were regulated, traders utilised this loophole to lawfully possess and breed CITES-listed species (UNODC 2017).

In November 2019, a new set of wildlife laws were approved by the National Legislation Assembly and enforced under the Wildlife Conservation and Protection Act B.E. 2562 (2019). In general, the

reformation reclassifies five categories of wildlife, from the previous three groups, to include preserved wildlife, protected wildlife, controlled wildlife, dangerous wildlife, and wildlife carcasses. Additionally, it also increased punishable terms for the hunting, trading and possession of prohibited wildlife, to strengthen details of protection on all CITES-listed species (Anonymous 2019h; Anonymous 2019i). As the new WARPA laws were enforced towards the end of the data collection for this thesis, in chapters 3 to 6, I will discuss the context of wildlife trade under the previous set of WARPA (1992) laws. In the final chapter, I discuss how the new WARPA (2019) laws would have had an effect on the species traded.

In Thailand, wildlife trade can also be managed by several different government agencies and under many different separate laws adding a degree of complexity for authorities as they have an overlapping scope of work. For example, trade on the Internet is regulated under a separate law under the Ministry of Commerce (Commercial Registration Act B.E. 2499 (1956)), which has been criticised as inadequate in controlling trade activity of wildlife (Phassaraudomsak and Krishnasamy 2018). Furthermore, in addition to WARPA, there are also other related laws associated with wildlife trade for example, wildlife reserves and forests laws (e.g. Forest Act, B.E. 2484 (1981); National Park Act, B.E. 2504 (1961)), epidemiology and disease laws (Animal Epidemic Act. B.E. 2558 (2015); Public Health Act B.E. 2535 (1992)), and animal welfare laws (Cruelty Prevention and Welfare of Animals Act, B.E. 2557).

2.3 Data collection

Contrary to legal wildlife trade, collecting data on illegal wildlife trade presents its own sets of challenges due to the clandestine nature (Barber-Meyer 2010). Legal trade, on the other hand, is often reported or, it may be displayed publicly. Of course, legal trade is not without any challenges, where common issues include discrepancies in reporting volumes, legitimacy of source and identification, and exploitation of legal loopholes. Here are the different ways that wildlife trade data has been collected and how the methods have been applied in the following chapters of this thesis.

2.3.1 CITES trade data

Legal trade records in CITES-listed species can be obtained through the CITES trade database. The CITES trade database operates as the most significant global data centre for reporting wildlife crime where management authorities of each country need to report statistics. Analysis of CITES trade data have been conducted on nearly all taxa, focusing on individual taxonomic groups such as reptiles (Nijman 2010; Auliya et al. 2015; Robinson et al. 2015), amphibians (Carpenter et al. 2014), birds (Bessinger 2001; Li and Jiang 2014), seahorses (Bruckner 2001; Foster et al. 2014; 2016), cetaceans (Fisher and Reeves 2005) and succulents (Vaglica et al. 2017). In general, information on species

names, volumes of import, re-import and re-export volumes, and sources of wildlife can be obtained from the CITES trade database. It is open and free to download.

As data are annually submitted, there is often a minimum year-lag delay when trade statistics can be viewed by the public. There may also be discrepancies which have been highlighted such as inaccurate reporting and thus underreporting by CITES parties (Phelps et al. 2015), fraudulent or false declarations (i.e. elephant ivory with walrus or mammoth ivory; Martin and Vigne 2015) or misreporting origin from wild-caught to captive-bred individuals (Nijman 2010).

For chapter 3, I present the legal trade of reptiles and amphibian in Thailand. I retrieved data from international trade from the WCMC-CITES trade database (http://www.unep-wcmc.org/citestrade) from the period of 2008 to 2018. Many studies have used the CITES trade database to study the conservation status and evaluate, and each method has its own merits.

Since CITES do not offer guidance on methods to calculate trade volume, researchers have utilised different approaches to deal with incomplete data and discrepancies. Foster et al. (2014) dealt with double-counting by removing re-exporting data from analysis and retained only higher values for import and export data quantities, assuming that the smaller values will be encompassed by the larger values. Other researchers opt to use just a subset of the data, for example, in an analysis of amphibian trade, one study used values as reported by importers (Pernetta 2009; Carpenter et al. 2014; Auliya et al. 2016) while another used values reported by exporters only (Sinovas et al. 2016). There were stark differences in the export and import amounts as reported; therefore, comparisons of studies should be taken with consideration and caution. Discrepancies in reporting for other forms of wildlife products and derivatives beyond live individuals are even more complicated (Berec et al. 2018; Andersson and Gibson 2018).

As I aim to make direct comparisons with the previous decadal study carried out by Nijman and Shepherd (2011) throughout 1998–2007, I closely used these methods presented in the 2009 study as a primary guideline (Nijman and Shepherd 2011), supported by other studies (Pernetta 2009; Foster et al. 2016). Import and export data can be filtered according to the database categories. Within the dataset, commercial trade (listed as ‘T’ with source code) was included for captive-bred (‘C’ and ‘D’) and wild-caught (‘W’), and individuals that were imported into Thailand or exported from Thailand were included in the analysis.

2.3.2 Market surveys

Traditionally, wildlife trade is monitored by surveys collected at physical brick-and-mortar markets. Market surveys were often conducted by experts in the field, walking through markets and identifying

what species were offered for sale, the volume, and price. Though methodologies may differ between researchers, standardised methods are often implemented to ensure systematic data collection to ensure the independence of data and avoiding double-counting (Nijman and Shepherd 2007; Nijman and Shepherd 2014). However, openness in collecting data are dependent on the context of species traded but also the market culture. In some countries, it may be free to discuss with sellers, whereas in other locations, research may need to be done covertly. For example, in a survey of Bangkok's bird market at Chatuchak Market, Round (1990) collected data without any effort to conceal recording activity and counted birds which were openly on display. However, in my own experience, once I had a paper and pen out during surveys in the same place carried out in 2018, one shop keeper within the bird market aggressively asked me what I was writing down. Since then, I have stuck with primarily recording on my phone during my market surveys at Chatuchak Market.

In many cases where illicit activity may be recorded, undercover techniques are applied (Lee et al. 2005), or the use of informants is required (Sopyan 2009). It is often impossible to record everything due to the clandestine nature of the trade, and researchers often need to utilise techniques to address imperfect data collection (Barber-Meyer 2010). In particular, Barber-Meyer (2010) specifically focused on applying ecological approaches of occupancy methods in dealing with missing wildlife surveys to wildlife trade surveys. In general, examples of techniques that can be utilised to deal with imperfect data collection can vary from monitoring errors and limitations, standardizing processes and methods, validate the accuracy of the data collected, and cleaning up the data for duplicate data (Anonymous 2018h). Ultimately, the information collected should be considered as a representative or interpreted with a grain of salt.

During the period of my PhD, I had opportunities to carry out wildlife market surveys in Thailand under the guidance of my supervisor. In 2017, my supervisor and I travelled to Chiang Rai province to carry out a market survey at Taichilek market located at the northern border crossing between Thailand and Myanmar. In the same year, we also went to Kanchanaburi province to survey the border market at 3 Pagoda Pass, also between Thailand and Myanmar. In Bangkok, I conducted three surveys at Chatuchak Market, in November 2018, February 2019 and October 2019, which focused on monitoring trade of birds of prey. During the surveys at Chatuchak Market, I would enlist for help from local friends to join and assist me in the data collection. Data were recorded on my phone, either by sending messages on an instant text messaging platform or through recording of voice notes in the voice recording application. It was later transcribed. There are limitations which I came across in the market survey in Chatuchak Market. One limitation is that it was difficult to openly take photos to record collection in some shops; these specific shops will display signs saying No Photos, or even perhaps more direct, threatening warning messages. Another limitation is that taking notes using a pen

and paper also seems to be classified as suspicious behaviour to some shop keepers, while in some places like Three Pagoda Pass, it was not picked up on as suspicious behaviour.

2.3.3 Online wildlife trade data

Since the shift of wildlife trade on to online platforms, data on wildlife trade can also be monitored online. Conducting wildlife trade surveys on the Internet offers a wealth of information while also presenting its own sets of challenges (Di Minin et al. 2018). In the same way as physical brick-and-mortar markets, a systematic approach is necessary. The methods between surveys may differ based on platform, whether it is e-commerce platforms or social media platforms.

Traditional e-commerce platforms include Internet auction pages such as eBay were used to survey plant trade. Vaglica et al. (2017) studied methods consisted of recording offers of plants for sale from the specific auction and sales sites using search terms which included targeted scientific names, the generic names, and spelling variants. Data were collected on offers for prices and sources. The researchers explored sales from all countries but only inspected offers in English language or if it had an accompanying translation in English.

In a similar approach, Hinsley et al. (2016) also conducted a horticultural study on social media. Authors estimated the extent and structure of horticultural orchid trade on social media, focusing on themed forums (groups) and explored the network of consumers. The authors analysed social-networks to investigate the ties between 150 orchid-themed groups in order to determine the structure of the network. In this study, they used a 'research account' that noticeably displayed the statement that 'research on social media was being conducted' (Hinsley et al. 2016). By declaring the intentions to collect data, Hinsley et al. (2016) considered that an acknowledgement as a form of consent.

However, it is not always necessary to be overt about the status of a researcher while conducting data surveys. De Magalhaes et al. (2012) conducted a non-interactive study on non-native amphibians and reptiles sold on a local social media platform (Orkut) in south-eastern Brazil to determine availability and frequencies of individuals for sale. While Sung and Fong (2018) monitored reptile trade in Hong Kong on a social media site targeting forums which were accessible to the public, and only members could post. The authors simply state that they chose not to disclose the specifics of the forum name such as the site name and address (Sung and Fong 2018). Machine learning techniques are also becoming incorporated on social media platforms to investigate illegal wildlife trade by using steps of mining, filtering, and identifying data. These methods are still in its early development phases and more research is required especially related to ethics, data security and privacy requirements (Di Minin et al. 2018).

All studies commonly point to the adhering to similar ethical guidelines, which importantly, is not using personal pages or did not use automated web scrapers. Names and personal information were not collected, and there was no interaction or attempt to buy any items (Hinsley et al. 2016) Any recorded data were coded and anonymised instantly to avoid any ability to trace back to anyone identifiable person (Siriwat and Nijman 2018a).

In chapters 4 and 5, I present manually collected data from Facebook. During the Facebook online monitoring session, I followed the latter approaches in conducting the surveys. Groups were searched on Facebook using common tags such as 'exotic pets' or 'unusual pets' (Thai: สัตว์แปลก/สัตว์หายาก). Exotic pet groups were searched in Thai and English; however, only Thai-language based groups appeared to be active and popular. I joined groups that predominantly sell exotic pets and have over 1000 members. For any closed group that required entry approval, entrance was granted within a day, as a courtesy. All of the groups were accessible by a search and Facebook account, and we defined these as 'marketplace'. This may include groups which are listed as 'public', or 'closed'. Closed groups are still able to be freely joined; however, it may require approval to enter. The other remaining type of group is a 'secret' group which cannot be found in the search tool.

2.3.3.1 Ethics

For online data collection, I followed a typical economic market approach in observing the 'market' (see Nekaris et al. 2010, Barber-Meyer 2010). Considering the potentially sensitive and illegal activity occurring on the group, I abided by ethical guidelines from Roulet et al. (2017) to conduct covert observations. Specifically, Roulet et al. (2017) provided a perspective discussion on the costs and benefits of covert research, recognizing that observational studies often sit along a spectrum of consent and only a few are fully overt or fully covert due to practical limitations and the nature of consent. The authors especially recognised that covert participant observation is necessary to study deviant behaviours or secretive organisations (Roulet et al. 2017). Within the practical considerations of covert participant observation, under a guideline of situated ethics, is the question of using fake or real identities to penetrate the closed groups, surreptitiously recording data and to reducing harm to participants by preserving anonymity (Roulet et al. 2017).

I also followed recommendations of Kosinski et al. (2015) and adaptations by Martin et al. (2018) to follow the four-condition guideline to collect data on only publicly available posts, to anonymise data after collection, not to interact or communicate with any users, and not to publish any information that may be attributed to any one individual. Photographs were saved on the day that was uploaded onto Facebook, and all images were stored on an encrypted drive (cf. Eid and Handal 2018).

2.3.3.2 Data collection

Dependent of what the target species were, I recorded details in each monitoring session on what species are sold, selling post date, number of individuals being sold, age, price, location of sale, transfer method, and the end of sale date (cf. Siriwat and Nijman 2018a). If offered, species were identified based on the seller's description/caption. Seller names were anonymised, and pictures posted were used to cross-reference in cases of duplicated posts. I followed Iqbal's approach (Iqbal 2016) in determining our monitoring sessions. Facebook has a group photo limit that allows groups to archive 5,000 pictures at a time; therefore, I consider reaching the end of the archived posts as a complete monitoring session (cf. Iqbal, 2016).

If posts lacked description, I seek out expert advice in identification. If this was unable, it was later removed from further analysis. Price data were converted to US$ based on the conversion rate of the period monitored.

2.3.3.3 Analysis

In the Facebook chapter analysis, I explain what was being traded in terms of availability (volume) and price using predictor variables that are proxies for biological, geographical, temporal, rarity and legality of each species (Table 4). I explore the relationship and factors using linear regression or created generalised linear models (GLMs), where significance was accepted at $P < 0.05$. Continuous variables were log-transformed if not normalised. After creating a GLM, I chose the most parsimonious model with the lowest positive Akaike Information Criterion (AIC) score. I reported Wald χ^2 values from the GLMs and the associated p-values. Unless stated otherwise, all models were conducted in SPSS (IBM Corp. 2019).

Table 4. Variables used in Generalised Linear Models to analyse factors which influence availability and price for wildlife traded in physical brick-and-mortar markets and online platforms.

Variable (a type of variable)	Definition/reason
Price (random)	The average price offered in US$.
Availability (Anthropogenic Allee Effect) (random)	The number of individuals traded. We expect that species that are rare (and less available on the market) will be more expensive, based on the standard economic model prediction. We also expect the same pattern when the same species for sold, where months with fewer posts will result in higher prices.

(**Table 4** continued on the next page, 1/2)

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Variable (a type of variable)	Definition/reason
Availability (Anthropogenic Allee Effect) (random)	The further prediction of the Allee effect would state prices for wildlife products increasing with species rarity will lead to extinctions. Despite higher search and harvest costs, the price-rarity relationship creates a financial incentive to harvest the last remaining individuals of the population (Holden and McDonald-Madden 2017). To test the full AAE with availability will require data over an extended period of time.
Body Size (random)	Body size usually correlates with price, where larger individuals are more expensive. This relationship is seen from the trophy hunting industry where species with larger body sizes were found to be more economically valuable (Johnson et al. 2010). I include different indicators of body size, such as body mass, body size (length) or wingspan.
Geographic (fixed)	Variables under geography include native status (whether an individual species can be found in Thailand or not), and migratory status, especially for bird species.
Temporal (random)	As an indicator for temporality, I may include seasonality (a year or monthly periods in accordance with general breeding durations) as a variable to examine whether availability or price is associated with time.
Legality (fixed)	CITES Appendix listing (CITES I, CITES II, or CITES III/ Unlisted species) or domestic law protections (Protected under WARPA / Unprotected under WARPA) may be included as proxies for legality to explain availability and price
Conservation status (fixed)	As an indicator of conservation status, IUCN Red List Category (Least Concern, Near Threatened, Vulnerable, Critically Endangered, Extinct, or Data Deficient) or IUCN population trends (Increasing, Decreasing, Stable) are variables that may be included as proxies for rarity or its protective status.
Others (Fixed)	Other predictor models that may be included are dependent on the taxa. For example, 'Tameness' was a descriptive term often used to describe owls, and is, therefore, another term for 'Domesticated', whereas 'Trained' was a common term to describe raptor species. For owls, a Harry Potter effect variable was also included (Species or lookalike species found in the Harry Potter franchise, Species not found in Harry Potter). Clutch size was also included for bird models as a biological factor.

The IUCN Red List of Threatened Species is one of the predictors that will be included in many of the models, for both plants and animals. It is a global inventory of global conservation status of biological species (Henrique et al. 2020). A set of criteria is used to evaluate the current status of a species resulting in nine categories, including: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX). According to the IUCN, species evaluated as CR, EN, and VU are species which are already threatened with extinction. The IUCN Red List of Threatened Species also produces a population trend which I also will incorporate into the model as a proxy for threats in the case that species modelled all have the same Red List assessment.

2.3.4 Alternative methods (i.e. seizure records)

Third-party sources are one new way of gaining information on wildlife trade. For example, collection of seizure data has been conducted for wildlife at a regional to global scale (in the US: Petrossian et al. 2016; Hitchens and Blakeslee 2020, global scale; Rosen and Smith 2010). The UNODC seizure database system called The World Wildlife Seizure Database (World WISE) is also one of the largest global database systems that contain data from over 164,000 seizures from 120 countries, where data were sourced from the CITES Database (UNODC 2016). Petrossian et al. (2016) used a government database system from US Fish and Wildlife Service (USFWS) Law Enforcement Management Information Systems (LEMIS) to examine seizure patterns over a 10-year period. More recently, Hitchens and Blakeslee (2020) analysed personal baggage seizures imported through US ports of entries in the Pacific Northwest from 1999 to 2016 to demonstrated how seizure data could be used to inform about the central factors that have previously and presently contribute to IWT. Using the same LEMIS database in a more refined region of North America, the authors identified five significant factors that determined the numbers and types of baggage seizure which included taxonomic classification of wildlife, import date, wildlife product, source region, and the CITES status. Many charismatic species have independent 3rd party databases whereby there is seizure information including, elephants and ivory (Underwood et al. 2013; Yeo et al. 2017), pangolins (Challender et al. 2015b) and otters (Siriwat and Nijman 2018a). NGO based reports such as from TRAFFIC bulletin also compile information on seizure data.

In addition to official sources such as national government and regional agencies, seizure data can also be obtained from open sources such as media. Despite the limitations which arise from the inherently incomplete data (Rosen and Smith 2010; Underwood et al. 2013; Milliken et al. 2012), seizure reports generally contain fundamental information starting with confiscated species, number or volume of seized individuals, status or condition of animal/product, country source, destination country, etc. (Rosen and Smith 2010). Further information that can be obtained includes intended use, date of arrest or offence, whether people were arrested, and conservation status. Further analysis using

modelling techniques can also be used with seizure data (Clarke et al. 2006, Keane et al. 2008; Baker et al. 2007).

One of the discrepancies that may arise from using seizure data is that the interpretation of a seizure differs, especially when comparing across species. For example, quantification of the number of individuals impacted or appraising the value of a box of dried pangolin scales to sacks of bear carcasses, to a shipping container of ivory will differ. These three examples thus cannot be treated as equivalent in terms of incidents, the number of individuals impacted or volume as some products may have already gone through processing (UNODC 2016). According to the UNODC (2016) suggested guidelines in analysing seizure data are dependent on the purpose(s) of analysis. As such, one of the common ways to standardise measures for analysis and make comparisons is to use the monetary value of items as a starting point.

In chapter 4, I collected and analysed seizure reports using online news reports in Thailand. Tags for the target species were searched in the online news pages in Thailand. Websites were monitored twice each year. Details of the seizures were collected, where possible, for seizure date, location (district and province), number and volume seized, intended destination, suspect nationality, the arresting agency involved and the legislation applied to the case (Siriwat and Nijman 2018a). In the same approach as was conducted in chapter 4 and 5, GLMs were also used in the analyses of this chapter to predict and explain the provincial variation in the number of seizures, and the total number of logs seized (Table 5). Predictor factors are described in further detail in the chapter. An ANOVA test was also applied to quantitively test to examine group-wise differences in the number of logs seized annually for each species. In order to examine in detail the changes in the number of logs seized over time, an ANOVA test was implemented for each species using the year as a grouping. The differences in the number of logs in each year were compared to each other, and the changes according to the sequential year was used. All variables used were tested for normality and any variables which violated it was transformed and did not violate. Residuals and homoscedasticity were checked for using Q-Q plot. A Tukey post hoc test was applied to see the direction of the differences.

Table 5. Variables used in Generalised Linear Models to analyse rosewood seizure data. All variables are random variables.

Predictor variable (the type of variable)	**Proxy**
Number of logs (random)	Number of logs seized for the three species (Siamese rosewood, Burmese rosewood and Burmese padauk)

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Predictor variable (the type of variable)	**Proxy**
Number of seizures (random)	Number of seizure reports for the three species (Siamese rosewood, Burmese rosewood and Burmese padauk)
Spatial (random)	Distance (km) to the closest land border from the district within each province with the highest seizures. Distances were calculated from the district with the highest number of seizures to the nearest land or sea border crossing using roads available on Google Maps.
Temporal (random)	Number of seizures over time (annual)
Population (random)	Provincial population
Economy (random)	Gross provincial product (In Thai Baht per year)
Environment (random)	Provincial forest cover (Percentage of green cover in each province accounting for official government National Parks and Forest lands)

2.4 Other sources of information

My interaction to wildlife trade has been since I was young, often through visiting the infamous Chatuchak Market on weekends and observing all the animals offered on sale. In fact, my father brought home a dog from one of the pet shops in Chatuchak Market. Although it may seem like a typical location to see and purchase animals, the eclectic mixture of different species condensed in such a small area has always struck me as unnatural and unsanitary.

This PhD was also formed and put into context based on my previous and current interactions and experience, particular to the topic of wildlife trade in Thailand starting since around 2013. I was able to provide qualitative findings from relationships based on my previous job at Freeland Foundation (2014 to 2016), an NGO that combats the illegal wildlife trade and habitat destruction (www.freeland.org). My work experience there for two years helped gained a broader discussion and understanding with who work in this field, ranging from those working as rangers and the Deputy Director of the Department of National Parks, Wildlife and Plant conservation. In addition to that, I attended workshops, meetings and events prior and during my PhD which allowed me to continually interact with people in this field and shape the view of the direction on the management of wildlife trade and how laws are implemented, perceived and interpreted over the seven-year duration.

1. Illegal Wildlife Trade Conference held in London, 2013
2. Coordinating ‘No Photos Please’, a campaign to combat wildlife trafficking and wildlife photo prop trade by Freeland Foundation, October 2014 to February 2015

3. Establishing and training rangers as a special task force for 'Hasadin Rapid Response Field Unit' in Dong Phayayen-Khao Yai World Heritage Site in Nakon Ratchasima, Thailand.
4. Attending a workshop for Tiger Action Plan in 2016
5. Attending a meeting of Ivory Action Plan in 2016
6. Organising event at Park Ranger Day with IUCN for rangers of national parks in 2016, 2017
7. Speaker at Student Conference on Conservation Science at Cambridge University, May 2017
8. Key Note Speaker at the Wildlife Trade Symposium: Evolving Perspectives on the Demand for Illegal Wildlife Products, held by Oxford Martin School, Oxford University, 23 September 2017
9. Speaker at the Meeting of the Association of Tropical Biology and Conservation 2018, Kuching, Malaysia 1-5 July 2018
10. Slow Loris Workshop in Bangkok, January 2019
11. Poster presentation at the European Federation of Primatology 2019 and the Primate Society of Great Britain, Oxford, September 2019

2.5 A final note on methods

I think it is important to highlight that due to the nature of the topic of this PhD thesis, the contents and findings will be data-driven, meaning that most of my data collection depends primarily on what I am able to find online, for example, for the Facebook trade, it requires a few very general monitoring sessions to find out what types of wildlife are offered for sale. I am also not in control of when certain data sources, such as Facebook groups, or news websites, may shut down or become inaccessible to me. Snowballing methods, or being flexible in finding new sources of information is therefore important due to the uncertainty of the data sources as well as the clandestine nature of the data collected. I collected as much data as possible systematically; however, I regularly came across obstacles of Facebook groups or news websites suddenly shutting down, which may hinder the data collection. Even though I try to become flexible, and source for more groups or website, this means that each of the projects conducted may be monitored at different times or for different durations. As a result, monetary values reported in US$ will be dependent on the conversion rate at the time of data collection. Furthermore, throughout this thesis, I refer to 'I' as the speaker's voice, however, it is essential to note that the work in each of the individual chapters has been in collaboration with my supervisors, Professor Vincent Nijman and/or Professor Anna Nekaris.

Chapter 3: Using the CITES trade database to monitor the international legal wildlife trade in reptiles and amphibians into Thailand

3.1 Introduction

3.1.1 CITES trade database

Accurately estimating the scale of the global legal and illegal wildlife trade is accompanied by a multitude of challenges (Oldfield 2014). Fortunately, parts of the legal trade are monitored by CITES, which offers at the very least a fundamental understanding of the scope and scale of trade in certain species. CITES is the international agreement which operates as a licensing system through which import and exports of species must be recorded established in 1975 (unep-wcmc.org). Currently, there are 183 countries or states which are parties to CITES, whose national role is required to work within a legislative framework and submit annual reports of international trade and seizures to the United Nations Environment Program World Conservation Monitoring Centre (UNEP-WCMC).

Globally, CITES is the most vital initiative to monitor and regulate international trade in over 5,600 species of animals and 30,000 species of plants (https://stag.cites.org/). The importance of CITES is highlighted and has been set that checks and balances are analyses of CITES records are pertinent to increase the effectiveness of CITES both for traders and markets (Bickford et al. 2011). In theory, its database offers an unparalleled opportunity for species conservation and has been invaluable in directing actions for conservation action for multiple species such as seahorses (Foster et al. 2014) turtles and tortoises (Luiselli et al. 2016), and birds (Ribeiro et al. 2019; Harris et al. 2015; Li and Jiang 2014). A global review and analysis of the CITES Trade Database for all taxa show that in the period from 1975 to 2014 over 16 million records have been reported from 28,282 species (Harfoot et al. 2018). Within the period indicated in the study, the reported values quadrupled from 25 million individuals to 100 million per year, while the ratio between wild to captive sourced declined by an order of magnitude or more. This study reflected the large scale component of the legal wildlife trade, and that volumes of imported species, sources and trade routes may change rapidly within a period of time due to the dynamic nature of the wildlife trade (Harfoot et al. 2018).

As CITES depends on data from annual reports which summarise import and export records, with details on taxonomy, CITES listing, year, import and export countries and quantities, the purpose of transaction (scientific, education, medical), source of imported/exported specimens (wild, captivity, and confiscated), trade form (specimen term, such as skin, tusks, products). Only a few entries fulfil these form requirements. The credibility of CITES and the effectiveness of enforcement varies

throughout each country and is dependent on the quality of data reported. Incomplete data are one of the main problems. Effectiveness of reporting, compliances, and complete data varies and creates loopholes in the entire CITES database (D'Cruze and Macdonald 2015). This has led to concerns for trade in multiple species, for example, trade in the African grey parrot in Singapore (Poole and Shepherd 2017). The need to create an enhanced, rigorous analysis of trade data aims to encourage sustainable trade through the setting of realistic trade quotas (Phelps et al. 2010).

3.1.2 Trade in reptiles and amphibians

Reptiles and amphibians are two of the taxa that have been traded in large volumes (Nijman and Shepherd 2009). Legal trade of over 1,059 species of amphibians and reptiles are currently reported to CITES either as Appendix I, II or III species. Previous studies have explored the trade globally (Pernetta 2009; Robinson 2015), regionally (Auliya et al. 2016) and nationally (Tapley et al. 2011; Herrel and van der Meijden 2014; Nijman and Shepherd 2011; de Magalhães 2012). Globally, reptiles and amphibian species are increasingly under threat (Mohanty and Measey 2019; Alroy 2015). In 2016, it was estimated that international trade of approximately 98% of amphibian species was unregulated (Auliya et al. 2016). Within the region of Southeast Asia, Thailand is one of the major hubs for the trade in reptile and amphibian species, both in terms of consumers and logistical transport (Nijman 2010). Trade has been historically observed of international species traded in traditional brick and mortar markets and also on online platforms (Nijman and Shepherd 2011, Todd 2011).

3.1.2 Aims

Concerns drawn about the efficacy of CITES in regulating the reptiles and amphibian trade has been studied. Nijman and Shepherd (2011) reviewed the trade in live amphibians and reptiles to supply the demand for the international pet trade into Thailand and reported on the concerns of the legitimacy of captive-bred to wild-caught reported values in the trade from 1998 to 2007, with some discrepancies in Thailand's role in sending wildlife to recipient countries such as Kazakhstan using trade paths through non-CITES member countries of Lebanon and Macao. This raised concerns that might suggest illegal and legal trade utilising legitimate trade hubs.

I analyse the data of CITES-listed reptiles and amphibians imported into Thailand from 2008 to 2018. I examine the basic dynamics of trade, including, what is being traded in the past decade, where it is coming from and how it is sourced. This chapter concludes with a comparative reflective approach in how Thailand's role in the global reptile and amphibian trade have changed, and if there have been any changes in terms of volume, source and conservation statuses of imported wildlife from the previous decade. I make direct comparisons to the findings reported from 1998 to 2007 by Nijman and Shepherd (2011). When comparing both decades, I hypothesise that:

1. Overall the volume of commercial trade will increase

2. The proportion of captive-bred individuals will increase
3. The proportion of threatened species according to the IUCN Red List (Critically Endangered, Endangered and Vulnerable) will decrease.
4. There will be a decline in imports from non-CITES parties.

3.2 Methods

3.2.1 CITES trade data acquisition

Data records were downloaded from the WCMC-CITES trade database (http://www.unep-wcmc.org/citestrade) from the period of 2008 to 2018; data from 2019 were not yet available. Trade data of live specimens were downloaded as a comma-separated values file (.csv) format. In addition to describing the established trade of reptiles and amphibians in Thailand in the past decade, one of the further purposes of the research in this chapter is to provide a comparative study to see how this may have changed over time. As such, the methods used in tackling the CITES trade database will be mainly following the methods by Shepherd and Nijman (2011). Under exporting countries, I list 'All countries', and under importing countries, I select 'Thailand.'

Under 'Sources', I included all, which includes 'Captive-bred animals', 'Captive-bred/artificially propagated', 'Born in captivity', 'Confiscations/seizures', 'Pre-Convention', 'Ranched', 'Source unknown', and 'Wild', and focused on captive-bred ('C' and 'D') and wild-caught ('W'), focusing on entries reported imported into Thailand. Furthermore, records under unknown source ('U'), or without an indicated source were also removed from further analysis. The definitions used in this study follow those provided by UNEP-WCMC (UNEP-WCMC, 2004) and Nijman and Shepherd (2011). By the definition of CITES, captive-bred (hereafter referred to as CB) individuals are defined as at least second-generation offspring of parents bred in a controlled captive environment. CB is also defined as first-generation offspring from a facility that is considered to be capable of reliably producing second-generation offspring (Nijman 2010). According to CITES, wild-caught (hereafter referred to as WC) refers to specimens which originate from the wild.

As it is assumed that a large proportion of the trade of reptiles and amphibians imported into Thailand' is directed towards the exotic pet market, only entries listed under commercial trade (source-code: 'T') were included. Under the purpose of trade, I include other purposes of trade, such as exchanges made between zoos ('Z'), Personal reasons ('P'), educational or scientific purposes 'E', that may be for commercial or non-commercial reasons, were downloaded to better contextualise the overall trade but excluded from further analysis as there were only a few entries.

Trade terms include live specimens, as well as separate body parts of animals such as bones, claws, eggs, feathers, scales and teeth. Processed by-products, for example, handbags, horn and ivory carvings, leathers and wood products could also be included in the search database. In this case, only Trade terms that were included were only for 'live' individuals.

The CITES trade database is unidirectional (Harfoot et al. 2018). The volumes of trade were reported by either the importing country (Thailand) or exporting country (Nijman and Shepherd 2011). Furthermore, I also incorporated methods by Carpenter et al. 20074 and Pernetta 2009 that where both volumes were reported by the importer and exporter nation, the importer data were taken into account as it is based on the CITES permits that were actually issued and used rather than the CITES permits that were only issued. In some cases, re-export entries record the export of wildlife product originally exported to another country (Harfoot et al. 2018). In large scale global studies such as Harfoot et al. 2018, re-exports were removed to prevent double counting, but I solely focus on Thailand's role as an importer.

It is possible that there may be delays in the entries where comprehensive trade statistics are generally available is two years before the present one (Foster 2014). As data from 2018 was missing, it was removed from further analysis, limiting the study period to a 10-year span from 2008 to 2017.

3.2.2 Analyses

Species analysis

Analysis of global trade records was separated into species and source or destination countries. Associated species information was listed, including the conservation status of each species based on the IUCN Red List, IUCN global population trends obtained (iucn.com) and CITES listing (http://cites.org). First, the composition of species traded was presented and analysed. Following methods by Pernetta et al. (2009) and Panter et al. (2019), I analysed the number of individuals traded. I also calculate the annual proportion of CB and WC species over the study period and tabulate the countries of origins specific to CB and WC species.

Decade comparison

I compare the findings of 2008 to 2017 to the previous study by Shepherd and Nijman (2011) who analyse the trade from 1998 to 2008 with a specific focus on the reptile and amphibian species imported into Thailand. Species composition was compared to previous decadal study using a two-tailed independent t-test, comparing the number of individuals and the number of species traded over the 10-year period. A t-test was also used to compare the total number of individuals imported between the decades based on conservation assessments category, including, threatened, non-threatened and unlisted species. I also make direct comparisons to the proportion of CB and WC

species traded over the two study periods. I justified that the release and publishing of the paper marks a significant period where attention was given to the CITES management authorities in Thailand. In the lead to the paper's production and publication, the authors reached out to the Thai CITES authorities both the MA and the SA to inform them on the discrepancies regarding imports from non-CITES countries and requested for comments (V. Nijman, pers. comment, 2020). Additionally, the CITES secretariat was also in contact with Thailand's CITES MA to discuss issues related to the aforementioned discrepancies (V. Nijman, pers. comment, 2020). Therefore, I believe this is a valid reason to make direct statistical comparisons between the two decades.

As there are differences in the time of the study, the conservation status of species and criteria for IUCN Red List (www.iucnredlist.org) has changed over time. I went back to look into the IUCN Red List conservation status listed not beyond 2010. During the time of study of Nijman and Shepherd 2011, the criteria they considered as threatened were: Critically Endangered, Endangered or Vulnerable, excluding species that are listed as Near Threatened, Least Concern/conservation dependent or Data Deficient (Shepherd and Nijman 2011). Shepherd and Nijman (2011) restricted their analysis of volumes and species compositions to 10 years of data. Furthermore, I separated out import data for the order of Crocodilia (crocodile and alligator species). This is due to large volumes of individuals traded and the impact that it may have in skewing the analyses or leading to biased conclusions.

3.3 Findings

3.3.1 By species

From the period of 2008 and 2017, a total of 897 trade records (166,715 individuals) of amphibian and reptile species were retrieved from the WCMC-CITES trade database under the purpose 'Commercial – T'. Other possible commercial purposes were also examined (Breeding – B, Personal – P and Zoos -Z); however, the other purposes contributed to less than 1% of all imports.

A total of 149 species of reptiles were imported into Thailand and 21 species of amphibians (Figure 6), 42 species of which are considered globally threatened (VU, EN, CR; Table 6). Reptiles contributed more to the trade (87%) when compared to amphibians species (13%). Overall, a majority of the traded individual are listed under CITES Appendix I (69%) that come from two species of crocodiles. While the remaining volume of trade, 30% make up from Appendix II species.

Within the WC individuals, 86 species have been assessed by the IUCN Red List. Of this, 45% (n = 39/86) species listed for trade had decreasing global population trends. Of the remaining 31% (n = 27/86) have stable population trends, 2% (n = 2/86) have increasing population trends and 21% (n = 18/86) were unknown or unspecified; 20 species were unlisted. While for CB individuals, 77 species have been assessed by the IUCN Red List, where 42% (n = 32/77) of species listed for trade had a decreasing population, 26% (n = 20/77) stable wild population trends, 4% (n = 2/45) have increasing population trends, and 30% (n = 23/77) were unknown or unspecified. Twenty-three species are unassessed.

Table 6. Volume and proportion of imported reptiles (separated by all reptiles and crocodiles and alligators) and amphibians imported into Thailand from 2008 to 2017 with its associated IUCN Red List Conservation status updated in 2020.

IUCN Red List Conservation status (2020 update)	**Reptiles (excluding crocodiles) (142 species)**	**Crocodiles and alligators (7 species)**	**Amphibians (21 species)**
LC	69 % (30,956 individuals)	3 % (3,977 individuals)	88 % (2,911 individuals)
NT	5 % (2,121 individuals)	0 %	0 % (10 individuals)
VU	20 % (8,882 individuals)	0 %	4 % (127 individuals)
EN	0 % (146 individuals)	0 %	6 % (195 individuals)
CR	1 % (274 individuals)	96 %	2 % (70 individuals)
DD	0 % (66 individuals)	0 % (114,030 individuals)	0 %
Unlisted	6 % (2,670 individuals)	0 %	0 %

In an examination of popularity of top five imports by volume (**Table 7)** , the top species traded for reptiles (excluding alligators) consist of three tortoise species, one python and a common iguana. For crocodiles and alligators, Siamese crocodile (*Crocodylus siamensis) and* Saltwater crocodile (*C. porosus)* dominant by volume of imports. While, frogs are traded in smaller numbers, with a specific trend for poison frogs native to Central and South America and Madagascar.

Table 7. The top five number of reptiles and amphibians species imported into Thailand from 2008 to 2017 ranked by volume.

Group	Species (IUCN Red List)	Family	No. indiv.
Reptiles (excluding crocodilia)	1. Leopard tortoise *Stigmochelys pardalis* (LC)	Testudinidae	8,622
	2. Ball python *Python regius* (LC)	Pythonidae	4,608
	3. African spurred tortoise *Centrochelys sulcate* (VU)	Testudinidae	3,792
	4. Red-footed tortoise *Chelonoidis carbonarius*	Testudinidae	2,765
	5. Green iguana *Iguana iguana* (LC)	Iguanidae	2,739
Reptiles (crocodilia)	1. Siamese crocodile *Crocodylus siamensis* (CR)	Crocodylidae	114,030
	2. Saltwater crocodile *C. porosus* (LC)	Crocodylidae	3,400
	3. Nile crocodile *C. niloticus* (LC)	Crocodylidae	444
	4. Smooth-fronted caiman *Paleosuchus trigonatus* (LC)	Crocodylidae	105
	5. Cuvier's dwarf caiman *P. palpebrosus* (LC)	Crocodylidae	82
Amphibians	1. Red-eyed tree frog *Agalychnis callidryas* (LC)	Hylidae	727
	2. Baron’s mantella *Mantella baroni* (LC)	Mantellidae	536
	3. Betsileo golden frog *M. betsileo* (LC)	Mantellidae	414
	4. Parker’s golden frog *M. pulchra* (LC)	Mantellidae	283
	5. Green and black poison dart frog *Dendrobates auratus* (LC)	Dendrobatidae	263

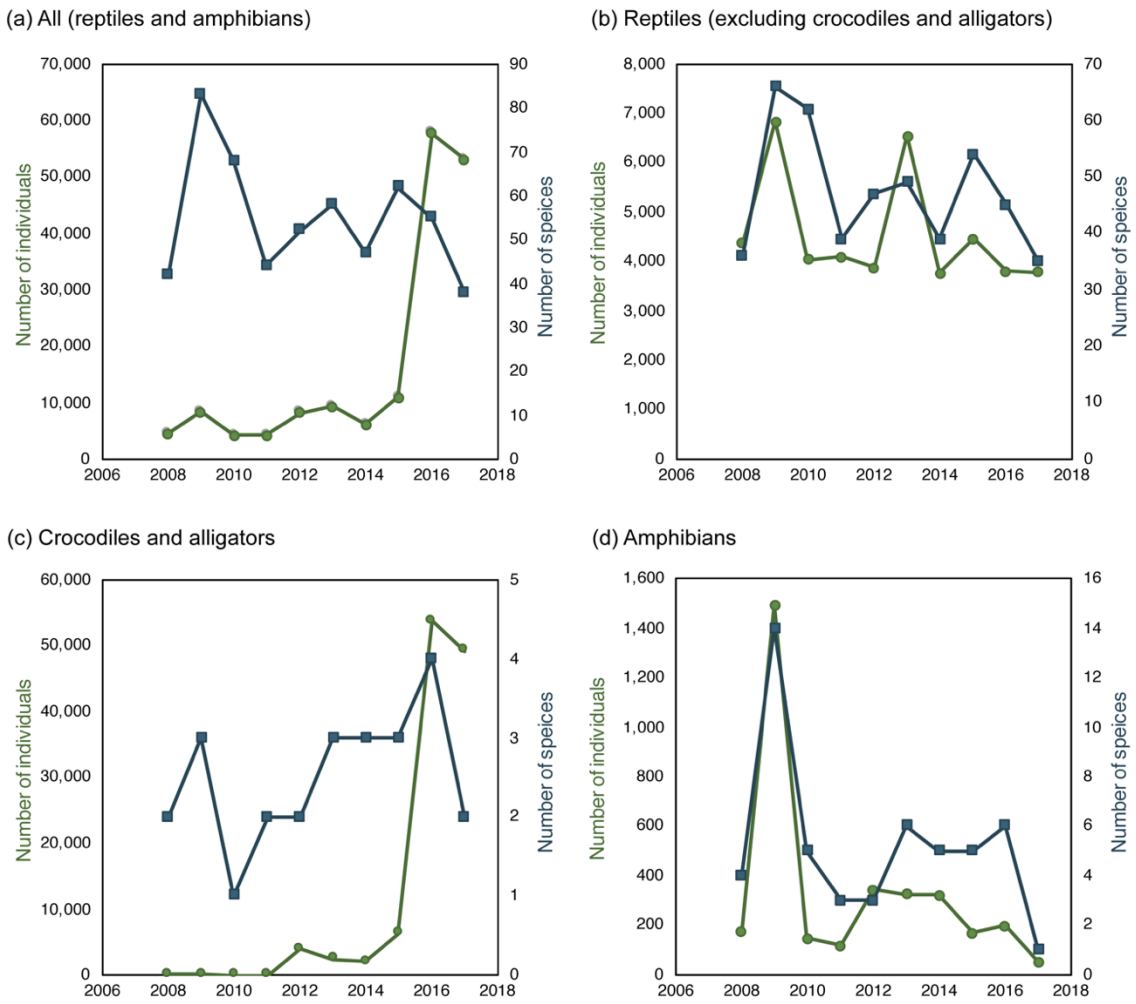

Figure 6. The (a) total number of individuals and species of reptiles and amphibians imported into Thailand from 2008 to 2017; broken further into (b) the total number of individuals and species of reptiles (excluding crocodile species); (c) the total number of individuals and species of crocodile and alligators species and (d) the total number of individuals and species of amphibians.

3.3.2 By source (captive/wild) and country

The majority of imported individuals were reported as sourced from captivity (under source codes C, D, and F; n = 184,071, 87%), compared to WC (n = 25,623 , 12%; Figure 7). There were 30 individuals listed under unknown source (U). The top-ranking countries which imported WC individuals into Thailand are Madagascar (n = 6,127), Ghana (n = 1,860), and Namibia (n = 1,086). All of Madagascar imports were from WC individuals. For CB individuals, most originated from the USA (n = 17,968) followed by Zambia (n = 6,890), Myanmar (n = 4,350) and Ukraine (n = 3,415).

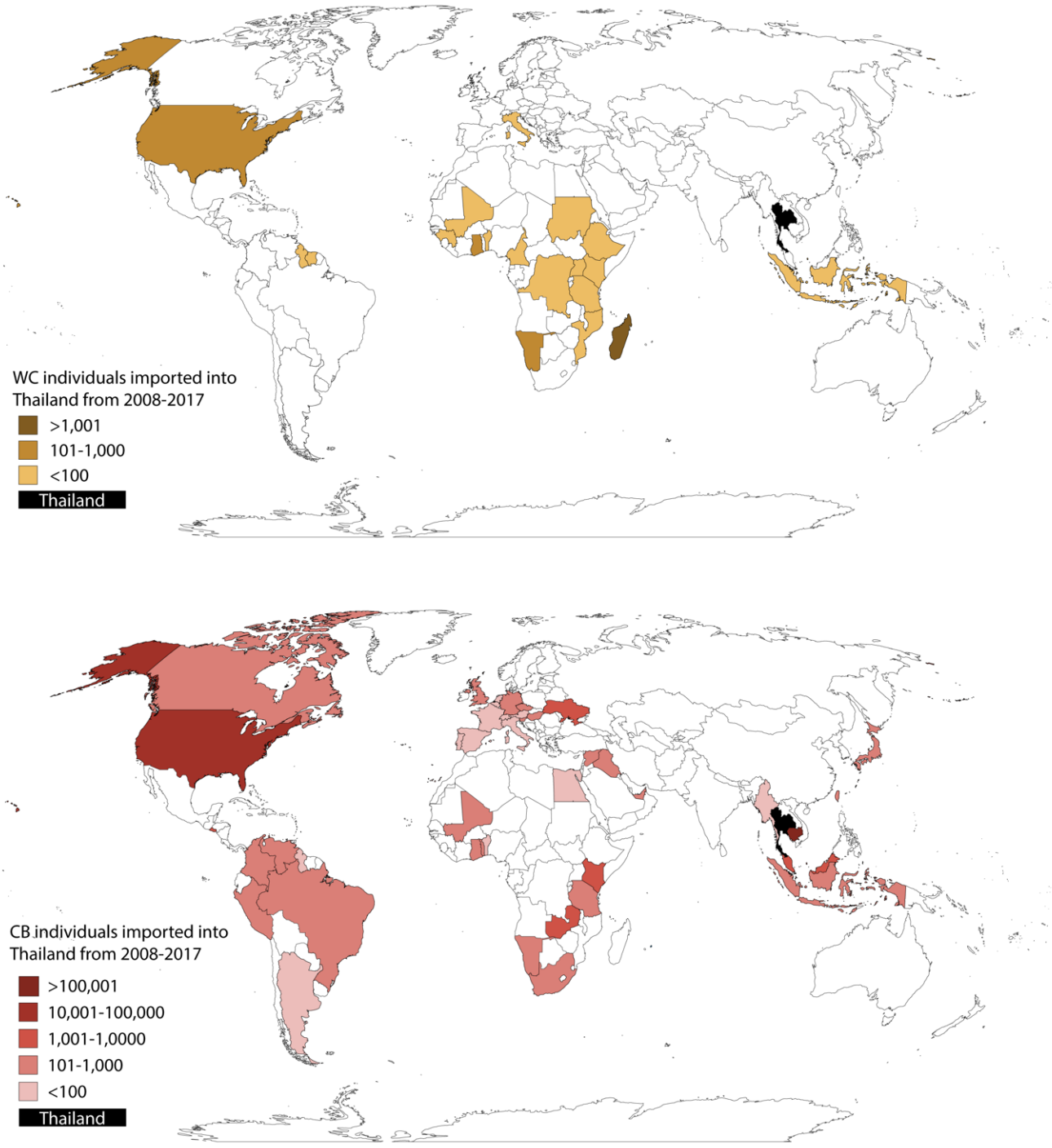

Figure 7. Map of source countries of (a) wild-caught (WC) and (b) captive-bred (CB) species imported into Thailand from 2008 to 2017. The top three countries which exported WC individuals into Thailand are Madagascar (n = 6,127), Ghana (n = 1,860), and Namibia (n = 1,086). The top countries that Thailand imports captive-bred species from are USA (n = 17,968), Zambia (n = 6,890) and Myanmar (n = 4,350).

3.3.3 Comparison to Shepherd and Nijman (2011)

The data analysed here can be compared to Shepherd and Nijman (2011), which summarised the CITES trade data trends for Thailand for the same taxa from 1990 to 2007 (Table 8). Nijman and Shepherd reported a total of 75,594 individuals of at least 169 species imported into Thailand. The total number of individuals traded increased, but this is not consistent with the species number, which experienced more fluctuation (Figure 8). I developed the set of hypotheses mentioned in the introduction that cover changes related to volume, proportion (in percentage) of captive-bred imports, the proportion of threatened species and imports from non-CITES parties.

Table 8. Summary statistics comparing imports of reptiles and amphibians between 1998 to 2007, to 2008 to 2017.

Category		**Total volumes imported from 1998-2007 ± S.D.; % (where applicable) - (Shepherd and Nijman 2011)**	**Total volumes imported from 2008-2017 (± SD); % (where applicable)**
Total trade records		555	897
Total individuals		43,130 ± 4,241	166,715 ± 20,594
Total species	Reptiles	366 ± 29	497 ± 10
	Amphibians	77 ± 6	52 ± 3
CITES (% Individuals)	Appendix I	2,075	116,430
	Appendix II	40,891	50,165
	Not listed or III	96	120
Source (% Individuals)	Wild-caught	13,145 ± 1,147; 30%	12,478 ± 1,159; 7%
	Captive-bred	29,985 ± 3,527; 70%	154,086 ± 20,970; 93%
IUCN Red List conservation status	LC	4,647 ± 565; 11%	37,844 ± 1,057; 23%
	NT	1,722 ± 258; 4%	2,131 ± 280; 1%
	VU	6,465 ± 666; 15%	9,009 ± 403; 5%
	EN	1,467 ± 144; 3%	341 ±76; 0%
	CR	3,339 ± 655; 8%	114,374 ± 20,470; 69%
	DD	477 ± 12; 0%	66 ± 10; 0%
	Unlisted	25,301 ± 2703; 59%	2,670 ± 157; 2%

Firstly, between the two decades, the number of individuals traded was statistically different (independent t-test; $t = 2.32$, $df = 18$, $p = 0.032$) with a positive increase, whereas the number of species traded were not reported significantly different (t-test; $t = 1.59$, $df = 18$, $p = 0.12$). When

crocodiles and alligators were removed from the analysis, the number of individuals traded was not statistically different ($t = 0.58$, $df = 18$, $p = 0.56$); This suggests that the spike of import in Figure 8 is attributed to mainly the import of crocodiles and alligators in the recent years.

Secondly, the annual proportion of captive-bred individuals imported has also increased. The range in the annual proportion of captive-bred individuals reported by Shepherd and Nijman (2011) was from 0% to 79% with a yearly mean of 46% ± 36% citing that there was no apparent pattern in the proportion of CB individuals imported into Thailand (Figure 9). However, in the past decade, the proportion of captive-bred imports ranged from 42% to 79% between each year, with an annual mean of 83% ± 16%. The difference in means between the two decades was statistically significantly (t-test; $t = -2.96$, $df = 18$, $p = 0.0084$).

There were still some similarities when examining the different country origins based on source countries between the two decades. The proportion of WC individuals were still mainly sourced from African countries. The same patterns were not present among imported CB individuals; individuals originated in countries ranging from the Americas, Africa, Europe and Asian countries. Between the two decades, WC individuals and species of reptiles and amphibians imported into Thailand were not statistically different (individuals: t-test; $t = 0.31$, $df = 18$, $p = 0.75$; species: t-test; $t = 0.73$, $df = 18$, $p = 0.48$; Figure 8a). While for CB individuals, the difference in imported volumes between the two decades were statistically significant for individuals (individuals: t-test; $t = 2.32$, $df = 18$, $p = 0.032$), but not so for species (t-test; $t = 1.79$, $df = 18$, $p = 0.090$).

With crocodiles excluded from the analysis, shows a non-statistically significant relationship between CB individuals imported (t-test; $t = 0.76$, $df = 18$, $p = 0.45$), signifying that behaviour of import CB individuals did not clearly change over the two decades. The proportion of CB individuals relative to WC individuals once crocodiles and amphibians were removed was also evidently lower throughout the 20-year period (Figure 8b).

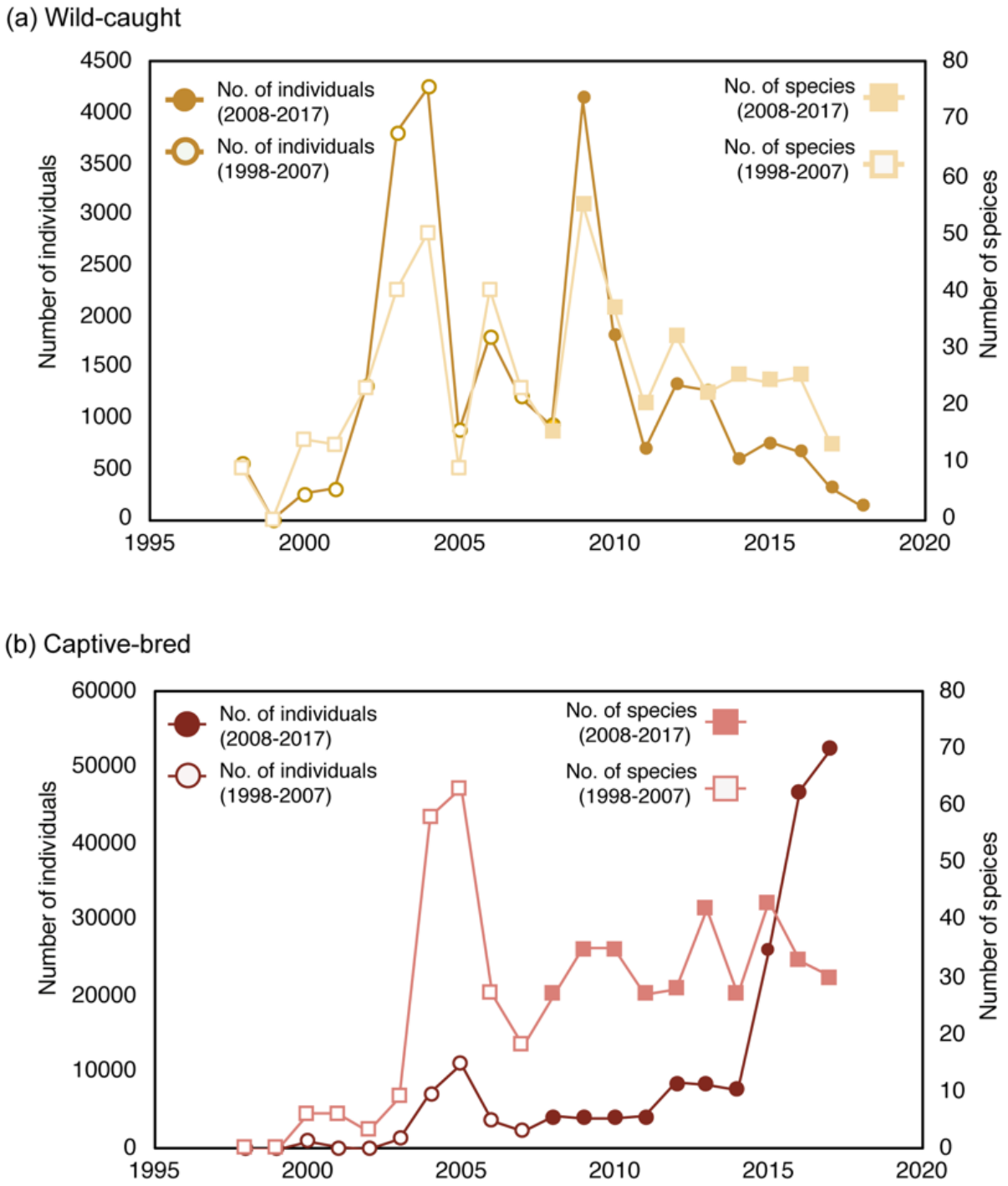

Figure 8. Comparison of changes in the number of (a) wild-caught (WC) and (b) captive-bred (CB) individuals and species imported into Thailand based on 1998-2007 (period of the Nijman and Shepherd 2011 study) and 2008 to 2017 (the period of the analysis in this chapter).

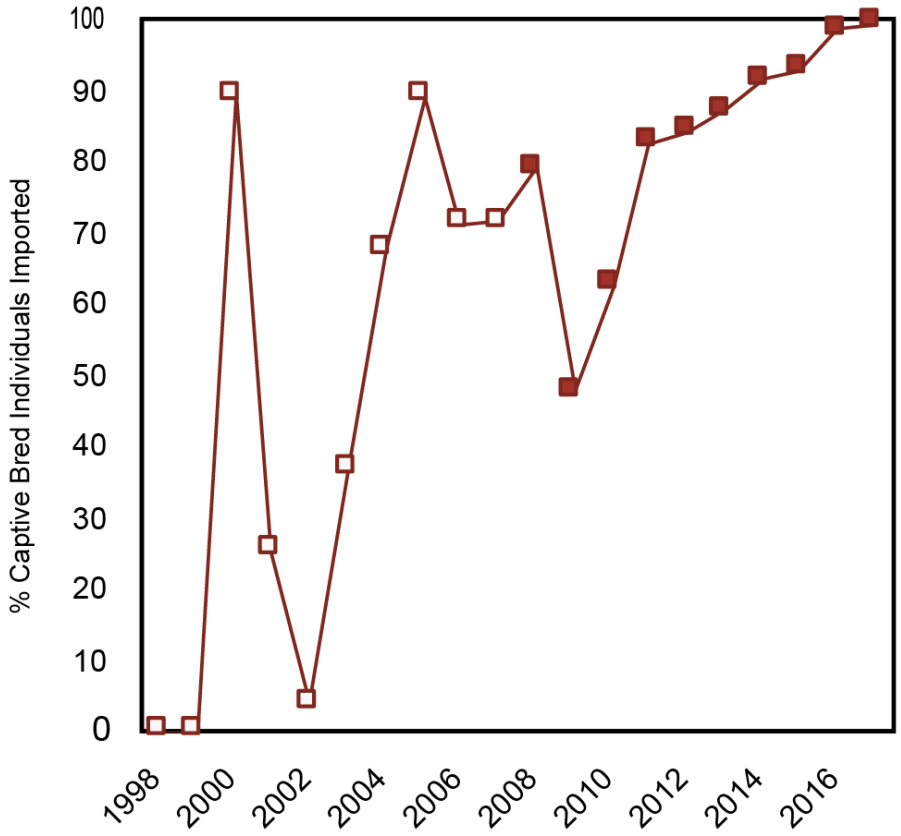

Figure 9. Percentages of captive-bred (CB) species of reptiles and amphibians as imported into Thailand in the period from 1998 to 2017. The overall proportion of CB individuals show an increasing trend. Open squares are data points from Nijman and Shepherd (2011) and closed squares are from 2008 to 2017 data set.

Thirdly, the total number of species traded in this decade study is fewer than the previous decade. However, when examining its conservation statuses, the number of globally threatened species increased, from 19% (n = 33/169) to 26% (n = 45/176) species. Three categories of conservation statuses were created, includes, threatened which includes IUCN Red List listing VU, EN, CR, non-threatened which includes NT and LC, and unlisted which includes DD and unassessed species (**Figure 10**). The differences between the annual imports of each decade were statically significant across all groups. Non-threatened species showed an increase in number from the previous decade ($t = 7.96$, $df = 18$, $p<0.0001$). Unlisted or data deficient species significantly decreased ($t = 2.63$, $df = 18$, $p = 0.017$). For threatened species, there was not statistically significantly difference in annual means of import volume ($t = 1.74$, $df = 18$, $p = 0.098$). It is evident that the threatened species are skewed entirely by the crocodile and alligators; however, there is an insufficient data point to specifically make comparisons between the crocodile imports between the decades.

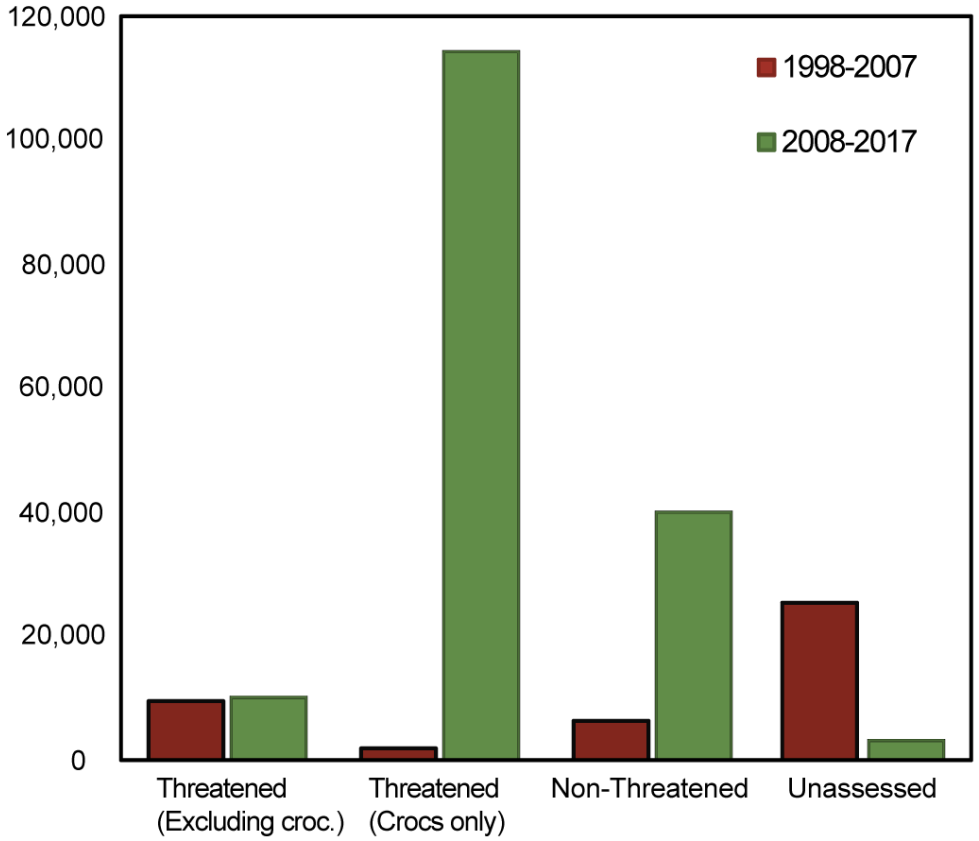

Figure 10. Comparison of import volumes from Nijman and Shepherd (1998-2007) in red and this study (2008-2017) in red by their IUCN Red List status. The group includes: Threatened (Critically Endangered, Endangered, Vulnerable), Non-Threatened (Near Threatened, Least Concern), and Unassessed.

Lastly, Shepherd and Nijman (2011) specifically highlighted a trade route, imports from Kazakhstan to Thailand that were irregular and strongly possibly used as an illegitimate trade route. It accounted for missing up to 10,000 individuals from 51 species. From 2009, nine additional counties have joined as a CITES member party, including, Lebanon in 2013. From 2008 to 2017 there were no imports from non-CITES parties.

3.3.4 Importer and exporter values

Importer and exporter reported quantities could also be examined based on Thailand's imported wildlife (Figure 11). Shepherd and Nijman (2011) commented that while there appeared to be no discrepancies between source codes, there appeared to be wider discrepancies in the volume export and imported particularly examining captive-bred specimens, in particular, examining Indian star tortoise *Geochelone elegans*, African spurred tortoise *G. sulcata*, and leopard tortoise *Stigmochelys pardalis*.

Overall, 21% (14,657 individuals) was reported only by the importer (Thailand), and 33% (22,796 individuals) were reported only by the exporter (not Thailand). Meanwhile, 46% of trade (31,961 individuals) were reported by both importer and exporter. However, looking at records where both reported values and volumes reported by exporters and importers in the past decade, it overall looks like often exporter reported quantities are higher than importer quantities, though the total discrepancies between the two do not significantly differ in terms of volume (total importer reported quantities: 34967; total exporter reported quantities: 53,211). One reason that may explain higher export volumes than import volumes could be due to the actual issuing of certificates and relate to mortality during the transfer of individuals.

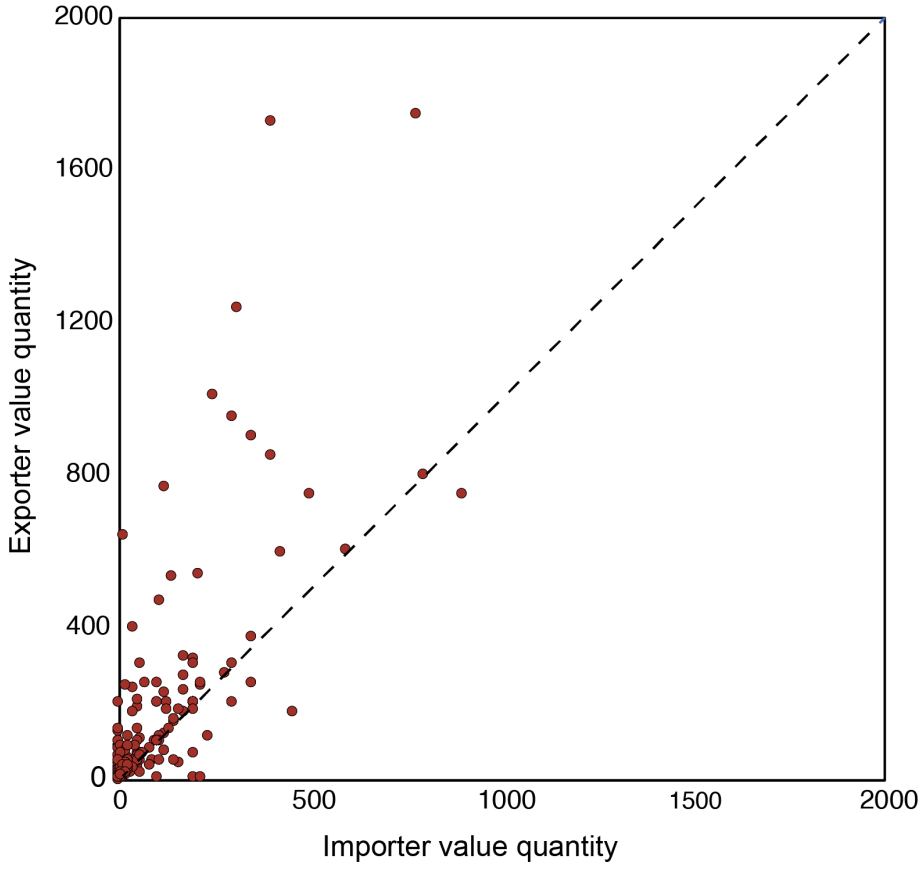

Figure 11. Importer and exporter reported quantities for trade recorded on CITES trade database for amphibian and reptile species in Thailand from 2007 to 2018, compared to the expected value (linear line) where importer and exporters are expected to report the same number.

3.4 Discussion

3.4.1 Thailand's role as a consumer

Here, I analysed the dynamics of the import of CITES trade in reptiles and amphibians in Thailand from 2008 to 2017. The records presented here showed a growing volume of commercial legal trade

of reptiles and amphibians into Thailand, with a consistently high demand for tortoises as observed from the previous decade, and also an increase in snake imports. While the number of species imported is not statistically different, the number of individuals are consistent throughout the 1990s to 2000s with a stark increase in 2016, specifically related to imports of crocodile species. When crocodiles were removed from the equation, the number of individuals imported into Thailand from the two decades did not differ statistically, suggesting that the import trading volume is similar across the decades. The proportion of captive-bred species has also increased in the past decade. However, a significant portion of captive-bred imports is more highly threatened conservation status. Finally, Thailand has done relatively well to minimise discrepancies, as reported in the previous decadal study, reporting no imports from non-CITES parties.

Certain countries act predominantly as re-exporters. For example, Hong Kong, Italy, Japan 100% records of imports into Thailand are of re-exporters. Namibia and Taiwan are also close, at nearly 100%, as only a re-export. Significantly, The United States is the country that re-exports the most reptiles and amphibians into Thailand with origin countries ranging from the region of Central and South America and even the African continent, highlighting the United States' pivotal role in the legal wildlife trade. Furthermore, Madagascar remains a major source of imports of reptiles and amphibian species into Thailand, since the study conducted by Nijman and Shepherd (2011) in the previous decade. In this study, a large volume of threatened species also originate from Madagascar. Species of WC Malagasy chameleons (*Furcifer* spp. and *Calumma* spp.) are popularly traded in markets in Asia, recorded in Thailand, Japan, Singapore and Hong Kong (Todd 2011).

Not all commercial trade is intended for the exotic pet trade. In the past decade, two of the top traded reptile species by volume are Siamese crocodile and ball pythons (*Python regius*). African species of snakes, including African rock python (*P. sebae)* and ball pythons, have also been extensively reported in the international trade in skin and leather products (Lyons and Nautsch 2011; Luiselli et al. 2012; Jensen et al. 2018). Southeast Asia, including Thailand, are key importers of live snakes and exporters of snakeskin products (Hierink et al. 2020). Additionally, Under the Crocodile Co-operative of Thailand, 12 commercial captive facilities host a large number of *C. siamensis* for the leather and food industries, whereas *C. porosus* populations are managed under captivity without commercial use (Lapbenjakul et al. 2017). Since 2000, Thailand has become one of the global centres for crocodile farming, reporting over 1.2 million crocodiles in over 1,000 farms (Anonymous 2017a). In 2017 alone, the value of crocodile export totalled over US $120,000,000 (Anonymous 2017b). The reason for the spike in an increase of imports of crocodiles in staggering numbers is likely related to farmers preparing the farms for a government endorsed scheme by the Ministry of Agriculture and Cooperatives in 2017 to make Thailand the global export leader in crocodile products (Anonymous 2017b). Interestingly, the Siamese crocodile and Saltwater crocodile are arguably two of the most

endangered animals in Thailand (Lapbenjakul et al. 2017), which draws into question how effective or successful wild population management and conservation can be if there is such commercialization.

3.4.2 Implications to the conservation of reptiles and amphibians

Over time, the total proportion of wildlife imported from captive sources shows an increasing trend both when including crocodiles and alligators into the account, as well as without the inclusion of crocodiles and alligators. This may be a result of many reasons ranging from stricter controls on sourcing and importing wild individuals, or an increase or improvement in captive breeding efficiency, but also a depletion in the wild. This trend is consistent with global markets; within legal wildlife markets, there is a reported shift of predominantly wild sourced individuals to captive sourced individuals consistently seen for many taxonomic groups, especially reptiles (Harfoot et al. 2018, Sung and Fung 2018).

Geographically, there are patterns of countries which mainly imported WC species into Thailand, where 84% of imported WC individuals originated from countries on the African continent, led by Madagascar and Ghana. While there were not as apparent patterns for CB individuals, originating from 45 countries from six continents. However, issues pertaining to the legitimacy of captive-bred individuals are not a new issue as it is argued that captive breeding is not always possible, or that legitimate breeding facilities were used as a scheme to launder wild animals (Janssen and Chng 2018; Bush et al. 2013; Lyons and Natusch 2011). Poole and Shepherd (2017) reported that parrots and cockatoos imported into Singapore from the Solomon Islands were falsely declared as being captive-bred as the origin country lacked avian breeding facilities. While Nijman and Shepherd (2009) reported that records of Indonesian wildlife marked as captive-bred were seriously questionable as the numbers of reptiles that purported breeding facilities in Indonesia are actually producing, or have the capacity to produce. Currently, as there are no clear methods to differentiate the source of an individual, CITES will need to ensure that the source declared for captive-bred is correct and truly relieving the pressure of harvesting from wild populations (Sung and Fong 2018).

With the random spikes of import of wild-caught individuals may be a result of the fickleness of the trade, especially amongst hobbyists. Consumer preferences may range from rarity, source, as well as morphologies (Lyons and Natusch 2013). that still has preferences for wild-caught individuals in some case (Sung and Fong 2018). Authorities will therefore need to consistently monitor the sources of wild sourced individuals and its conservation statuses to protect its wild populations.

Furthermore, despite seeing a reduction of wild-caught individual and increase in captive-bred individuals in the past decade for CITES-listed raptor species, the researchers also raised concern for the suspected potential increase in illegal trade seemingly under the appearance of a decrease in wild

sourced species (e.g. Levin 2000, Karyakin 2005). A case study examining the trade of Malagasy reptiles sold in Thailand reported that there is a strong consumer preference for individuals caught from the wild, and thus sustaining the importance of illegal markets in Bangkok (Todd 2011). It is also important to note that despite a global trend towards CB individuals, this is not apparent for every case, especially considering different abilities for captive breeding. There are presences of increasing trade of WC species of elephants, rhinos and zebras that have been growing in demand as a result of trophies. The concern is that the species are unsuitable for species for being CB (Harfoot et al. 2018).

Welfare issues concerning trade in the growing pet market, regarding reptiles and amphibians have also been highlighted. Baker et al. (2013) found that amphibians were most often associated with welfare impact domains, for example, *environmental challenges*; *behavioural, or interactive restriction* as well as stress and anxiety, while birds are most often associated with disease, injury and functional impairments. Reptiles reported the least association with the four of the five welfare impact domains; it is acknowledged that recognition of welfare indicators in reptiles is considered to be fairly challenging (Hernandez–Divers 2001). There still lacks reporting in the literature on the welfare impacts on reptile trade and mortality, considering the sheer volume of individuals traded globally.

3.4.3 Limitations of the CITES trade database

Using CITES trade database offers an opportunity to glean on baseline data for analysis of national relationships, and common trade pathways and channels (Vall-Llorsera and Su 2018). The data represented in this chapter represents legal trade and how it can be publicly accessed and used to understand an aspect of the trade better. CITES itself has some loopholes and concerns in interpretation (Berec et al. 2018). Since it relies on country self-reporting and lack of external auditing, there are often issues of discrepancies. Additionally, time delays are also common, as seen in the dataset of this study that lagged for over a year. Furthermore, it is also dependent that importers follow the guidelines for breeding and selling beyond just reporting in this database to the government. Governments need to be vigilant and thoroughly monitor the legal trade. Also, there needs to be consistent cross-checking between individuals offered for sale and those reported through the imported databases in order to reduce discrepancies. The CITES database is growing in content, and with more nations joining within the past two decades, it will be pertinent for governments to have a thorough approach in detailing with larger datasets.

The CITES trade database needs to be carefully interpreted, and its caveats and limitations need to be acknowledged for each analysis (Robinson and Sinovas 2018). There have been instances where CITES and custom data records have also been examined to be non-matching (Blundell and Rodan 2004; Foster et al. 2014). While, other aspects of the database, such as reporting volume still has discussion to how ‘completeness’ of the CITES trade database needs to be. Berec et al. (2018) argue

that incomplete data is a key discrepancy, while Pavitt et al. (2018) views that missing data does not necessarily mean inaccuracies but rather is the nature and format of the database. The difference between importer and exporter values could be a result of the different number of permits issued from the exporter versus the actual number of permits used, changes in the actual volume of individuals traded different source codes or purpose codes used on permits, or delay in reporting from one year to another (Harfoot et al. 2018; Pavitt et al. 2018).

Furthermore, the database is limited to the international trade of CITES-listed species. Therefore, when considering the entire 'legal' wildlife trade, it is not full, not wholly representative (Panter et al. 2019). Trade in unlisted species, poached species, and domestically protected species are often under-reported traded under the radar (Shepherd 2010; Janssen and Leupen 2019). In addition to the bias towards wild-caught species, in some cases for some traders, the costs involved to import wildlife legally is more than the cost to smuggle it (Todd 2011). Therefore, although official legal data offer a very valid starting point to understand wildlife trade data as discussed here, it is likely to be an underestimation considering the data gaps in both the legal and illegal trade. Although data may be poor, there is a necessity to use available data even if incomplete to better understand the threats posed by unsustainable trade (Harfoot et al. 2018). In the following chapters, I will present findings on the legal and illegal wildlife trade as found in physical markets and online platforms to demonstrate how to trade in CITES and non-CITES listed species can be monitored in today's global markets.

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Chapter 4: Trade on the Internet – shifts from physical markets to online platforms

4.1 Introduction

4.1.1 Pet trade

Historically, 'pet keeping' has been in existence for a very long time, dating back to at least 17,000 years starting with dogs, cats and barnyard animals (Driscoll and Macdonald 2010). In recent decades, there has been a growing interested specifically on exotic pets (Grant et al. 2017). Exotic pets are defined as animals that are non-native to a region or non-domesticated to the location (Warwick et al. 2018). It could also be defined as animal species without a 'long history of captivity' and these populations may also be 'sourced directly or within a few generations from wild populations' (Bush et al. 2013). The exotic pet trade encompasses a range of animals across the globe (Lockwood et al. 2019), and the unsustainable exploitation of many species is one of the drivers of biodiversity loss (Bush et al. 2013; Auliya et al. 2016).In 2013, Baker et al. (2013) systematically reviewed the global pet trade and identified that one-fifth of recent wildlife trade was driven by the demand for pets or animals for use in entertainment. The pet trade is pervasive and challenging to monitor and therefore, often understudied (Harris et al. 2017). The trade in exotic pets can be legal, illegal or both, where it is estimated that 25% of the global exotic pet trade is unlawful (Karesh et al. 2007).

The volume of the exotic pet trade is enormous. Su et al. (2014) reported over 2 to 5 million individual birds were sold annually as pets worldwide during the 1990s, representing one-quarter of all extant bird species. Robinson et al. (2015) found that CITES-listed reptile species, 18.8 million individuals were imported into the European Union (EU) between 1996 and 2012. Marine fish, account for a large proportion of exotic pets by volume and number of species. In 2017, Rhyne et al. (2017) reported that the US, one of the largest importers of marine aquarium fish, reached annual imports of over 11 million individual fish, representing over 2,300 species from 125 families (Rhyne et al. 2012, 2017). Bush et al. (2013) found that the three main taxonomic classes of terrestrial vertebrates traded were birds, reptiles and mammals, with birds as the most species-rich taxa traded. Reptiles were found to be the second most abundant traded but most studied. Mammals and reptilian species were more likely to be threatened than expected (Bush et al. 2013).

The reported pet trade in literature mainly focuses on species listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; Bush et al. 2013). However, species traded under CITES represent a small fraction of all species sold as exotic pets (Bush et al. 2013). For legal trade of non-CITES species that can be freely traded, there has been a

lack of follow-up and issues to do with the effectiveness of reporting. There is also the illegal trade component that is obviously underreported. Unfortunately, many countries do not keep comprehensive records (Lockwood et al. 2019). This has been evident for large volumes of 'unidentified' wildlife recorded in marine and freshwater fishery trade (Smith et al. 2009; Rhyne et al. 2012), or species which have been misidentified and/or mislabelled (Gerson et al. 2008).

4.1.2 The online pet trade

There is strong evidence that shows the Internet has shifted the way wildlife has been traded over the past decade (Lavorgna, 2014). Trade is exposed and accessible through the open web (Moorhouse et al. 2017; Harrison et al. 2016). Items for sale range from non-living wildlife products (such as leather, ivory) to live species (Stringham and Lockwood 2018). On the Internet, traders use traditional e-commerce platforms such as eBay and Amazon, as well as social media platforms such as Instagram and Facebook (Hinsley et al. 2016; Vaglica et al. 2017; IFAW 2018). This new trade relationship between buyer-seller on non-traditional platforms offers a more direct-to-consumer connection (Lockwood et al. 2019). In comparison, there was a negligible level of illegal trade activity recorded on the dark web as the open or closed Internet is the preferred tool by traders (Harrison et al. 2016).

CITES has recognised the growing threat of unsustainable wildlife trade on the Internet. At the 69th meeting of the Standing Committee in 2017, CITES signatory parties established a working group on combating wildlife Cybercrime. The aims were to engage with social media platforms, share information with enforcement agencies, such as INTERPOL and the International Consortium on Combating Wildlife Crime (ICCWC), as well as to work with Parties to update domestic legislation pertaining to wildlife cybercrime (CITES 2017).

Rigid domestic legislation is conservative and often unable to keep up with the fast-moving nature of these e-commerce platforms (Wu 2007). As a result, this delay in enforcement has posed challenges for operators to effectively monitor and prosecute law-breaking activity while considering the extensive volume of trade posted online daily. For example, over 94,000 pet listings were reported on three popular reptile and amphibian online web vendors in the US between 2012 and 2016 (Stringham and Lockwood 2018). In the Philippines, a survey of Facebook listings revealed over 1,600 live birds and reptiles for sale over a 17-day period (Canlas et al. 2017). Jensen et al. (2018) reported that between 2013 and 2017, there were up to 42 species of African snakes from 15 African countries reported for sale, totalling up to 2000 individuals. Much of the trade is unregulated as these species were not-CITES listed. In Thailand, a rapid assessment conducted on Facebook reported over 200 species for sale from 12 Facebook groups in a one-month span (Phassaraudomsak and Krishnasamy 2018). There are variations in the extent of the sale (i.e. domestic or international) and details in

regards to *modus operandi* and trading methods depending on the country and the type of individual traded.

Much of the online exotic pet trade is for domestic but appears overlooked and underreported (Lockwood et al. 2019). Many vertebrate species can be transported across nations and move into novel regions outside their original native range (Lockwood et al. 2019). This is extremely plausible in Thailand's context, given that the country has relatively porous borders with its ASEAN neighbours (Phelps et al. 2010).

This chapter aims to identify the online trade of birds of prey found on Thailand's most popular social network and to directly make comparisons to the trade in the physical brick-and-mortar markets. I conduct market surveys, both in-person and online, and use past studies to build a complete picture of the bird of prey market in Thailand. I attempt to characterise the trade and explain availability and price within the context of physical markets and online markets using predictor variables. I also investigate how market compositions may have changed over time.

4.1.3 Study taxa

Bird-keeping is interwoven into the culture of many societies around the world, especially in the region of Southeast Asia (Lin 2005). Legal and illegal demands for birds are driven by popularity and specific bird aesthetic or singing abilities (Ribeiro et al. 2019). In many of those areas, trade is also not often regulated and thus, leads to overexploitation, something that affects over a third of bird species traded (Harris et al. 2015). While songbirds and parrots have often been discussed in literature due to its extensive volume of trade (Pires 2012; Lee et al. 2016), birds of prey have become of growing interest. Perhaps considered as non-traditional as pets, the trade of live birds of prey contribute to a significant and increasing proportion of the avian trade (Panter et al. 2019). Birds of prey include both diurnal birds of prey (referred to as raptors) and nocturnal birds (hereafter referred to as owls). They are also known to not be bred in captivity (MaMing 2014).

One of the main reasons for the trade of raptors has traditionally been for falconry or recreational hunting, especially popular in the Middle Eastern region and the United States of America (Wyatt 2009; Roldan-Clara 2014; MaMing 2014). In some cultures, raptors are also consumed as bushmat or for medicinal purposes (Zhang 2008; Buij et al. 2015). A recent analysis of the global bird of prey trade from 1975 to 2015 revealed that current levels of legal, commercial trade does not appear to threaten conservation, there is a lack of quantifiable evidence on the extent and potential impacts of the unregulated trade (Panter et al. 2019). Legal and illegal trade in of birds of prey species have been reported globally, for example, in Indonesia (Nijman et al. 2009, Eaton et al. 2015), Japan (Vall-

llosera and Su 2018) and in Russia (Wyatt 2009). There has also been a notable increase of raptor trade on social media platforms (Iqbal 2015; 2016; Gunawan et al. 2019).

Furthermore, social media has also been accredited as a tool in the rise of trade of nocturnal birds of prey. Predominantly, the film franchise of Harry Potter has been cited as a reason for a 'Harry Potter effect', a phenomenon whereby the presence of owls in the films normalises the keeping of owls as pets. This has ultimately led to an increase in the trade in Indonesia (Nijman and Nekaris 2017) and Japan (Vall-Llosera and Su 2018). There are arguments for and against the theory of the 'Harry Potter effect.' The studies by Nijman and Nekaris (2017) and Megias et al. (2017) were conducted under different situations; in one country, the trade in owls is illegal and strictly regulated (Indonesia) whereas the other, the trade in owls is legal under a permit system (UK). Despite the differences in findings, both studies voiced concerns over the realised and perceived impacts that the films may have on trade and species conservation, and in the larger picture, the need for further research to understand films as drivers of wildlife trade (Militz and Foale 2017; Vesper 2017).

4.1.4 Aims

Many studies recognise the appearance of wildlife on online platforms. Still, to date, there have only been a few studies that evidently report the changes in a specific taxa of animals offered for sale between physical markets to online market platforms (Nijman et al. 2019b). There are challenges in making direct comparisons between the two platforms as they are inadvertently different. There are also survey-related limitations such as conducting the surveys at different times, disjointed monitoring duration and the variation in survey efforts and methods. Nevertheless, it is pertinent as it offers an opportunity to better track how wildlife markets have evolved, and perhaps even provide an insight on the direction of change it is moving towards (Harris et al. 2015).

Birds of prey offer a great opportunity as a case study taxon as there is a large amount of literature available previously historically on the physical markets. Individual species are also easily identifiable and hold ecological value. In this chapter, I aim to evaluate the trade of both nocturnal and diurnal birds of prey in both markets and online using market surveys dating back to the 1960s to the present day, and an online survey carried out for the past 24-month period.

I conducted a physical and online survey for birds of prey. I recorded the number of individuals, species and prices offered for sale. I also compile their associated conservation statuses from the IUCN Red List and their protection in accordance with Thai law. I also spatially map out where the posts are originating from and test to see if there are differences between the origin of sales of raptors and owls.

For the online trade of raptors and owls, I analyse price data in two steps to examine factors and variables that may explain price from the trade observed using a Linear regression and a Generalised Linear Model. For each of the taxa found traded online, I expect that there will be typical market drivers and factors that can significantly explain the price. Dependant on whether there will be sufficient data, I examine if the price is associated with temporal patterns or availability.

In the second part, I directly make comparisons between the findings of the physical markets (literature review) and online markets. I compare the variability of species reported as well as the volume of each species. In this part for both raptors and owls, I expect that there will be a decrease in the volume and species composition of individuals offered for sale in markets, and an increase in online markets. I also expect that the factors that explain availability in both markets and online platforms should be the same. To test these hypotheses for each taxon, I use a Wilcoxon signed-rank test to compare the difference in species composition between market and online surveys. Subsequently, I use a Generalised Linear Model to explain the differences in availability. I also compare temporal patterns associated with availability.

I will first present the findings for the online market collection and the associated analyses. Then, I present the comparative analyses between physical and online markets.

4.2 Methods

4.2.1 Market survey data collection

The primary location that was surveyed is Chatuchak weekend market (hereafter referred to as JJ market), located in Chatuchak district in Bangkok. Market surveys were carried out for the presence of birds of prey in June 2011 (two visits), December 2018, February 2019 (three visits), and October 2019. Though the bird market in Chatuchak has moved from past surveys, it is now predominantly in Zone D, next to JJ Mall, which is also the area where other exotic pets are being sold such as reptiles.

Surveys were conducted on either a Saturday or a Sunday between 09:00-15:00 and conducted by walking through markets and recording species and numbers in mobile phones (cf. Nijman et al. 2019b). I did not interact with any of the sellers or make any purchases for birds. Due to the potentially sensitive nature of the wildlife being sold, open recording is not encouraged; in many cases, photography is also not allowed.

4.2.2 Group search

Groups were searched for using the tag ‘exotic pets’, ‘wild animal’, ‘for sale’ on Facebook in Thai language. Groups that were public were joined automatically. For closed groups that required

approval to enter, I acknowledged and accepted the requirements required for entry. All group approval was made within a few days. In total, eight Facebook groups were monitored, and data were collected for two years. For raptors, the monitoring period was February 2017 to January 2019. For owls, the monitoring period was from April 2017 to March 2019. Seven groups were focused on exotic pets, while one was focused solely on pet birds.

I followed the methods and ethical guidelines, as highlighted in chapter 3 on Methods. I recorded details in each monitoring session on species, postdate, number of individuals being sold, age, price, location of sale, transfer method, and the end of sale date (cf. Siriwat and Nijman 2018a). If offered, species were identified based on the seller's description/caption. Seller names were anonymised, and pictures posted were used to cross-reference in cases of duplicated posts. I followed Iqbal's approach (Iqbal 2016) in determining our monitoring sessions. Facebook has a group photo limit that allows groups to archive 5,000 pictures at a time; therefore, I consider reaching the end of the archived posts as a complete monitoring session (cf. Iqbal, 2016). If posts lacked description, I sought out expert advice in identification. If this was unable, it was later removed from further analysis.

4.2.3 Meta-analysis (comparative literature search methods)

Previous market surveys were collated specifically on birds of prey in Thailand. The surveys have been carried out in Chatuchak weekend market. I compiled data from McClure and Chaiyaphun (1971), Round (1990), Nash (1993), Round and Jukmongkkol (2003), and Chng and Eaton (2016). From the reported data, I collected survey dates, the number of visits, total birds observed, species observed, and the number of birds of prey observed. I also collected, where available, data on temporal, availability (numbers sold per month), and price.

4.2.4 Statistical analyses

In the first part of the analysis, I examined the online trade of birds of prey as recorded from February 2017 to January 2019. I first analyse the price data and availability data, using a linear regression to explore the relationship between price, availability at the individual and species level. Each set of data for raptors and owls were conducted separately. The rationale for conducting two levels of analyses is to first the basic relationship between key factors, and then subsequently to build more complex models adding in factors.

I then created a Generalised Linear Model and added other predictor factors to explain price for each taxa (Table 9, Column A). For raptors, clutch size and migratory status were added as a predictor in addition to wingspan. Migratory statuses were obtained from the IUCN database, and included as an indicator of seasonality. For owls, there were enough data points at the individual level that enabled analyses for 'tameness' to be included in the model. At the species level, body mass was used as a

biological indicator as well as, the Harry Potter association. The Harry Potter association is a variable based on previous research that suggested a possible link to trade, so any species that appeared in, or lookalike species that featured on the franchise were considered a to be 'Harry Potter associated' (Nijman and Nekaris 2017). The IUCN Red List was not included as it was confounding. The inclusion of various variables depended on the type of analyses (Table 9, Column (B)).

In the second part of the analysis, I compared the availability of birds offered for sale in the physical and online markets. For raptors, an analysis was carried out at the species level, whereas for owls, an analysis was carried out at the genus level due to the limitation of identification from previous literature surveys. I used a Wilcoxon Signed test to make comparisons between species composition for market surveys and online surveys. Then, I created a Generalised Linear Model to predict availability, incorporating factors specific to each taxon. For raptors, wingspan, clutch size and the IUCN Red List population trends were included. For owls, body mass, clutch size, IUCN Red List population trend were incorporated in the model.

Table 9. Predictor variables used in Generalised Linear Models to explain price and/or availability of owls and raptor species offered for sale on Facebook.

Factors	**(A) To explain price in the online survey**		**(B) To explain availability in physical and online markets**		**Prediction**
	Raptors	**Owls**	**Raptors**	**Owls**	
Availability	✓	✓	NA	NA	More availability = lower price
Body size	✓ Wingspan	✓ Body mass	✓ Wingspan	✓ Body mass	Larger body size = fewer available = Higher price
Clutch size	✓		✓	✓	Larger clutch size = more availability
IUCN Red List population trend	Not included[a]	✓		✓	
Migratory status	N/A	N/A	N/A	N/A	Non migratory = more available / lower price
Tameness	N/A	✓	N/A	N/A	Tamed = more expensive
Harry Potter association	N/A	✓	N/A	N/A	More recognizable = more expensive
WARPA	Not included[a]				

[a]Variable was not included in the model because it was of confounding or redundant nature

In the third part of the study, I analysed seasonality. Seasonality analysis was dependent on the availability of data. For the online market analysis, given sufficient data, a binomial test will be used to predict patterns if price outcomes correlate with availability. Then, a χ^2 test will be applied to examine specific patterns for each species to test whether there are seasonality trends between availability associated with price. To compare current findings with previous literature, seasonality analysis was also conducted to compare the seasonality trends as found in previous market surveys.

4.3 Findings

4.3.1 Overall

Of the eight groups, one group primarily focused on birds, and the remaining seven groups sold a variety of exotic pets. The number of members in each group ranged from 4,080 members to 31,557 members (mean 18,379 members). All but three posts were advertised in Thai, and all public communication between buyer and seller was carried out in the Thai language.

Raptors

From February 2017 to January 2019, we found 17 species of birds traded, totalling 261 individuals from 178 posts (Table 10; Figure 12). The most commonly sold species was the Brahminy kite (*Haliastur indus*) both by the number of posts and number of individuals. The highest average price was the mountain hawk eagle (*Nisaetus nipalensis*) at an average of US$ 593. Price data were unavailable for three species. Specific species-level identification could not be determined for three posts and four individuals, the reason being they were too young and lacked description. All raptors have native distributions in Thailand and are supposed to be protected under Thai wildlife laws, therefore in this thesis, it is classified as illicit activity.

Table 10. Summary of raptor species found in online trade in Thailand as monitored over the 24-month study period, including the number of posts, number of individuals offered for sale, mean price, population trends and movement migration patterns based on the IUCN Red List. All species have native distributions in Thailand and are protected under under the Wildlife Preservation and Protection Act. Mean wingspans are reported as an average for both sexes, but for sexually dimorphic species, where data is available, mean female wingspans are used.

Species (IUCN Red List)	*N* (posts)	*N* (indiv)	Mean wingspan (cm)	Mean price (US$)	Trend	Migration
Shikra *A*ccipiter *badius* (เหยี่ยวนกเขาชิครา) (LC)	19	28	62	55	Stable	Migratory
Crested goshawk *A. trivirgatus* (เหยี่ยวนกเขาหงอน) (LC)	27	34	64	123	Decreasing	Non-migratory
Besra sparrowhawk *A. virgatus* (เหยี่ยวนกกระจอกเล็ก) (LC)	1	1	38	30	Decreasing	Migratory
Black baza *Aviceda leuphotes* (เหยี่ยวกิ้งก่าสีดำ) (LC)	2	3	73	59	Decreasing	Migratory
Rufous-winged buzzard *Butastur liventer* (เหยี่ยวปีกแดง) (LC)	2	2	88	40	Decreasing	Non-migratory
Black-shouldered kite *Elanus caeruleus* (เหยี่ยวขาว) (LC)	20	49	88	44	Stable	Non-migratory
Common kestrel *Falco tinnunculus* (เหยี่ยวเคสเตรล) (LC)	3	10	74	91	Decreasing	Migratory
Sea eagle *Haliaeetus leucogaster* (นกออก) (LC)	1	1	215	N/A	Decreasing	Non-migratory
Brahminy kite *Haliastur indus* (เหยี่ยวแดง) (LC)	31	51	117	91	Decreasing	Non-migratory
Black eagle *Ictinaetus malayensis* (นกอินทรีดำ) (LC)	1	1	165	N/A	Decreasing	Non-migratory
Black kite *Milvus migrans* (เหยี่ยวดำ) (LC)	3	3	145	126	Unknown	Migratory
Blyth's hawk eagle *Nisaetus alboniger* (เหยี่ยวดำท้องขาว) (LC)	20	24	108	202	Decreasing	Non-migratory

(**Table 10** continued on the next page, 1/2)

(**Table 10** continued from the previous page, 2/2)

Species (IUCN Red List)	*N* (posts)	*N* (indiv)	Mean wingspan (cm)	Mean price (US$)	Trend	Migration
Changeable hawk eagle *N. cirrhatus* (เหยี่ยวต่างสี) (LC)	23	24	132	178	Decreasing	Non-migratory
Wallace's hawk eagle *N. nanus* (เหยี่ยวหงอนสีน้ำตาลท้องขาว) * listed under *Spizaetus nanus* (VU)	1	1	100	N/A	Decreasing	Non-migratory
Mountain hawk eagle *N. nipalensis* (เหยี่ยวผึ้ง) *listed under *S. nipalensis* (LC)	2	2	155	576	Decreasing	Migratory
Rufous-bellied eagle *Lophotriorchis kienerii* (NT)	1	1	123	N/A	Decreasing	
Oriental honey-buzzard *Pernis ptilorhynchus* (เหยี่ยวผึ้ง) (LC)	2	2	135	40	Stable	Migratory
Crested serpent-eagle *Spilornis cheela* (เหยี่ยวรุ้ง) (LC)	16	20	139	107	Stable	Non-migratory
Unidentified	2	3				

Figure 12 has been removed from this version of the thesis due to copyright restrictions

Figure 12. Examples of photographs posted to Facebook selling raptors (a) common kestrel (*F. tinnunculus*) being transported wrapped in a sock, (b) an adult mountain hawk eagle (*N. nipalensis)* with training gear (c) an unidentifiable young bird (d) a nest of young shikra (*A. badius*) chicks posted for sale with the date and contact details.

Owls

I recorded 311 individuals of 17 species from 206 posts from 39 monitoring sessions (Table 11, Figure 13). Two posts (four individuals) were unidentifiable as the pictured owls were too young and lacked description in the captions. Prices ranged from US$ 12 to US$ 1,676. The barred eagle owl (*Bubo sumatranus*) accounted for most of the trade by posts (n = 36), while the spotted owlet (*Athene brama)* was the most popular by individual count (n = 60).

Table 11. Summary of owl species traded on Facebook in Thailand as monitored over the 24-month study period, includes the number of posts, number of individuals offered for sale, native species status, the status under Wildlife Preservation and Protection Act (WARPA), mean mass obtained from König and Weick (2008) and population trends obtained from IUCN RL.

Species (IUCN Red List)	*N* (posts)	*N* (indiv.)	Mean mass (g)	Price in US$ (mean±sd)	Native status; WARPA	Trend	Harry Potter species
Spotted owlet *Athene brama* (LC) นกเค้าจุด	27	60	113	45±20	Native; Yes	Stable	No
Snowy owl *Bubo scandiacus* (LC)	2	2	1,567	884	Non-native; No	Decreasing	Yes
Barred eagle owl *B. sumatranus* (LC) นกเค้าใหญ่พันธุ์สุมาตรา	45	45	1,516	116±40	Native; Yes	Stable	Yes
Northern great horn owl *B. virginianus* (LC)	1	1	1,400	1,677±4	Non-native; No	Stable	Yes
Buffy fish owl *Bubo ketupu* [a] (LC) นกทึดทือมลายู	27	31	1,104	83±29	Native; Yes	Stable	No
Brown hawk-owl *B. zeylonensis*[b] (LC) นกทึดทือพันธุ์เหนือ *under	5	7	1,800	36±18	Native; Yes	Decreasing	No
Collared owlet *Glaucidium brodiei* (LC) นกเค้าแคระ	2	4	58	37	Native; Yes	Decreasing	No

(**Table 11** continued on the next page, 1/3)

(**Table 11** continued from the previous page, 2/3)

Species (IUCN Red List)	*N* (posts)	*N* (indiv.)	Mean mass (g)	Price in US$ (mean±sd)	Native status; WARPA	Trend	Harry Potter species
Asian barred owlet *Glaucidium cuculoides* (LC) นกเค้าโมง หรือ นกเค้าแมว	11	29	195	21±23	Native; Yes	Increasing	No
Collared scops owl *Otus lettia* (LC)	1	7	139	Not available	Native; No	Stable	Yes
Mountain scops owl *O. spilocephalus* (LC) นกเค้าภูเขา	1	1	83	24	Native; Yes	Stable	Yes
Oriental scops owl *O. sunia* (LC) นกเค้าหูยาวเล็	15	29	85	31±21	Native; Yes	Stable	Yes
Northern white-faced owl *Ptilopsis leucotis* (LC)	5	7	204	899	Non-native; No	Stable	No
Brown wood owl *Strix leptogrammica* (LC) นกเค้าป่าสีน้ำตาล	33	38	950	88±33	Native; Yes	Decreasing	No
Spotted wood-owl *S. seloputo* (LC) นกเค้าป่าหลังจุด	15	25	1011	86±13	Native; Yes	Stable	No
Oriental owl *Phodilus badius* (LC) นกแสกแดง	5	7	282	50	Native; Yes	Stable	No
Australasian barn owl *Tyto javanica*[c] (LC)	7	13	467	27	Native; Yes	Stable	Yes
Eastern grass owl *T. longimembris* (LC) นกแสกทุ่งหญ้า	1	1	416	28±4	Native; No	Decreasing	No
Unidentifiable	2	4					

[a]listed in the WARPA as *Ketupa ketupu,* [b] listed in the WARPA as *Ketupa zeylonensis*

[c] listed in the WARPA as *Tyto alba*

Figure 13. Examples of photographs of owls posted to Facebook (a) a screenshot of a video-post showing the friendliness of a brown wood owl *(S. leptogrammica*) with a comment saying 'I will take this one', (b) Australasian barn owl (*T. javanicus*) taken from the nest (c) nest of young oriental scops owl chicks (*O. sunia*) (d) spotted owlet (*A. brama)* adorned with a cute clip on its head (e) young spotted wood owl (*S. seloputo*) in a basket.

4.3.2 Geographic

Posts originated from 28 provinces, and the provincial distribution was not statistically different between raptors and owls (paired t-test, t = 0.4377, df = 54, p = 0.66; Figure 14). Most of the posts originated from the capital city, Bangkok (n = 44) followed by Yala province in the south (n = 43). International sellers were present for both owls and raptors, from Indonesia (n = 3) and Malaysia (both crested serpent eagle, *Spilornis cheela*; n = 4)

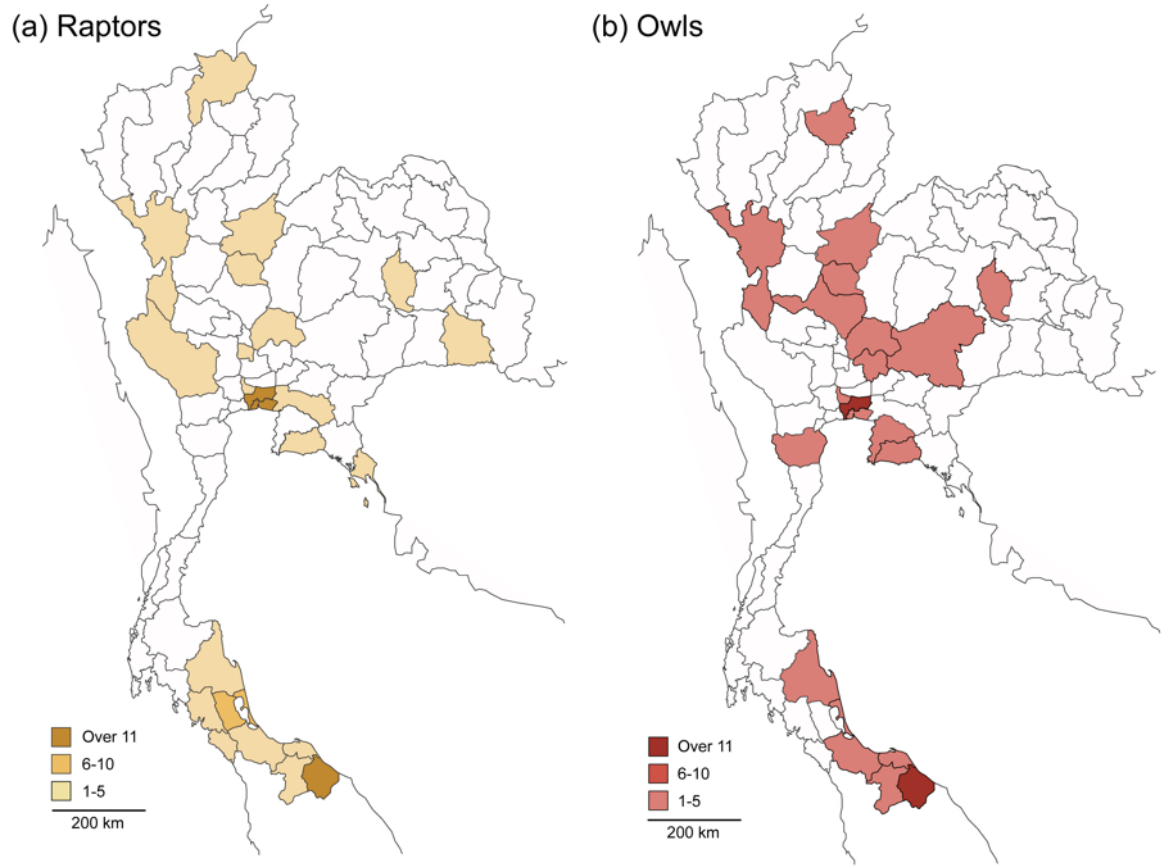

Figure 14. Map of origin of sellers for posts of (a) raptors and (b) owls offered for sale on Facebook from February 2017 to January 2019 and April 2017 to March 2019, respectively.

4.3.3 Selling terms

Pon is the term used to describe when the bird has been reared as an egg. Egg-reared raptors were accounted for in 42 posts, and 16 posts were explicitly stated that it was caught from the wild. The other identifiable phrase used to describe raptors was '*phuk-laew'*, meaning 'trained', and this was noted in 12 sales posts.

Pon was used as a descriptive term in 44 posts for selling owls. Another term that is often to describe owls for sale is '*cheung'*, meaning 'tame', often associated with domestication or friendliness; it was used to describe owls in 35 posts. In contrast, the term '*cheung'* is not as commonly used to describe

the trade of raptors, as it was only mentioned in seven posts. Four posts explicitly stated that the owl was obtained from the wild, which is to be suggested it is unfriendly. In two cases, they described the entire owl nest was being taken out and offered for sale, with a discounted price if the buyer takes the lot as a whole.

4.3.4 Conservation status and legality

Under the IUCN Red List, most birds of prey observed traded are listed as Least Concern, except for two species (Wallace' hawk eagle and snowy owl, both listed as Vulnerable). According to the predicted population trends, 42% (n =15/35) are have stable population trends, and 51% (n = 18/35) are listed as decreasing trends. The population trend for black kites is was unknown. Proportionally, more raptors are threatened with a decreasing population than owls.

By Thai law, all native birds are naturally protected under Thai wildlife laws. Thirty-two bird of prey species (18 raptors, 14 owls) are native to Thailand, which means that they are protected, and therefore trade is illegal. Only trade in three owl species was non-native, and could possibly be legal given proper paperwork required for import. This trade of exotic imported non-native species (white-faced owl *P. leucotis*, the snowy owl *B. scandiacus* and northern great horn owl *P. leucotis)* contributed to less than 5% (n = 7/151) of posts. Two species of owls (collared scops owl *O. lettia* and eastern grass owl *T. longimembris*) have extant ranges in Thailand, however, are not listed under the status under Wildlife Preservation and Protection Act (WARPA). The mean prices of the exotic imports were US$ 891 compared to the mean price of domestic owls at US$ 65. Within the seven imported listing, only three posts offered specific importation documentation associated with the sale of these CITES-listed.

4.3.5 Price analysis

Raptors (GLM price analysis)

Within data for raptors, at the individual level, there was a statistically significant correlation between number of individuals offered for sale and price ($R^2 = 0.040$; $F(1, 135) = 5.698$, $p = 0.018$; Figure 15) but this was not found at the species level ($R^2 = 0.00$; $F(1, 15) = 0.001$, $p = 0.98$).

At the species level, a model was created to explain price data on average for species. I included factors of **wingspan and clutch size** as variables, using the number of individuals as weighted factors. Migratory statuses of raptors were not included as they all have range extant populations in Thailand. IUCN conservation status and protective status on WARPA were also not included as it was found to be redundant for the species surveyed. In the best fit model, no variable was statistically significant at $p < 0.05$. Clutch size was close to significant (glm, $t = -2.14$, $p = 0.056$), and wingspan was not significant (glm, $t = -13.04$, $p = 0.66$).

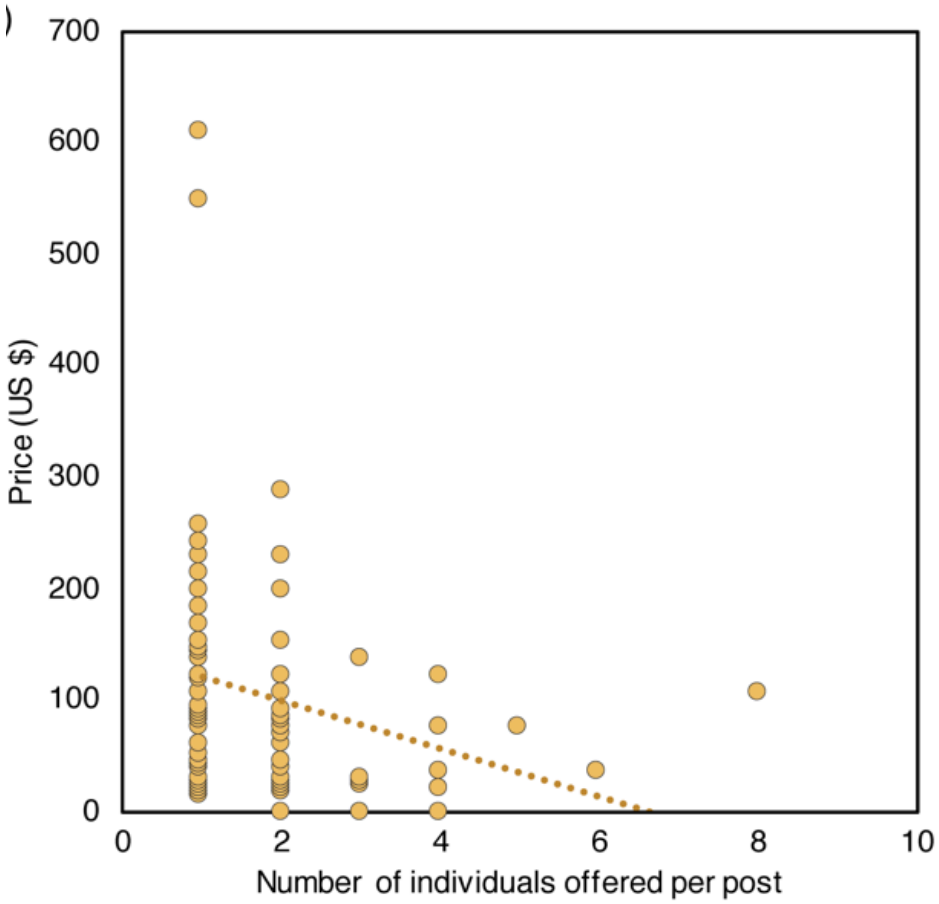

Figure 15. Availability (n = 134) plotted against the price on offer (in US$) for raptors offered for sale on Facebook ($R^2 = 0.040$; $F(1, 135) = 5.698$, $p = 0.018$).

Owls (GLM price analysis)

For owls, there was not a statistically significant correlation between posts and price both at the individual level ($R^2 = 0.02$; $F(1, 138) = 2.58$, $p = 0.11$; Figure 16) and species level ($R^2 = 0.18$; $F(1, 13) = 2.93$, $p = 0.11$). In n = 63 posts, advertised elements of tameness using descriptive advert captions such as 'friendly' and 'egg-reared'.

Since there is some evidence to potentially explore if there is a 'Harry Potter effect' present in the owl trade in Thailand, the Harry Potter association was added as a predictor variable. The model for owl species included variables of **body mass**, **clutch size, tameness** and **Harry Potter association**. Only clutch size was the significant predictor of price (glm, Wald $\chi^2 = 13.7$, df = 4, $p = 0.008$). For the other predictor factors, I did not find the other predictor variables to be a statistically significant, for body mass (glm, Wald $\chi^2 = 1.69$, df = 4, $p = 0.79$), population trend (glm, Wald $\chi^2 = 0.26$, df = 1, $p = 0.608$), tameness (glm, Wald $\chi^2 = 0.012$, df = 1, $p = 0.91$) and Harry Potter association (glm, Wald $\chi^2 = 0.11$, df = 1, $p = 0.74$).

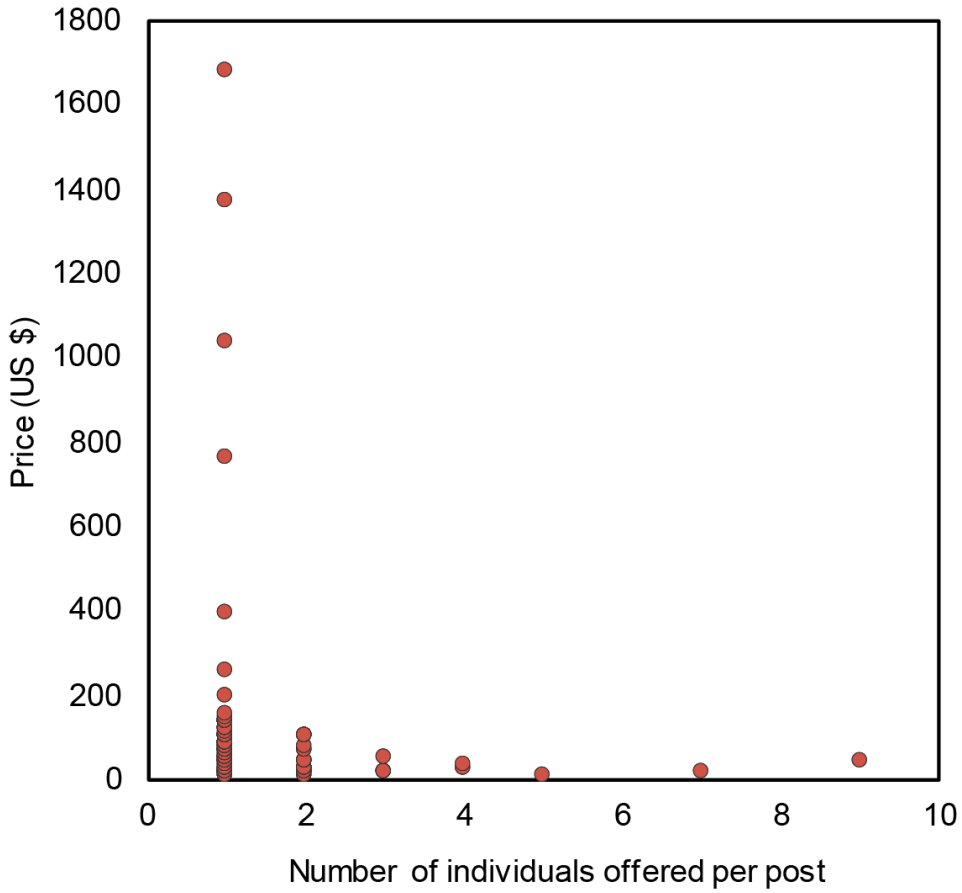

Figure 16. Availability (n = 138) plotted against the price on offer (in US$) for owls offered for sale on Facebook ($R^2 = 0.02$; $F(1, 138) = 2.58$, $p = 0.11$).

Temporal analysis (owls only)

For species with price data available, I tested the relationship between price on offer and availability (Table 12). A binomial test was used to predict if price outcomes correlated with availability, and found that this deviated significantly from what was expected in no particular pattern (binomial test, $p = 0.04$). Though breeding periods can extend throughout the year in tropical regions, seasonality of nesting may exist in the wet-dry months. As there will be variation for different species, the time frame for seasonality was selected with some estimation. In Thailand, the hotter dry months (February to April) and rainy period (August to October) was as a rough estimation. In the three months period from February to April, spotted owlets were not cheaper when significantly more owls were offered for sale when compared to other months combined ($\chi^2 = 0.25$, df = 1, $p = 0.617$), but they were more expensive when fewer owls were advertised ($\chi^2 = 4.22$, df=1, $p = 0.040$). In the same time duration comparison, brown wood owls were significantly cheaper during periods of high owl availability ($\chi^2 = 4.60$, df = 1, $p = 0.032$) and significantly more expensive when few owls were offered for sale ($\chi^2 = 3.95$, df = 1, $p = 0.047$). Prices of barred eagle-owl were not as impacted by availability ($\chi^2 = 0.83$, df = 1, $p = 0.362$ and $\chi^2 = 0.01$, df = 1, $p = 0.975$ for periods high and low owl availability).

Table 12. Seasonality in trade and asking prices of owls in Thailand (mean and standard deviation), showing that in the peak season from February to April when more owls are available and more are advertised, prices are lower for two of the three most commonly traded species. The opposite is observed during the seasonal period from August to October.

Trade	Sample size (N)	24 months period	February-April	August-October
All owls (number of individuals per month)	311	13.0±10.3	27.3±9.2	4.5±0.8
All owls (number of posts per month)	206	8.6±5.8	16.0±5.9	4.0±1.1
Spotted owlet (monthly asking price, US$)	60	45.1±30.3	41.7±33.9	58.9±41.6
Barred eagle owl (monthly asking price, US$)	44	116.4±31.5	106.6±5.3	116.9±35.2
Brown wood owl (monthly asking price, US$)	38	88.1±37.6	67.9±19.9	106.7

4.3.6 Market survey and literature review comparisons

I collated five previous market survey data on the bird trade in Thailand at Chatuchak weekend market from McClure and Chaiyaphun (1971), Round (1990), Nash (1993), Round and Jukmongkkol (2003), Chng and Eaton (2016), and Phassaraudomsak and Krishnasami (2018). Each has varying findings on birds and raptors. In total, the six surveys (including the one collected by myself) can be separated into two groups based on the physical location of the survey: physical market surveys and online surveys.

Comparative: species distribution (raptors)

No raptors were recorded from the physical market survey conducted in 2011 or 2018 to 2019. Historically, based on five studies, over 2526 individuals of 23 species were reported (Table 13). There were five raptor species that have notably been exclusively offered for sale online within the past few years never found in any market survey prior. Even though there were some stark declines within physical market surveys for certain species, for example, Collared falconet (*Microhierax caerulescens*) and the white rumped falconet (*Polihierax insignis),* in comparing the physical (survey A – survey D) and online markets (survey E – survey F), a Wilcoxon Signed-Ranks test showed that

difference in species composition between physical and online markets was not statistically significant (Wilcoxon Signed-Rank; Z = -1.87, p = 0.051).

As there was a significantly comparable number of individuals offered for sale, I created a model to explain the availability of species found in the markets and online platforms. The predictor variables included in the model were **wingspan, clutch size, and IUCN RL trend**. In the best fit model, for physical markets was only explained by clutch size (glm, t value = -2.09, p = 0.49) and not wingspan (glm, t value = -1.02, p = 0.32) or IUCN trend (glm, t value = 1.14, p = 0.26). Raptor availability in online markets could be best explained by wingspan (glm, t value = -2.42, p = 0.024), and not clutch size (glm, t value = -0.38, p = 0.71) and IUCN population trend (glm, t value = 1.22, p = 0.23).

Table 13. Raptors for sale in Thailand in Chatuchak market in Bangkok and online on Facebook for the period 1968 to 2019. Studies include: A = McClure and Chaiyaphun, 1971; B = Round 1990; C = Round and Jukamongkkol 2003; D = Chng and Eaton 2016; E = Phassaraudomsak and Krishnasami 2018; F = this study. Only individuals that were identified to the species were included.

Common name / Scientific name	A (1968-1969)	B (1987-1988)	C (2003)	D (2015)	E (2016)	F (2017-2019)
Shikra *Accipiter badius*	37	1			22	28
Crested goshawk *A. trivirgatus*	58				8	34
Besra *A. virgatus*	93					1
Black baza *Aviceda leuphotes*	19				3	3
Rufous-winged Buzzard *Butastur liventer*	63	6			3	2
Hen harrier *Circus cyaneus*	21					
Pied harrier *C. melanoleucos*	6					
Eastern marsh harrier *C. spilonotus*		1				
Black-shouldered kite *Elanus caeruleus*	322	61	5	9	22	49
White-bellied sea-eagle *Haliaeetus leucogaster*	1				1	1
Grey-headed fish eagle *H. ichthyaetus*	12					

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Common name / Scientific name	A (1968-1969)	B (1987-1988)	C (2003)	D (2015)	E (2016)	F (2017-2019)
Brahminy kite *Haliastur indus*	12	3			11	51
Rufous-bellied eagle *Lophotriorchis kienerii*	1					1
Black eagle *Ictinaetus malaiensis*	1					1
Black kite *Milvus migrans*	402	6		2	2	3
Crested serpent-eagle *Spilornis cheela*	50	44			5	20
Blyth's Hawk-Eagle *Nisaetus alboniger*	3				2	24
Changeable Hawk Eagle *N. cirrhatus*	27				1	24
Wallace's Hawk Eagle *N. nanus*						1
Mountain Hawk-Eagle *N. nipalensis*						2
Oriental Honey-Buzzard *Pernis ptilorhynchus*						2
Oriental hobby *Falco severus*	1					
Common Kestrel *F. tinnunculus*	1					10
Brown falcon *F. berigora**					8	
Peregrine falcon *F. perigrinus*					2	
Collared falconet *Microhierax caerulescens*	971	2				
White rumped falconet *Polihierax insignis*	164	31				
TOTAL SPECIES	21	9	1	2	13	17
TOTAL INDIVIDUALS	2265	155	5	11	90	256

Comparative: species distribution (owls)

Owls were not as observed in the same volume and frequency as raptors. No owls were recorded in Chatuchak during the visits in 2011 or 2018-2019. Based on all the surveys, McClure and Chaiyaphun (1971), Round (1990) and Chng and Eaton (2016) recorded a total of 402 owls. There was one exception in a single visit by Chng and Eaton (2015) who recorded 17 owls from 3 species.

Since the numbers are much lower and much less detail of species identification was provided in the previous surveys, comparison over time is relatively challenging. Comparisons made for the purposes of the analysis was carried out at a genus-level (Table 14). There was not find statistically significant variation in genera surveyed for sale from McClure and Chaiyaphun (1971) and in this study (Wilcoxon Signed-Rank; W = 32, critical value for W at N = 11 ($p < .05$) is 10, not significant at $p < .05$). Overall, the composition and distribution of species listed for sale were similar. However, we recorded more owlets (*Glaucadium* spp) in our online study compared to the surveys in Chatuchak, whereas conversely, McClure and Chaiyaphum (1971) recorded more barn owls (*Tyto* spp.) for sale.

Table 14. Comparison of species composition of owls by genus as observed from physical markets reported by previous market surveys.

	Number of individuals observed traded	
Genus	**(A) Physical market: McClure and Chaiyaphum (1971); Round (1990)**	**(B) Online market: This study (2019); Chng and Eaton (2015)**
Otus *(O. bakkamoena; O. lettia; O. spilocephalus; O. sunia)*	30	41
Ptilopsis (*P. leucotis)*	0	7
Bubo (*B. coromandus; B. scandiacus; B. sumatranus; B. virginianus)*	5	48
Strix (*S. leptogrammica; S. seloputo)*	56	63
Glaucadium (*G. brodiei)*	0	4
Athene (*A. brama*)	92	73
Ketupu (*K. ketupu; K. zeylonensis)*	111	38
Taenioglaux (T. cuculoides)	6	29
Ninox *(N. scutulata)*	26	0
Phodilus *(P. badius)*	6	7
Tyto (*T. javanica; T. longimembris; T. alba)*	47	14

To predict availability of owls on the two platforms, predictor variables included were body mass, clutch size, and IUCN RL trend. In physical markets, none of the predictor factors significantly explained price, including, body mass (Table 14(A), glm, Wald $\chi2 = 3.88$, df = 4, p = 0.42), clutch size (glm, Wald $\chi2 = 3.99$, df = 5, p = 0.55) and IUCN RL trend code (glm, Wald $\chi2 = 0.12$, df = 1, p = 0.73). Owl availability in online markets was significantly explained by clutch size (Table 14(B), glm, Wald $\chi2 = 12.44$, df = 5, p = 0.029), but not body mass (glm, Wald $\chi2 = 2.08$, df = 4, p = 0.72) and IUCN RL trend code (glm, Wald $\chi2 = 1.49$, df = 1, p = 0.22).

Comparative: Price

No price data were offered for raptors based on previous markets surveys in Thailand; however, there are data from other countries such as in Indonesia. Bird surveys were consistently reported in Java and Sumatra in the 1990s to 2000s (Nijman et al. 2009; Shepherd 2006), but at present, very few are recorded (Chng et al. 2015; Chng and Eaton 2016; Harris et al. 2015; V. Nijman, unpubl. data). Large numbers of individuals of over two dozen species of raptor were now frequently offered for sale on online platforms reported by Iqbal (2016) and Gunawan et al. (2017).

For owls, there are a few studies which have offered price data. There are price data based for one species of owl, the spotted owlet, where Chng and Eaton (2016) recorded a price of US$ 15 in Chatuchak market, compared to US$ 12 and US$ 106 (mean US$ 45) found in this study. In comparison to Indonesia markets with data on owl price, Nijman and Nekaris (2017) reported that for that one species (spotted wood owl *Strix seloputo*) prices were higher online, for two species (buffy fish owl and Javan owlet *Glaucidium castanopterus*) prices were lower, and for another four species, there was no difference in price.

Comparative: Seasonality

In the online survey of raptors, there was not an equal distribution of species across the months ($\chi^2 = 100.32$, df = 11, $P < 0.0001$), where during months March to May, the number of raptors offered for sale was significantly higher than the rest of the year ($\chi^2 = 37.76$, df = 1, $P < 0.0001$). Findings from McClure and Chaiyaphun (1971) were used to compare temporal analyses as it was the only study with detailed monthly accounts (Figure 17). The authors reported more individuals in the summer months from April to June. Additionally, although McClure and Chaiyaphun (1971) indicated months where chicks were more frequently sold; there was not enough data for comparative analysis.

For owls, the number of posts and number of individual owls that were recorded for sale was not equally distributed over the 12 months (posts: $\chi^2 = 68.37.49$, df = 11, $P < 0.001$; individuals: $\chi^2 = 166.49$, df = 11, $P < 0.001$;). From February to April, owls were offered at higher numbers than other

months combined (χ^2 = 127.57, df = 1, P < 0.0001) whereas in August to October significantly fewer owls were offered for sale than in the other months combined (χ^2 = 44.16, df = 1, P < 0.001). This was similarly found in the market surveys that showed an extended breeding period in Thailand from March to August, where more nestlings and fledglings were offered for sale (McClure and Chaiyaphun 1971). Though there is insufficient data for comparative cyclical analysis, it could suggest linking to sourcing of wild-trapping or nest stealing.

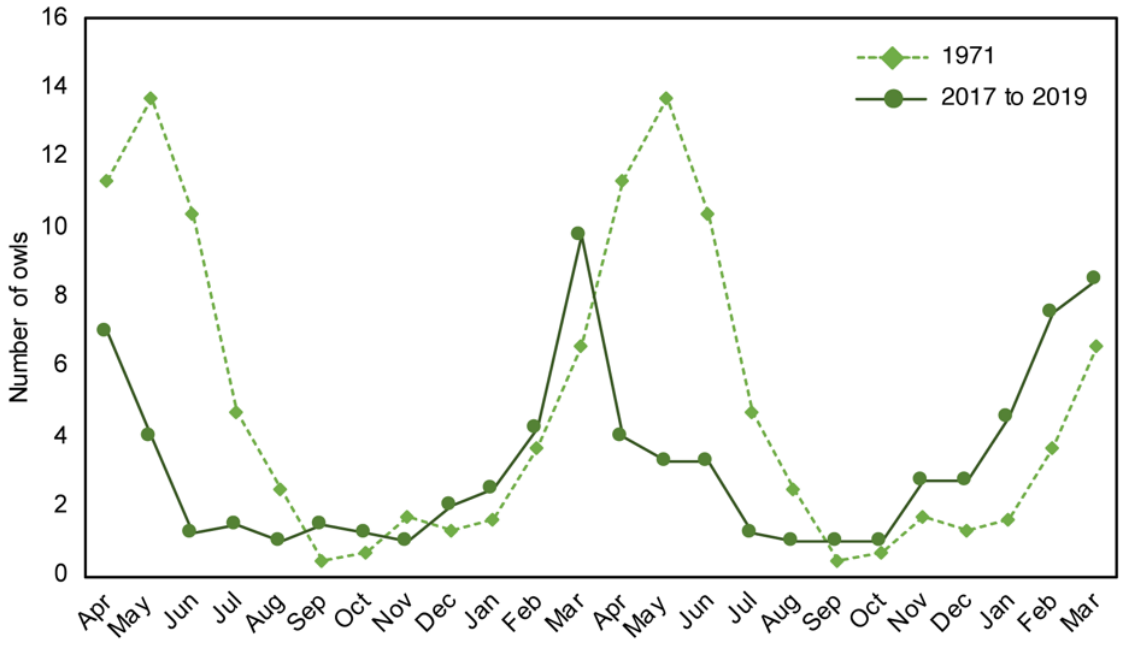

Figure 17. Comparison of seasonality on owls offered. McClure and Chaiyaphun (1971) conducted surveys at Chatuchak market in 1971 (diamonds), and online market surveys were conducted in this study on Facebook from 2017-2019 (circles).

4.4 Discussion

4.4.1 Trade in birds of prey

There has been a decline in the availability of raptors and owls in physical markets, and an observed increase of trade on online market platforms. For the two taxa of birds of prey, there was no clear statistical difference in species composition and distribution when comparing findings from markets surveys conducted since the 1960s to online surveys carried out from 2017. In all but one model, predictor factors of body size, whether body mass and wingspan, were not significant correlates of price. While clutch sizes were more often significant factors in explaining both price (for owls) and availability (for market place raptors and online owls). Though the predicted trends are not as hypothesized, it may somehow be that clutch size may relate to availability especially in relation to sourcing and hunting, or that availability and price of birds of prey offered for sale are driven by other

unknown factors. One known limitation that should be acknowledged is that there are differences in the situation of the surveys conducted decades ago compared to the present time. For one, the species distribution, the population may be different. Furthermore, the perception of hunting or sales of wildlife has also changed over time.

The market of the birds of prey offered for sale is mostly of native birds. In total, less than 5% of the total number of birds of prey in the online trade were sourced abroad. For the native birds, there is no evidence to suggest that the birds were sourced from anywhere other than Thailand. Comparably to other taxa, 80% of primates and carnivores traded for sale online in Thailand were of species that were found in Thailand (Siriwat et al. 2019), while in Chatuchak, Chng and Eaton (2016) found that 44% of bird species and 45% of the individual birds offered for sale were exotic species. This proportion was even more extreme for reptiles where 97% of the turtles and tortoises belonged to non-native species. Todd (2011) found 32 Malagasy species (reptile, amphibian and mammal species) offered for sale during a one-month survey in 2010 in Chatuchak market. There is not a lot of evidence to believe that the birds sold here are captive-bred, and highly likely that it is wild-caught. Conditions in the photos provided show trapping and the conditions of captivity are not nice. At most, the birds are described as hand-reared since egg, but no clear indication of any breeding, something that is common for the trader to advertise.

4.4.2 Legality

Native species of birds of prey, including diurnal and nocturnal, are protected from trade under the Thai WARPA law. Therefore, the evident trade is a reflection of a lack of law enforcement or monitoring within the easily-accessible virtual markets (Siriwat and Nijman 2018a). Although the majority of the trade is directed to domestic markets, a few posts may have originated from neighbouring countries, such as Malaysia or Indonesia. This reflects the potential avenue of unregulated international trade.

4.4.3 Conservation

Birds of prey are top predators in their ecosystems, and hold value in many cultures (Comay and Dayan 2018; Schuetz and Johnston 2018). Artificial breeding of birds of prey, especially owls, is difficult. Additionally, the trade of raptors does not seem exclusively for falconry as previously used but appears to also be for the regular pet trade, extending beyond traditional functions, such as falconry (Roldan-Clara 2014; Wyatt 2009; MaMing 2014). Thailand has also been reported as a vital site for raptor migration (Decandido et al. 2004). As a point of concern, it appears that a lot of the trade is also possible hunted and wild-sourced. Therefore, until more research is conducted on the impact of hunting on the wild populations, the harvesting of birds of prey for the pet trade must be monitored. Globally, trade in birds of prey is increasing, while the proportion of species with

decreasing population trends according to the IUCN Red List, is also rising (Panter et al. 2019). Though it was not a statistically significant explanatory factor, similar patterns were observed here, where 76% of raptors and 30% of owls found to be traded here do show decreasing populations under the recent assessment by the IUCN Red List.

4.4.4 Challenges in moving away from physical markets

The shift towards online markets is not always by choice of the trader. In this chapter, we used Chatuchak as the example of a physical market, and though we observed fewer birds of prey, currently to this day, it still maintains its name as an animal market where you can still find native exotic species for sale. Globally, the shift towards reducing wildlife being traded in markets extends beyond the reasoning of exotic pets. The closure of physical markets that sell high-value wildlife products such as ivory was incentivised to reduce the poaching of African elephants (Doak 2014; t' Sas-Rolfes et al. 2014; Yeo et al. 2017). Whereas another driver to push for the closure of physical markets are due to the zoonotic threats (Karesh et al. 2007). The 2002 outbreak of Severe Acute Respiratory Syndrome (SARS) coronavirus (CoV) in humans was linked to wet markets in Shenzen, China (Webster 2004), whereas the 2019 outbreak of a novel coronavirus (COVID-19), was linked to Huanan wet market in Wuhan, China (Li et al. 2020). This consequence of the outbreak to the domestic and global economy has led the Chinese government to impose a comprehensive ban on the trade and consumption of wild animals, with the exception of for medicinal purposes (Anonymous 2020).

There have only been a handful of studies which have directly examined the shift from physical markets to online platforms. The challenge remains in how to systematically obtain data on what wildlife is being sold, the volumes, turnover rates and market dynamics. Previously, the comparison has been drawn in the global cat trade in eight countries on three continents. Nijman et al. (2019b) analysed the market and online surveys and revealed that in some countries wildlife trade is indeed shifting to online platforms. They reported that the shift to online platforms depends on external factors such as a country's Internet penetration rate, or enforcement of protected species legislation inside physical markets (Nijman et al. 2019b). Vitally, identification of a shift would be important to closely track the direction of movement. Traditional markets usually require authorities visiting stores at city markets, border markets, or trading hubs at ports. Online traders, on the other hand, are more flexible and traders do not necessarily need to have a pet shop front, and therefore operating costs are cheaper. In general, anyone can become a trader in the online context, and buyers can view and choose the items they are interested in. Additionally, sellers may also favour selling online as there is less risk, and they have some flexibility to switch platforms depending on enforcement or consumer preferences (UNODC 2020). The delivery system that traders utilise ranges from local pick-ups, bus deliveries, or even courier services. These novel manoeuvres and approaches will inevitably pose

challenges for law enforcement officers to crack down on illicit trade activity seen in the present day and the future.

4.4.5 Culture and social media

The evolving role and function that social media plays in wildlife trade is something that needs to be addressed. Though the link between social media and species extinction is tenuous and subjective, it has previously been recognised, including for raptors and owls (Iqbal 2016; Kitson and Nekaris 2017; Panter et al. 2019), among other species (Martin et al. 2018, Di Minin et al. 2018). Owl parts have been reportedly traded for use in traditional medicine and superstitious beliefs (Shepherd and Shepherd 2009, Williams et al. 2014, Padhy 2016). The use of non-living owl parts has been popularised by televised news media in India during the Diwali light festival (Padhy 2016). The perception of owls has been changed due to the impact of the Harry Potter film franchise. Although without direct statistical correlation, there were distinctive references to Harry Potter, or Harry Potter's owl, Hedwig, in the description. There may also be cultural differences and sensitivities present. One example of this is the emergence of 'Harry Potter' themed cafes which have emerged throughout Asia, including Japan, Malaysia, and Thailand (Figure 18). Thailand has a growing affluent consumer base, with increased access to exotic pets. In combination with weaker law enforcement and less social stigma on keeping legally protected pets, this may lead to an increase of trade in these species. Further discussion on the emergences and consequences of exotic pet cafes will be elaborated in more detail in Chapter 5.

Figure 18. Owl and Harry Potter themed-cafes popped up throughout Asia as evident in (a) Nara, Japan, (b) Osaka, Japan, (c-d) Bangkok, Thailand. Café goers can wear Harry Potter themed props and take selfies with the birds on display in the store. All photographs were taken by me in 2019.

Chapter 5: Online trade on Facebook to inform on market dynamics

5.1 Introduction

5.1.1 Facebook trade, continued

As demonstrated in the previous chapter on the online trade of birds of prey, the encompassing exotic pet trade is a significant market involving several hundred species of wildlife. Exotic pets, or 'species with a long history of captivity are likely to have been sourced directly or within a few generations from wild populations' (Bush et al. 2014). The domestic component of legal and illegal wildlife trade is often overlooked and unmonitored (Lockwood et al. 2019).

Trade and movement of wildlife species out of its native range has consequences (Essl et al. 2011). It has been accelerated by globalisation and the rapid sharing of information and awareness of traded species that has led to an increase in pet demand (Clarke et al. 2019; Toomes et al. 2020). Currently, there are limited data available on the intra-country movement of species out of their native ranges. The global exotic pet trade is taxonomically dynamic; this is even expanded with the increase of trade on Internet platforms, especially social media (Romagosa 2014). The trade is expanded so far beyond non-living wildlife products (e.g. ivory and leathers), to trade in actual living wildlife species. The tropics are one of the key areas for the pet trade, the reason being strongly related to the region's species richness, but also, preference for certain taxa (Scheffers et al. 2019). The expansion of the pet trade likely has a strong impact to detrimental consequences, such as over-exploitation of wildlife, the introduction of alien species, and a violation of animal welfare (Lockwood et al. 2019; Toomes et al. 2020). The lack of data highlights the need for a better understanding of what is being offered online, in order to develop a better understanding of the market to inform on regulation policy and enforcement.

In the previous chapter, I highlighted the evident shift of trade from market platforms from physical brick-and-mortar markets to online platforms using birds of prey as a case study. In this chapter, I will also use trade monitored on the social media platform, Facebook, and examine it more comprehensively to better understand the drivers of market dynamics behind what is offered for sale.

5.1.2 Study taxa and aims

Here, I focus on the trade in primates and carnivore species. Both taxa include many species of easily identifiable species found traded for commercial and personal purposes, (Shepherd 2010; Chutipong et al. 2014; Harrington 2015). There is also a range of origins, with non-native and native species

which have historically been observed to be traded. Many of the species within these taxa are also of conservation concern, domestically and globally. I aim to characterise the online trade by examining species composition, volume and its conservation status, identify legal and illegality of trade and identify factors that may influence price dynamics.

5.2 Methods

5.2.1 Group search methodology and analysis

I followed the same approach as used in chapter 3, where groups were searched on Facebook using common tags such as 'exotic pets' or 'unusual pets' (Thai: สัตว์แปลก/สัตว์หายาก). I also abided with the same ethics approach, as highlighted in chapter 2 (methods).

5.2.2 Model analysis

I analysed the different species traded through the number of sales posts and number of individuals traded. For the data used in this chapter, the exchange rate used in this study was US$ 1 = 32.8 Thai Baht (exchange rate ranged from 31.1 Thai Baht to 34.5 Thai Baht within the monitoring period). All price data presented are mean prices. I used Generalised Linear Models (GLMs) to evaluate the variables that influence price (Table 15). The four variables and their proxies included were native status (whether or not the species are found in Thailand), domestic legislation (whether or not they are protected under Thailand's Wildlife Preservation and Protection Act; WARPA), international regulations (CITES listing) and its threatened status (IUCN Red List). Although there was a reformation of the WARPA laws in 2019, I used the previous set of protection measures in the analysis, as it was the protection of the species at the time of data collection. I took into consideration the number of individuals posted for sale in each individual post as a weight in the model.

Table 15. Predictor variables included in the GLM to explain availability and price.

Variables	Hypothesis	Reference
Availability	Availability may influence price, where species that are more commonly offered will be cheaper on average. This may also be linked temporally or seasonally to certain months where individuals are offered for sale than others.	Courchamp, et al. 2006; Daut et al. 2015
Body mass	Average body mass included as a variable. Body mass may correlate with price, where it is expected that larger animals are more expensive.	

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Variables	Hypothesis	Reference
Native status	Native species are species that have range distributions in Thailand. Import premiums are imposed on non-native alien species, and therefore, will be expected to be more expensive when compared to native local species.	Daut et al. 2015, Su et al. 2015
Domestic legislation - Wildlife Preservation and Protection Act (WARPA)	Species protected under the WARPA law will be less available and offered at higher prices. Rarity drives desirability and value. The WARPA listed species have native distributions, with the exception that there are a few species with native distributions in Thailand that are not under the WARPA.	Courchamp, et al. 2006; Fernandes-Ferreira et al. 2012
International trade regulation - CITES	Non-CITES listed species and CITES Appendix II species are legally tradable in Thailand, and be more available and offered at lower prices. Rarer species (such as Appendix I listed species) will be more expensive.	Rivalan 2007; Su et al. 2015
Conservation status – IUCN Red List (IUCN RL)	Species classified as more threatened will not be as available and also offered at higher prices.	Fernandes-Ferreira et al. 2012
Taxa – Primates vs Carnivores	There is no literature to suggest that there may be a difference in offering prices between the two taxa.	Harrington *et al*. 2005.

Models were selected by the same approach as highlighted in the Methods chapter, where models were compared with the dependent variable (price) fitted to either a normal or gamma distribution. The model with the lowest Akaike's information criterion (AIC) value was selected. I used a backwards approach to select the best model. I reported Wald χ^2 statistics from likelihood ratio tests and associated p-values. To determine differences within the categories of the variable in the model, I carried out a posthoc test with Bonferroni correction. A complete model (with five variables) was first analysed, and a native-only species model was secondarily analysed.

5.3 Findings

5.3.1 Overall findings

From the eight groups monitored over the 24-month period from February 2017 to April 2019, participant numbers for the groups ranged from 2,255 members to 31,557 members (Table 16). There were 221 individual accounts where wildlife was posted for sale. Eight frequent posters (>50 posts)

had usernames that were variations of the same name, believed to be the same person with multiple accounts. In some cases, the sellers indicate that their geographic location is specifically at the 'southernmost tip of Thailand, at the border to Malaysia.'

Table 16. Summary of group monitoring dates and membership numbers monitored on Facebook over a 24-month period.

Group	Start date	End date	start member no	number of members
1	Oct-18	Jun-19	2,255	26,851
2	Feb-17	Dec-18	8,649	9,484
3	Apr-17	Mar-19	14,136	13,663
4	Jun-18	Mar-19	14,716	19,480
5	Apr-17	Mar-19	27.637	26,718
6	Jun-18	Mar-19	15.816	15,206
7	Jun-18	Mar-19	28.890	31,557
8	Jun-18	Apr-19	4.393	4,080

I recorded 858 posts of primates and carnivores, totalling 1,377 individuals from 46 species. Geographic information was available for 470 posts. Posts originated from 38 provinces in Thailand. Most of the posts (31%) originated from the capital city of Bangkok. There were four posts which originated from abroad, which included three listings from Indonesia (Asian golden cat *Catopuma temminckii*, binturong *Arctictis binturong*, and a leopard cat *Prionailurus bengalensis*) and one listing from Laos (slow loris *Nycticebus* spp.). Specific species-level identification could not be determined for 7% of posts accounting for 5% of individuals.

The breakdown of legality can be viewed in Table 17. In total, 27% of posts (25% of individuals) could be classified as 'legal'. Legal trade comprised of non-native species (11% of posts) and native species (16%). In contrast, the illegal trade comprised of 66% of posts (70% of individuals), broken down into 2% of posts from non-native species, and the 64% of illicit posts from native species. Many of the non-WARPA listed species, in particular, primate species imported from South America were listed as breeding pairs. The profile of most of the marmoset sellers were breeders rather than individual sellers. The profile often had 'Farm' or a pet shop breeder affiliation, rather than an individual profile.

Table 17. Summary of trade observed on Facebook concerning the legality and its native statuses in Thailand.

Type of trade	Observed number and percentage of trade by post and individuals
Legal trade (non-native species)	14 species, 11% of posts (9% of individuals)
Legal trade (native species)	5 species, 16% of posts (16% of individuals)
Illegal trade (non-native species)	2 species, 2% of posts (1% of individuals)
Illegal trade (native species)	21 species, 64% of posts (69% of individuals)
Unknown	7% of posts (5% of individuals)

5.3.2 Species offered for sale

Carnivores

Carnivores totalling 26 species from 19 genera were listed for sale (Table 18; Figure 19), totalling 929 individuals listed for sale from 498 posts. The two species of otters, including the individuals which could not be identified to the species level, accounted for most posts and individuals posted for sales by taxa (*Aonyx*, *Lutrogale,* otter species; n = 226 posts; n = 527 individuals). This was followed by eight species of civets (*Arctogalidia, Hemigalus, Paguma, Paradoxurus, Prionodon, Viverra* and *Viverricula***;** n = 147 posts; n = 225 individuals). Servals (*Leptailurus serval*) were most expensive (n = 3 posts; n = 3 individuals; US$ 4,792), followed by fennec foxes (n = 2 posts, n = 3 individuals; US$ 1,309) and caracals (n = 2 posts; n = 3 individuals; US$ 1,297).

Table 18. Table of carnivores species offered for sale, including details on the number of posts, number of individuals, mean price and its conservation listing (IUCN Red List, IUCN RL; the Wildlife Preservation and Protection Act, WARPA; CITES Appendix listing).

Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Red panda *Ailurus fulgens* (หมาจิ้งจอก)	Auiluridae	1	1	937	EN	Protected	I
Common jackal *Canis aureus* (หมาจิ้งจอก)	Canidae (*Canis*)	5	9	109	LC	Protected	III
Arctic fox *Vulpes lagopus* (หมาจิ้งจอกอาร์กติก)	Canidae (*Vulpes*)	2	3	726	LC	Not Protected	

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Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Fennec Fox *Vulpes zerda* (เฟนเน็คซ์ฟอคซ์, จิ้งจอกทะเลทราย)	Canidae (*Vulpes*)	9	15	1,308	LC	Not Protected -	II
Caracal *Caracal caracal* (คาราคัล)	Felidae (*Caracal*)	2	3	1,296	LC	Not Protected	I
Asian golden cat *Catopuma temminckii* (เสือไฟ)	Felidae (*Catopuma*)	1	1	N/A	NT	Not Protected -	I
Serval cat *Leptailurus serval* (แมวป่าเซอวัล)	Felidae (*Leptailurus*)	3	3	4,792	LC	Not Protected	II
Leopard Cat *Prionailurus bengalensis*[a] (แมวดาว หรือ แมวแกว)	Felidae (*Prionailurus*)	45	56	122	LC	Protected	I
Fishing cat *P. viverrinus*[b] (เสือปลา)	Felidae (*Prionailurus*)	9	13	118	VU	Protected	II
Unidentified *Felidae sp.*	Felidae sp.	4	4	-	-	-	-
Small Asian mongoose *Herpestes javanicus* (พังพอนธรรมดา)	*Herpestidae (Herpestes)*	13	15	67	LC	Protected	III
Meerkat *Suricata suricatta* (เมียร์แคต)	*Herpestidae (Suricata)*	11	30	812	LC	Not protected	
Malayan porcupine *Hystrix brachyura* (เม่นใหญ่)	Hystricidae	2	2	164	LC	Protected	

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Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Asian small-clawed otter *Aonyx cinerea* (นากเล็กเล็บสั้น)	Lutrinae (*Aonyx*)	47	113	86	VU	Protected	II
Smooth coated otter *Lutrogale perspicillata*[c] (นากใหญ่ขนเรียบ)	Lutrinae (*Lutrogale*)	2	40	111	VU	Protected	II
Otter *Otter sp.*	Lutrinae	177	374	96	-	-	-
Skunk *Mephitis mephitis* (สกังก์ลายแถบ)	Mephitidae	2	3	859	LC	Not protected	
Common raccoon *Procyon lotor* (แรคคูน)	Procyonidae (*Procyon*)	8	11	968	LC	Not protected	
Binturong *Arctictis binturong* (หมีขอ หรือ บินตุรง)	Viverridae (*Arctictis*)	7	7	390	VU	Protected -	III
Three-striped palm civet *Arctogalidia trivirgata* (หูค่างอีเห็นหน้าขาว)	Viverridae (*Arctogalidia*)	8	11	134	LC	Not Protected	
Banded palm civet *Hemigalus derbyanus* (อีเห็นลายเสือโคร่ง / อีเห็นลายพาด)	Viverridae (*Hemigalus*)	2	2		NT	Protected	II
Masked palm civet *Paguma larvata* (อีเห็นเครือ)	Viverridae (*Paguma*)	7	9	156	LC	Not Protected	III
Asian palm civet *Paradoxurus hermaphroditus* (อีเห็นธรรมดา อีเห็นลายจุด)	Viverridae (*Paradoxurus*)	111	172	104	LC	Not Protected	III

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Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Banded linsang *Prionodon linsang* (อีเห็นลายเมฆ หรือ ชะมดแปลงลายแถบ)	Viverridae (*Prionodon*)	7	7	171	LC	Protected	II
Malay civet *Viverra tangalunga* (ชะมดมลายู)	Viverridae (*Viverra*)	1	1		LC	Not Protected	
Large Indian civet *V. zibetha* (ชะมดแผงหางปล้อง)	Viverridae (*Viverra*)	10	20	103	LC	Protected	III
Small Indian civet *Viverricula indica* (ชะมดเช็ด หรือ ชะมดเชียง)	Viverridae (*Viverricula*)	1	3	78	LC	Protected	III
Asiatic brush-tailed porcupine *Atherurus macrourus* (เม่นหางพวง)	Hystricidae	1	1	125	LC	Not Protected	

[a] listed under WARPA as *Felis bengalensis*

b listed under WARPA as *Felis viverrina*

c listed under WARPMA as *Lutra perspicillata*

Figure 19 has been removed from this version of the thesis due to copyright restrictions

Figure 19. Examples of photographs posted to Facebook selling carnivores (a) fishing cat (*P. vivverrinus)* in a cage (b) binturong (*A. binturong*) with a description that it has been trapped (c) a group of baby otters (*L. perspicillata*; *A. cinereus*) (d) banded linsang (*P. linsang*) (e) short young clawed otter (*A. cinereus*) being fed bottled milk.

Primates

Twenty species of primates from nine families were listed for sale (Table 19; Figure 20), totalling 448 individuals from 360 posts. Slow lorises (*Nycticebus* spp.) accounted for most of the posts (n = 152 posts; n = 195 individuals), followed by macaques (*Macaca* spp.; n = 98 posts; n = 116 individuals). On average, the most expensive group of primates were black-tufted marmoset (*Callithrix* penicillata.; n = 26 posts; n = 43 individuals; mean price US$ 1,875), followed by galagos (*Galago sp.*; n = 3 posts, n = 4 individuals; mean price US$ 1,172) and Geoffroy's tufted-ear marmoset (*C. geoffroyi*.; n = 1 posts; n = 2 individuals; mean price US$ 1,090).

Table 19. Table of primate species offered for sale, including details on the number of posts, number of individuals, mean price and its conservation listing (IUCN Red List, IUCN Red List; the Wildlife Preservation and Protection Act, WARPA; CITES Appendix listing).

Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Geoffroy's tufted-ear marmoset *Callithrix geoffroyi* (ลิงมาร์โมเส็ทจีโอฟรอย)	Callitrichidae (*Callithrix*)	1	2	N/A	LC	Not Protected	II
Common marmoset *C. jacchus* (คอมมอนมาโมเซท)	Callitrichidae (*Callithrix*)	24	39	1,090	LC	Not Protected	II
Black-tufted marmoset *C. penicillata* (มาโมเซทหูดำ)	Callitrichidae (*Callithrix*)	1	2	1,875	LC	Not Protected	II
Red-handed tamarin *Saguinus midas* (เรดแฮมด์แทมมาริน)	Callitrichidae (*Saguinus*)	3	4	1,031	LC	Not Protected	II
Squirrel monkey *Saimiri sp.*	Cebidae (*Saimiri*)	3	6	969	-	Not Protected	II
Patas monkey *Erythrocebus patas* (ลิงพาตัส)	Cercopithecidae (*Erythrocebus*)	1		N/A	LC	Not Protected	II

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Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Assam Macaque *Macaca assamensis* (ลิงอ้ายเงี้ยะ หรือ ลิงอัสสัม หรือ ลิงภูเขา)	Cercopithecidae (*Macaca*)	2	2	117	NT	Protected	II
Long-tailed macaque *M. fascicularis* (ลิงแสม)	Cercopithecidae (*Macaca*)	46	53	116	LC	Protected	II
Northern pig-tailed macaque *M. leonine* (ลิงกังเหนือ)	Cercopithecidae (*Macaca*)	4	4	115	VU	Not Protected	II
Rhesus macaque *M. mulatta* (ลิงวอก)	Cercopithecidae (*Macaca*)	2	2	N/A	LC	Protected	II
Southern pigtailed *M. nemestrina* (ลิงกัง)	Cercopithecidae (*Macaca*)	2	3	141	VU	Protected	II
Pig-tailed macaque (*Macaca sp.*)	Cercopithecidae (*Macaca*)	42	52	128	-		II
Banded langur *Presbytis femoralis robinsoni* (ค่างดำ)	Cercopithecidae (*Presbytis*)	5	5	125	NT	Protected	II
Unidentified gray leaf monkey *Presbytis sp.*	Cercopithecidae (*Presbytis*)	3	3	98	-	Protected	II
Indochinese lutung *Trachypithecus germaini*[a] (ค่างเทา(ค่างหงอก)	Cercopithecidae (*Trachypithecus*)	13	13	142	EN	Protected	II
Dusky langur[b] *Trachypithecus obscurus* (ค่างแว่นถิ่นใต้)	Cercopithecidae (*Trachypithecus*)	21	26	120	NT	Protected	II

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Name	Family (Genus)	*n* post	*n* indiv	Mean price (US)	IUCN Red List	WARPA	CITES
Trachypithecus Trachypithecus sp.	Cercopithecidae (Trachypithecus)	11	12	135	-		II
Galago Galagidae sp. (บูชเบบี้, กาลาโก้)	Galago	3	4	1,171	-	Not Protected	II
Agile gibbon Hylobates agilis (ชะนีมือดำ)	Hylobatidae (Hylobates)	1	1	N/A	EN	Protected	I
Lar gibbon H. lar (ชะนีธรรมดา หรือ ชะนีมือขาว)	Hylobatidae (Hylobates)	12	12	355	EN	Protected	I
Siamang H. syndactylus (ชะนีดำใหญ่ หรือ ไซแมง)	Hylobatidae (Hylobates)	3	3	365	EN	Protected	I
Unidentified gibbons Hylobates sp.	Hylobatidae (Hylobates)	5	5	276	<EN		II
Bengal slow loris[c] Nycticebus bengalensis (ลิงลมนางอาย)	Lorisidae (Nycticebus)	31 (18)	38 (26)	72 (70)	VU	Not Protected	I
Sunda slow loris N. coucang (ลิงลมใต้ หรือ นางอายใต้)	Lorisidae (Nycticebus)	15	21	47	VU	Protected	I
Pygmy slow loris N. pygmaeus (ลิงลมแคระ)	Lorisidae (Nycticebus)	14	17	83	VU	Not Protected	I
Unidentified slow lorises Nycticebus sp.	Lorisidae (Nycticebus)	74	93	71	VU	Not Protected	I

[a] Indochinese lutungs are listed under the WARPA as *Presbytis cristata*

[b] Dusky langur are listed under the WARPA as *Presbytis obscurus*

[c] Bengal slow lorises includes a subspecies of *Nycticebus tenasserimensis* in listed in brackets

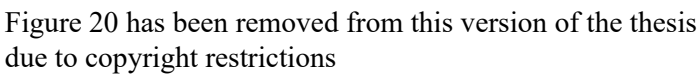

Figure 20. Examples of photographs posted to Facebook selling primates (a) young and sick slow loris (b) young pygmy slow loris (c) common marmoset from breeding company (d) baby gibbon and macaque (e) screenshot from a video showing a young langur playing with a young child.

5.3.3 Price analyses

The top ten most expensive species were all listed under CITES Appendix II, and non-native to Thailand. The correlation between the number of posts per species and price was found to be statistically significant (linear regression; $R^2 = 0.13$; $F(1,39) = 5.83$, $p = 0.02$). This was also evident for the number of individuals traded per species and price was found to be statistically correlated (Figure 21; $R^2 = 0.11$; $F(1,39) = 5.30$, $p = 0.026$). Species that were not as common (i.e. rarer occurrences) were often offered at higher prices.

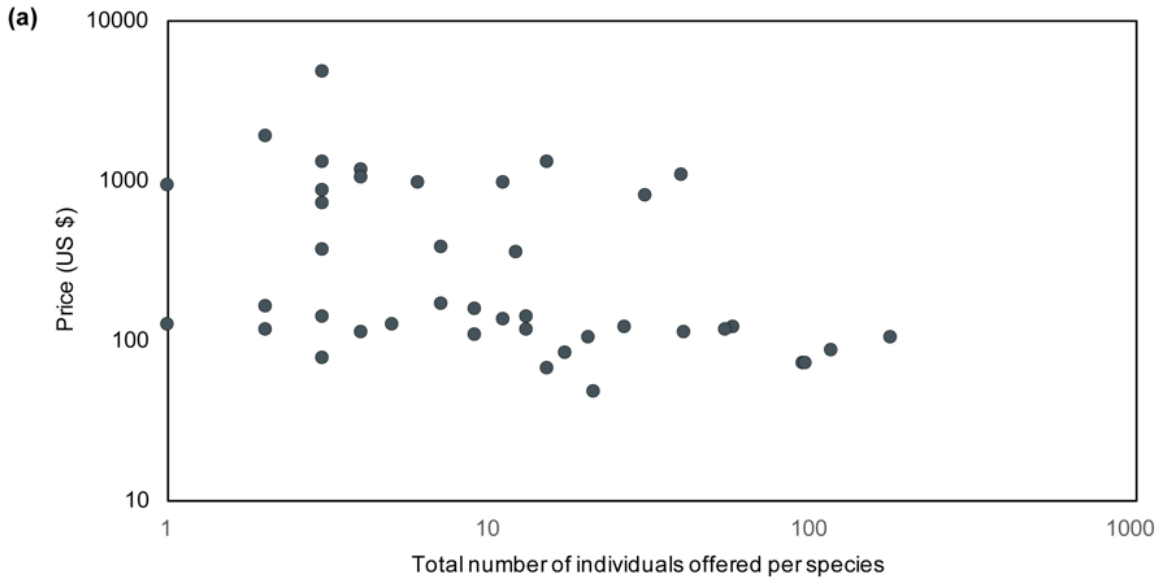

Figure 21. The number of individuals offered for sale with (a) mean price offered by seller (logarithmic scale) and (b) body mass combined both primates and carnivores (n = 41).

As an general overview, Figure 22 illustrates the price data points and mean prices of the different categories as observed from what was offered for sale. Threatened statuses according to the IUCN Red List, species which are listed as Endangered were offered at highest prices on average, followed by least Concern, Near Threatened and Vulnerable (Figure 22a). Non-native species, on average, were also offered at statistically significantly different prices (US$ 1236 compared to US$ 133; t-test, $t = 5.11$, $df = 38$, $p < 0.001$; Figure 22b), which is similar to WARPA patterns where Species not listed under WARPA were also on average offered at higher price range when compared to WARPA listed or protected species (US$ 883 compared to US$ 189; t-test, $t = 2.86$, $df = 38$, $p = 0.0069$; Figure 22c). Finally, legally tradable, CITES Listed species Appendix II, III and unlisted species were offered at higher prices when compared to CITES I (US$ 562.39 compared to US$ 372.20; Figure 22d) however, the difference is not statistically significant (t-test, $t = 0.59$, $df = 38$, $p = 0.55$), and carnivores were offered at higher prices than primates in general (US$ 597 compared to US$ 444; Figure 22e); the difference was not statistically significant (t-test, $t = 0.58$, $df = 39$, $p = 0.54$).

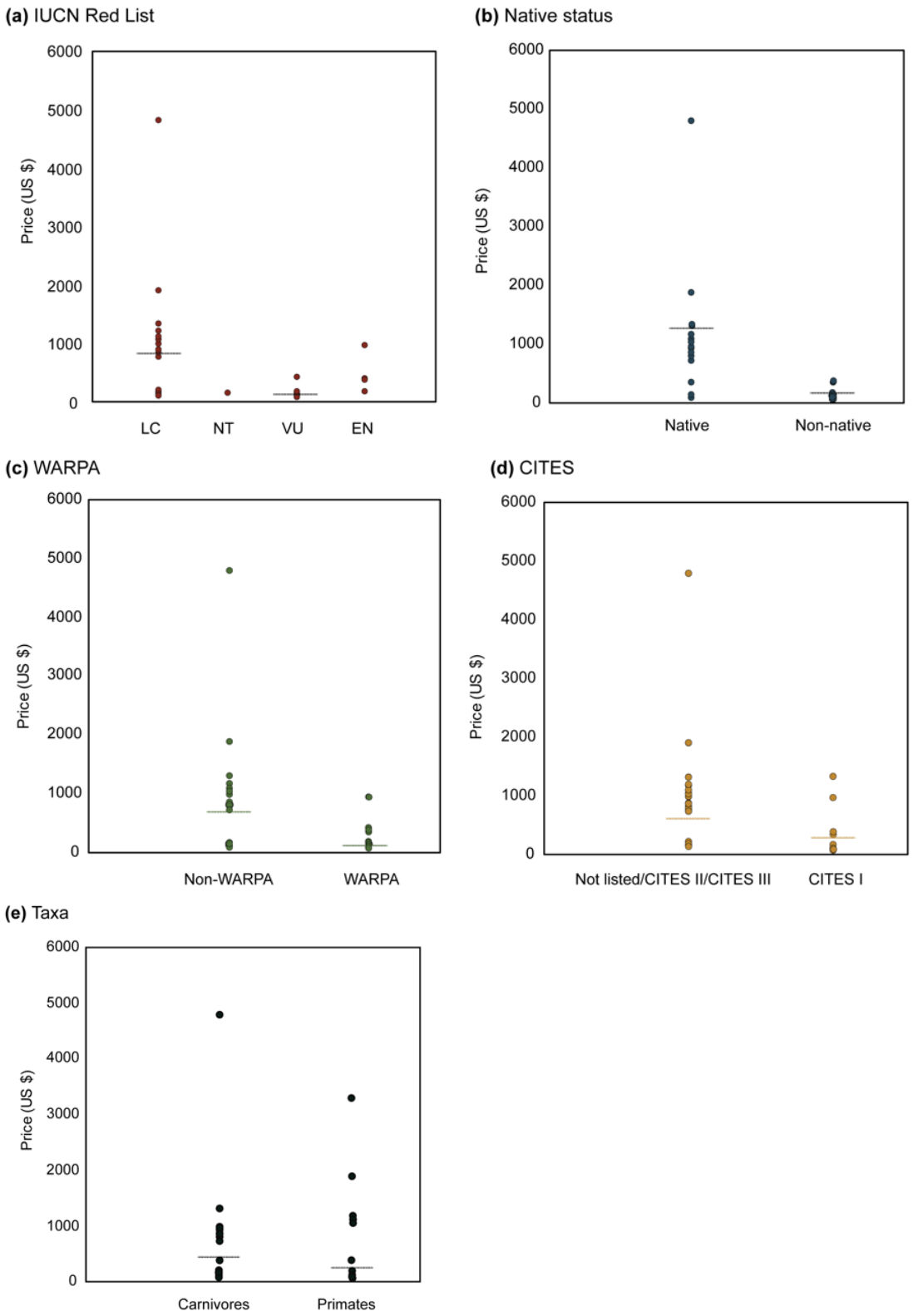

Figure 22. Price data (and mean prices) for each of the variables based on raw data according to (a) IUCN Red List category, (b) native status, (c) Domestic protection, (d) CITES classification and (e) taxa.

The detailed dynamic between availability and price was analysed specifically for two groups from each taxa where data were most available. This included otters (*Lutrogale* and *Aonyx* spp.) and civets (*Viverra, Viverricula, Paguma, Hemigalus, Arctogalidia, Patadoxurus* spp.), and slow lorises (*Nycticebus* spp.) and macaques (*Macaca* spp.). Data points based on otter species showed the strongest negative trend. However, correlates between availability per month and mean price on offer were analysed and were not statistically significant for all examples, which include, otters (R^2 = -0.02; F(1,16) = 0.60, p = 0.45; Figure 22a), civets (R^2 = 0.0022; F(1,22) = 0.82; Figure 22b); slow lorises (R^2 = -0.03; F(1,16) = 0.43, p = 0.52; Figure 22c) and macaques (R^2 = 0.004; F(1,20) = 0.0042, p = 0.94; Figure 22d).

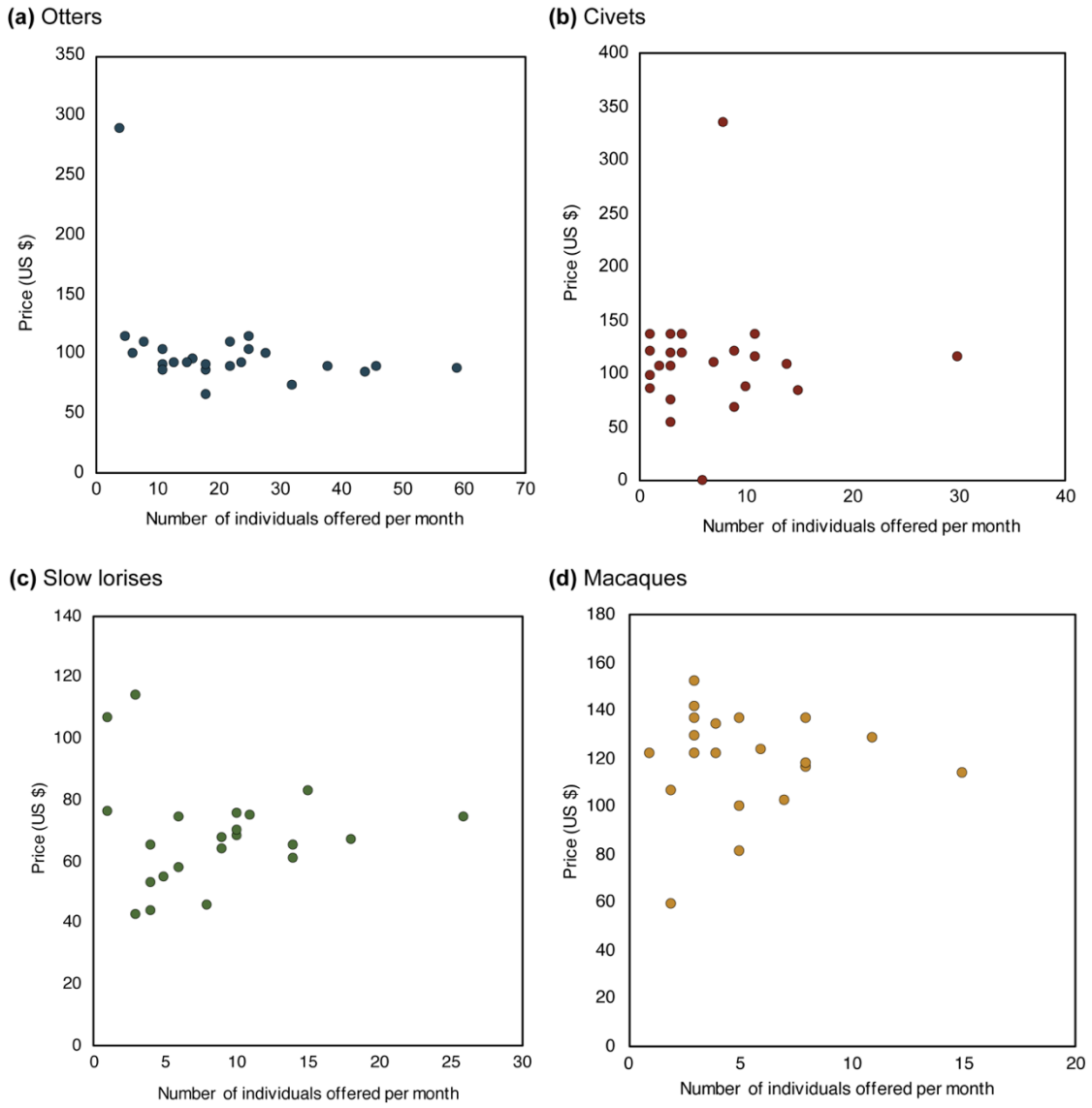

Figure 23. Species-specific analysis for price and availability offered per month for (a) otters (n = 25), (b) civets (n = 21), (c) slow lorises (n = 21), and (d) macaques (n = 20).

5.3.4 GLM model

GLMs were created to predict variables which may explain price and availability, which included predictor variables of **IUCN Red List**, **WARPA, native status, taxa** and **mean body mass** was incorporated to predict price, using the number of individuals as a weighted variable. The model with the best AIC (lowest positive) value of AIC was selected as the best fit. CITES was removed from the model as it was redundant with the **WARPA** variable, and inclusion did not improve on the AIC score.

Not all variables were found to be significant influencers of price (Table 20). In this model, the variables which were found to be significant predictors of price were **native status, body mass** and **IUCN Red List.** For **native** variable, non-native species were significantly offered at higher prices (Wald $\chi^2 = 29.47$, df = 1, $p < 0.001$). There was a positive direction for **body mass** variable where larger species had higher estimated prices (Wald $\chi^2 = 846.74$, df = 28, $p < 0.001$). For the threatened status or **IUCN Red List variable,** the model predicted an inverse direction where species listed higher in the IUCN Red List category (Near Threatened, Vulnerable, Endangered) had lower estimated mean prices compared to those listed under Least Concern (Wald $\chi^2 = 105.05$, df = 2, $p < 0.001$). The two other variables which were insignificant predictors in this model were **WARPA** (Wald $\chi^2 = 0.013$, df = 1, p = 0.91) and **taxa** (Wald $\chi^2 = 2.82$, df = 1, p = 0.93).

Table 20. GLM results and significances for variables modelled to explained prices offered in the primates and carnivores.

Variable	Wald χ^2	df	Sig.
Threatened status	105.049	2	.000***
WARPA	0.013	1	.910
Taxa	2.82	1	.093
Native	29.47	1	.000***
Body mass	846.75	28	.000***

5.3.5 Trade in native species

Since native status was a significant variable that skewed the price data (i.e. species imported from abroad from South America or Africa were significantly more expensive), further analysis was conducted on species just in Thailand. The refined model included predictor variables of **IUCN Red List, WARPA**, **taxa,** and **mean body mass** for species found in Thailand. In total, 25 species were included in the refined model. Two primate species (*Nycticebus bengalensis* and *Macaca nemestrina*) were found to have native distributions in Thailand but not included in the list of species protected under WARPA.

Following the same model approach, the final chosen model was significantly explained by all predictor variables (Table 21). **IUCN Red List category** (Wald χ^2 = 34208.17, df = 2, p < 0.001), where mean estimated prices correlated each IUCN Red List category, with Least Concern species offered at lower prices and Endangered species at highest prices. **WARPA** (Wald χ^2 = 130.17, df = 1, p < 0.001) was a significant predictor variable, where species protected under WARPA were modelled to have higher estimated means than unprotected species. Body mass (Wald χ^2 = 137522.26, df = 17, p < 0.001) was significant where species with larger body mass means were associated with higher estimated prices. **Taxa** (Wald χ^2 = 2.15, df = 1, p = 0.14) was also a significant predictor variable where native species of primates had higher estimated means than carnivore species. From the native species, agile gibbons (*Hylobates agilis*) were the most expensive (US$ 518), while otter species (*Aonyx cinerea* and *Lutrogale perspicillata*), accounted for 44% of the trade by volume.

Table 21. GLM results and significances for the refined model (only native animals) to explain price in the primates and carnivores offered for sale.

Variable	Wald χ^2	df	Sig.
IUCN Red List	34,208.17	2	.000 ***
WARPA	130.17	1	.000 ***
Taxa	130.90	1	.000 ***
Body mass	137,522.26	17	.000 ***

5.3.6 Temporal trends in trade

For species that were most commonly traded, a χ^2 test was applied to see if there was a temporal pattern of trade. The number of individual which were recorded for sale was not equally distributed over the 12 months for otters (individuals; χ^2 = 101.53, df = 11, P < 0.001), civets (χ^2 = 66.88, df = 11, P < 0.001), and slow lorises (χ^2 = 81.13, df = 11, P < 0.001). There was no clear distinctive pattern across all the taxa. However, temporal analysis is relatively limited due to the duration of the study, but also, the lack of comparative data, and there is no clear indication of seasonality, for example, certain times of the year where there were more individuals offered for sale.

5.3.7 Additional qualitative observations

During the monitoring period, I came across multiple conversations between sellers and buyers in the comments section in regards to the legality of possession. For example, an interested buyer would ask if it was legal to have a civet or otter as a pet. In all cases, the query was answered either by the seller or other group members. The comments posted in the thread of the conversation would often acknowledge the illegality in the case of selling a protected animal. Some standout comments

mentioned were, ‘nothing in Thailand is legal’, ‘Thailand has archaic wildlife laws’ or even ‘usually if officers see you, one or two is ok to have in your possession’.

Moreover, during the species identification process, I sought out assistance from Prof. Nekaris (pers. comment) for her expertise in identifying slow loris species. In addition to primates that were too young to be identified to species level, many were identified as unhealthy or sick. Several individuals appeared to have eye infections, and there was no mention of the condition in the caption.

5.4 Discussion

5.4.1 Online Facebook trade

Trade in primates and carnivores was observed on Facebook in Thailand. At the current time and legal stature, this was a combination of legal and illegal trade of both native and non-native species. In total, 858 posts totalling 1,377 individuals from 46 species were traded from eight Facebook groups.

Based on the data, price dynamics can be influenced by several factors and not always in the hypothesised direction (Table 22). In both models, body mass was found to be a significant predictor variable. The relationship was consistently in the same direction in both models where larger individuals were offered at higher prices. Comparatively, trophy hunting of larger animals was also found to be prized higher, irrespective of its rarity (Johnson et al. 2010). Another variable that clearly explained price is the native status. Exotic imports from abroad, which accounted for fewer individuals in terms of volume, were offered at significantly higher prices. This import premium placed on rare wildlife that geographically originates from the region of Africa, South America or in the Arctic, seemed to be a crucial selling factor which enabled sellers to establish relatively higher prices. As such, when collectively viewing the species offered for sale and the associated IUCN Red List categories, meant that Least Concern species were in fact, offered at higher prices compared to species in other categories such as Near Threatened, Vulnerable and Endangered. The demand for non-native CITES-listed primate species (pygmy marmoset *Cebuella pygmea)* was also evident in a study of the demand in exotic pets in Australia (Toomes et al. 2019). In a further study, the researchers found a marked demand for IUCN-listed and CITES-listed species for which they cite is consistent to Anthropogenic Allee Effect (AAE) (Toomes et al. 2020).

Comparatively, when examining just species native to Thailand, or species which have range distributions limited to just Thailand, influences of price dynamics appeared to be more nuanced. The price trends followed the fundamental theories of the economic model of value and potentially can lead to the AAE. In particular, species listed as Least Concern were offered at lower prices when

compared to the more threatened groups, which is what would be expected. Other factors, such as protected status or WARPA, were also consistent as hypothesised, where protected species were more expensive than unprotected species. These factors seem to imply that there are degrees of 'perceived or realised' rarity associated as a key selling point and thus relates to the demand and prices of individuals, and with each passing generation of exploitation and trade, can therefore lead to the Anthropogenic Allee Effect (Earle and Fraser 2019). This could attribute to the cycle towards extinction that threatened many rare species (Courchamp et al. 2006; Tella and Hiraldo 2014). The extent or the rate of the AAE will need to be further explored in detail.

Table 22. Evaluation of expected outcomes (hypotheses) and direction of outcomes from the linear regression and GLM to explain availability and price and primates and carnivores offered for sale on Facebook.

Variable	Hypothesis	Results	Expected direction?
Availability	Availability may influence price, where species that are more commonly offered will be cheaper on average. This may also be temporally or seasonally linked to when more individuals are offered for sale than others.	Number of individuals per species significantly correlated with price	✓
		Temporal using slow lorises and otters as a case study	✖
Body mass	Body mass may correlate with price, where it is expected that larger animals are more expensive.	Full model: Statistically significant – higher body mass more expensive	✓
		Native model: Statistically significant - higher body mass more expensive	✓
Native status	Non-native alien species will be expected to be more expensive when compared to native local species.	Full model: Statistically significant – non-native more expensive than native	✓
		Native model: Not included	-
WARPA	Species protected under the WARPA law will be less available and offered at higher prices.	Full model: Not statistically significant	✖

(**Table 22** continued on the next page, 1/2)

(**Table 22** continued from the previous page, 2/2)

Variable	Hypothesis	Results	Expected direction?
WARPA	Species protected under the WARPA law will be less available and offered at higher prices.	Native model: Statistically significant, protected more expensive	✓
IUCN Red List Threatened status assessment	Species classified as more threatened will not be as available and also offered at higher prices.	Full model: Statistically significant – Least concern most expensive than other categories	✖
		Native model: Statistically significant – Endangered species at the highest prices	✓
Taxa	There is no literature to suggest that there may be a difference in offering prices between the two taxa.	Full model: Not statistically significant	✖
		Native model: Statistically significant – primates more expensive than carnivores	-
CITES	Rarer species (such as Appendix I listed species) will be more expensive.	Full model: Not included in models	-
		Native model: Not included in models	-

5.4.2 The role and implications of the Anthropogenic Allee Effect

Though the relationship between exact drivers of the Anthropogenic Allee Effect may not be direct and clear-cut, there is some evidence to support that rarity or perceived rarity is indeed a driver of Anthropogenic Allee Effect (Courchamp et al. 2006; Hall et al. 2008; Holden and McDonald-Madden 2016). Species that will be most at risk are those that are popular among hobbyists, those where captive-bred are not acceptable to consumers or those that cannot be captive-bred at all (Sung and Fong 2018). Moreover, even positive actions such as uplisting a species in CITES appendices makes them more desirable as it becomes rarer and valuable to traders (Rivalan et al. 2007). In this particular case, we found that rarer species or non-native exotic species, though not necessarily under threat at the moment, were offered at higher prices which is more fitting with the standard economical model of supply and demand. However, when native species were specifically examined, incorporated with their threatened conservation statuses, the price of protected, threatened species was higher, and this is

the start of entering the cycle of the AAE. Only monitoring the same species over time, to see if the price increases while the number in the wild decreases, will answer if it is truly entered into an AAE.

Most recently, one study reviewed the direct impact of AAE on the trade of cycads (*Encephalartos* spp.) in South Africa. The authors used the change in the data collection on wild populations, auction prices and IUNC Red List status to evaluate the 37 species and found that price was positively correlated to the rarity of species, and the price was also negatively correlated to wild population sizes (Earle and Fraser 2020). Furthermore, the trade of three species has already gone extinct in the wild. This demonstrates future avenue for the study of AAE which will need to incorporate threatened statuses or wild populations to more strongly prove the theory.

It should also be considered that the measure of rarity is dynamic, especially with a biologically living individual. It may be a direct result of the threatened status, but it may also be a result of human-imposed values. The conservation status of species is also always fluctuating over time; some species may not yet be formally recognised as threatened, but have a high likelihood of, or a decreasing population trend. Furthermore, demand may also be influenced by the nature of the market, and with the pet trade, the 'valued' in trend species may change.

Another interesting discussion on the future implications of AAE is that a correlation has been found between species desired specifically for its rarity, and its likelihood to become an invasive species (Toomes et al. 2020). Just by chance, there is some association between the two factors and this poses a great concern to biosecurity as it suggests a link between illegal or legal smuggling of animal and traits that make tendencies to be a successful invader, for example, high fecundity and broad climatic tolerances (Herrel and van der Meijden 2014; Capellini et al. 2015; Howeth et al. 2016). This relationship requires further research.

With the time delay in implementation of any trade restriction, traders often have the time to acquire individuals or clear stocks of trade. In response to shifts in changes and shift in supply and demand, this will then impact prices and consumers. This idea will be further explored in the rosewood trade in chapter 6. To better understand 'rarity-fuelled' exploitation, consumer demands need to be explored more thoroughly (Sung and Fong 2018). Furthermore, incorporating an understanding of cultural consumer trends with conservation agendas such as the event of uplisting a species in CITES may enable researchers and conservationists to mitigate responses for the demand which may be first unexpected (Rivalan et al. 2007; Hall et al. 2008).

5.4.3 Trade methods and supply chain

There was no requirement or expectation to provide where wildlife was being sourced from in any of the posts. Though the demand seems to be for the domestic pet trade, it is possible that the animals could be sourced from neighbouring countries, especially Malaysia. Some sellers, clearly specify their geographic location as being in the border of Thailand to Malaysia. Another clear example of international trade is pygmy slow lorises that are extremely popular in trade but are not native to Thailand. However, pygmy slow lorises have range distributions in Laos and Vietnam, and it may indeed be possible that they are sourced from there. In 2013, the infamous selfie of Rihanna with a pygmy slow loris taken on Thailand's resort island of Phuket was at least 1,500 km apart from the Thai-Laos border (Kitson and Nekaris 2017). Hunting wildlife from across the border is likely, considering the relatively porous borders in the region (Phelps et al. 2010). Movement of wildlife within the country also seems relatively unchallenged.

Furthermore, issues related to animal welfare should also be mentioned. Several photographs of animals even appear to be explicitly stressed or ill. On many Facebook pages, many wildlife species are described as 'cute', 'friendly', 'easy to keep' or 'fit for beginners'. These misleading guarantees of selling often lead to further lack of information on the management of welfare and health issues; animals traded face a risk of death (Moorhouse et al. 2017).

Other information could also be gleaned on trade methods, including financial transactions, where the seller and buyer never actually have to meet to complete the purchase. Many use the national bus services as a means to transport live animals; however, for smaller items also use private logistic companies to send items, especially within urban areas. Financial transactions have also changed. The money of course, can directly be exchanged from buyer to seller as in a normal market context. There is also an additional option now set up to avoid scams and illegitimate activity. The option to involve a third-party, often the Facebook group administrator in completing the transaction; where the money is transferred to the group administrator until the item has been received, and the customer is satisfied. Only then will the administrator transfer the funds to the seller.

5.4.4 A note on the legality

The first note on legality is that in the observed trade in CITES II listed species, especially related to captive-bred exotic primate species such as marmosets and tamarins. It is assumed that there is paperwork applied, even though only handfuls of posts offer paperwork. This potential negligence opens up the possibility for potential discrepancies in any follow up reporting regarding the import populations and future regulation (Nijman and Shepherd 2011). Secondly, there also seems to be discrepancies within the WARPA laws that overlook species that have recently been speciated or identified as a new species. This loophole is a result of the fact that Thailand's wildlife law had

remained unchanged since 1992. The main differences were that it did not take into consideration new taxonomic changes in recent years, such as Bengal slow loris (*N. bengalensis*), are not protected even though they have natural distributions in Thailand. These discrepancies offer up loopholes for traders to continue trading protected and endangered species (Zhou et al. 2016).

It is also important to mention that since the monitoring period, Thai WARPA laws had undergone reform that included strengthened regulation of online trade and more inclusive protection of CITES-listed species. Legally, it would mean that the trade in non-native CITES I listed would be automatically protected as well. Based on the data presented in this chapter, it would increase the protection of six species which contributed to 16% of posts (13% of individuals).

5.4.4 Emergences of wildlife cafes

Building on to the 'Harry Potter' themed café introduced in chapter 4.4.5, exotic animal or pet cafes are becoming more and more popular, especially in Asia especially emerging since 2014. These cafes often operate as a small indoor petting zoo that allows direct (handling and feeding) or indirect (playing with toys, feeding with a barrier) (McMillan et al. 2020). McMillan et al. (2020) reviewed all establishments across Asia and identified 406 animal cafes with over 250 exotic species including birds (owls, hawks, parrots), reptiles (pythons and turtles), and mammals (otters, slow lorises, meerkats). Of the exotic species, 46% were classified as threatened under the IUCN Red List or have a decreasing population trend (McMillan et al. 2020). In the region of Southeast Asia, Thailand leads the way in the number of exotic animal cafes, following Japan, China, Taiwan and South Korea.

In Thai animal cafes, there are overlaps in the types of animals one may encounter at these establishments and the exotic species offered for sale here on Facebook, including, red foxes, arctic foxes, fennec foxes, meerkats, servals, racoons, marmosets and galagos (Figure 24). The combination of both CITES-listed and non-CITES-listed exotic species are on display in addition to dogs and cats. McMillan et al. (2020) reported that exotic animal cafes are quickly becoming a destination for threatened wildlife. This poses impacts to future populations especially as the source of animals range from clearly captive-bred animals to ones with an uncertainty of where it is sourced from. In this study, some shops owners clearly advertise their business or breeding facility along side their profile or sale post, focusing exclusively on imported species. Furthermore, the cause of concern is that in Thailand animal cafes such as these are not illegal but they also have no legal regulations. At present, Thailand has no laws that regulate this type of businesses or that which regulates animal welfare within these establishments (Anonymous 2017c).

The increased popularity of the cafes is credited mainly due to the growth of social media, in particular of Instagram. One specific café called Mini Zoo café has over 150,000 followers on

Facebook. Additionally, Little Zoo café, that has recently expanded to two outlets in Bangkok has nearly 15,000 followers on Instagram and over 120,000 followers on Facebook. Café owners consistently have to source out rarer species or more exotic species in order to differentiate their businesses from others. Furthermore, the relationship between social media on the trade of exotic pets in general, though difficult to directly quantify, is also slowing becoming more identified and examined. Nekaris et al. (2013) found that the platforms increase access and exposure to exotic animals through spreading viral pet images and videos, as seen for slow lorises. Likewise, Harrington et al. (2019) found an increase in pet otter videos on social media from 2016 to 2018. The authors suggest that the increased activity had the potential influence the popularity of pet otter ownership, as well as normalised pet keeping of this exotic endangered species.

The impact of these exotic animal cafes is not yet fully known. At the basic level, there may be an impact on wild populations, present or in the future that may have implications for conservation. Furthermore, the gaps in the laws may encourage the emergence of similar establishments, that in turn increases the visibility of animals and glorify and naturalise the perception of exotic pets or as a normal phenomenon, thus impacting the exotic pet trade. Targeting especially rare animals, or ones that are in 'trend' this can lead to consumer demand may lead a species population into the anthropogenic Allee effect (Harrington et al. 2019). Moreover, it is clear that further research is required to examine the impact of these cafes whether related to animal welfare (D'Cruze et al., 2019), the risk of zoonotic disease (Karesh et al. 2007), or the mechanisms and impact of these cafes to public perception and the wider exotic pet trade. Stricter legislative regulations will also be equally necessary to regulate these businesses and enforce transparent registration and possession of animals, especially the threatened species, alongside public education and awareness to disincentivise exotic pet ownership (McMillan et al. 2020).

Figure 24. Photographs from the exotic pet cafes in Bangkok

(a) A red fox (*Vulpes vulpes*) kept in a cage in the playroom, 2017

(b) Visitors take a photo while feeding prairie dogs (*Cynomys* sp.), 2017

(c) A tourist takes a photo feeding foxes, 2017

(d) A clearly overweight racoon (*P. lotor*), 2017

(e) A customer plays with a Wallaby (*Macropus* spp.) in a room with other foxes, cats and dogs, 2020

(f) A Fennec fox (*Vulpes zerda*) perches at the window with cats, 2020

Chapter 6: Using the Internet to gather seizure data

6.1 Introduction

6.1.1 Global rosewood trade

Often, elephants, tigers, rhinos and pangolins and their products are commonly reported at the forefront of the illegal wildlife trade. However, the trade of illegal wood products, specifically, the rosewood trade is the world's most trafficked wild product (UNODC 2016). 'Rosewoods' are the term used to generally describe richly-hued hardwoods. Within the group of hard redwoods, there also exists a subgroup, called '*hongmu*,' which is a commercial classification of timber consisting of 33 rosewood species distributed across Africa, Latin America and Asia. The characteristic of *hongmu* is its deep-red colouring, aromatic scent and distinctive durability against termites and rot (CITES 2016a). Rosewood is a broad trade name that refers to a number of species (UNODC 2016); therefore, it may encompass both *hongmu* species and non-*hongmu* species as well as CITES-listed species and non CITES-listed species. In this chapter, I will refer to the globally recognised term of rosewood and *hongmu* terms interchangeably.

China is the leading global importer of rosewoods (Treanor 2015). Rosewood has mainly been used for furniture manufacturing (UNODC 2016). Its association as a status symbol has led to increased demands, particularly in China among the emerging and rapidly growing group of wealthy middle-class elites (Schuurman and Lowry II 2009; Treanor 2015). This has, in part, been, facilitated by governmental commodification and lax import laws in China (EIA 2016). Unsustainable logging and unregulated trade have led to the commercial decline of several species such as fragrant rosewood or *huang hua li* (*Dalbergia odorifora*) in China (EIA 2016) and Madagascar rosewood (*D. baronii*) (Schuurman and Lowry II 2009; Wilmé et al. 2009; Innes 2010; Randimalala and Lui 2010). Traditionally, rosewood is the term reserved for dark-hued redwood from *Dalbergia* and *Pterocarpus* genera. However, since its explosive demand in the Chinese markets, the Chinese government established a Hongmu National Standard, which includes 33 species from a range of genera, including *Pterocarpus, Diospyros, Dalbergia, Millettia* and *Cassia*. Not all of these genera are 'true rosewoods'; For example, *Diospyros* are black or brown ebony hardwood. As a result of the Hongmu National Standard, species that are not true rosewoods are also included in reference to the 'global rosewood trade'. The list ranks from highly collectable species to moderately collectable species, from all over the tropics.

6.1.2 Rosewood trade in Asia

Rosewood species are found globally from South to Southeast Asia, Latin America as well as West and East Africa. Asia is home to 17 of the 33 species listed under China's *hongmu* standard. One of the key hot-spots for rosewoods is in Southeast Asia. In particular, the region of southeast Asia is home to *Dalbergia* and *Pterocarpus* species, or what may be commercially known as Tamalan (*D. oliveri)* (Treanor 2015). More famously, it is the home to a high-value species called Siamese rosewood (*D. cochinchinensis)* which is found in Cambodia, Laos, Thailand and Vietnam (UNODC 2016). Trade of rosewood timbers in the region has skyrocketed since 2000, where the Mekong region comprising of Laos, Myanmar, Vietnam and Thailand combined have exported over US$ 2.4 billion value of timber to China. Just this region alone accounts for up to 70% of Chinese markets imports of hongmu (EIA 2014). Prices reflect demand and scarcity of product; as an ever rarer species, the estimated market value of Siamese rosewood in 2015 had jumped 15 times from its original price in 2005, valued at $15,000 per m^3 (Wenbing and Xiufang 2013).

Enforcement action in the area has also responded in parallel, especially within the range forests where the rosewood species naturally occur. In the respective countries, despite increased law enforcement in protective areas, logging rates still surged (Dwyer et al. 2016; Singh 2014; EIA 2016). The high-value product led to exploitation of corrupt individuals along the supply chain, ranging from local communities, middlemen and traders and government officials (EIA 2014). There is also evidence reported from NGO reports that loggers are often backed by organised syndicates which provide loggers with weapons and equipment to camp out inside the protected areas in order to log timber and move it out of the area (Treanor 2015). In my own experience in discussion with rangers, I was also informed that the organised syndicates hire individuals from abroad to illegally cross borders. With illegal loggers and law enforcement being equipped with more armoury, facing off in the forest has led to inevitable injury and fatalities between loggers and enforcement officers (Dwyer et al. 2016; EIA 2014; Ferriss 2014).

In recognising the threats to rosewood species globally, CITES has increased its regulations on species in the past decade. Only one species, Brazilian rosewood (*D. nigra)* is listed as an Appendix I species. In 2008, Siamese rosewood was legally protected in all its range states (EIA 2014). In 2013, CITES moved to include Siamese rosewood as an Appendix II species (CITES 2016a). As an Appendix II species, it is permissible to be traded with proper permits (UNODC 2016). Additionally, at the 2016 CITES Conference of Parties in Johannesburg, further listings were accepted include all *Dalbergia* species under Appendix II (CITES 2016b). Still, only eight of the 33 listed *hongmu* species are regulated under CITES. Some of the remaining *hongmu* species lack data and therefore have not been proposed to be listed under CITES; they have either have not yet been assessed or only recently assessed since 2018 and thus have not been proposed to be listed.

However, despite increased international regulation and attention, the illicit rosewood trade still thrives in many places. This is due to the combined reason of flawed domestic governance, limited resources of law enforcement as well as the fast-moving nature of harvesting unlisted or unprotected replacement species by traders (Reeve 2015; UNODC 2016). An example of this is in Madagascar, where despite up listing of the Madagascar rosewood (*D. baronii*), overexploitation of rosewood timber has been exacerbated by government instability and loopholes in law enforcement, leading to a 'rosewood massacre' (Schuurman and Lowry 2009; Barrett 2010). Continued increased incidences of illegal logging from national parks still happen, and as a result, several species in Madagascar remain still under threat from extinction (Zhu 2017).

6.1.3 Data gaps in research and policy

Plants are not as often reported in illegal wildlife trade studies (Margulies et al. 2019). There are biases between the studies of animal and plant species, as well as within plant species are also evident. Studies on plant trade often revolve around illegal timber trade, orchids and cactuses (Margulies et al. 2019). In the past decade, recent interest in the illegal timber trade and the threats to many timber species have led to over 900 species of timbers being listed on CITES. Of the 900 species, 200 belong to the genus *Dalbergia*; however, it is important to reiterate that not all of the 300 *Dalbergia* rosewood species are targeted for the hongmu trade (Willis 2017).

The research involved in the trade of rosewood is mainly covered by NGO reporting who operate in the area where rosewoods are found (Figure 25). Key findings of NGO reports have focused on investigative aspects of corruption within the supply chain. From 2008 to 2018, there have been 55 studies that focused on illegal *hongmu* or rosewood trade. The majority of the existing works focus on Madagascar rosewood (*D. baronii)*, followed by Siamese rosewood. Overall, seven species of *hongmu* across ten countries were found to be key study species. Five reports focused on the illegal *hongmu* trade with a focus on China as the consumer or key importer (Wenbing and Xiufang 2013) or its trade relations with Cambodia (Global Witness 2015), Zambia (Cerutti et al. 2017), and Madagascar (Randriamalala and Ku 2010; Ke and Zhi 2017). Reports conducted by non-government organisations contributed to the highest volume of studies (n = 27/55), followed by research or peer-reviewed academic papers (n = 22/55).

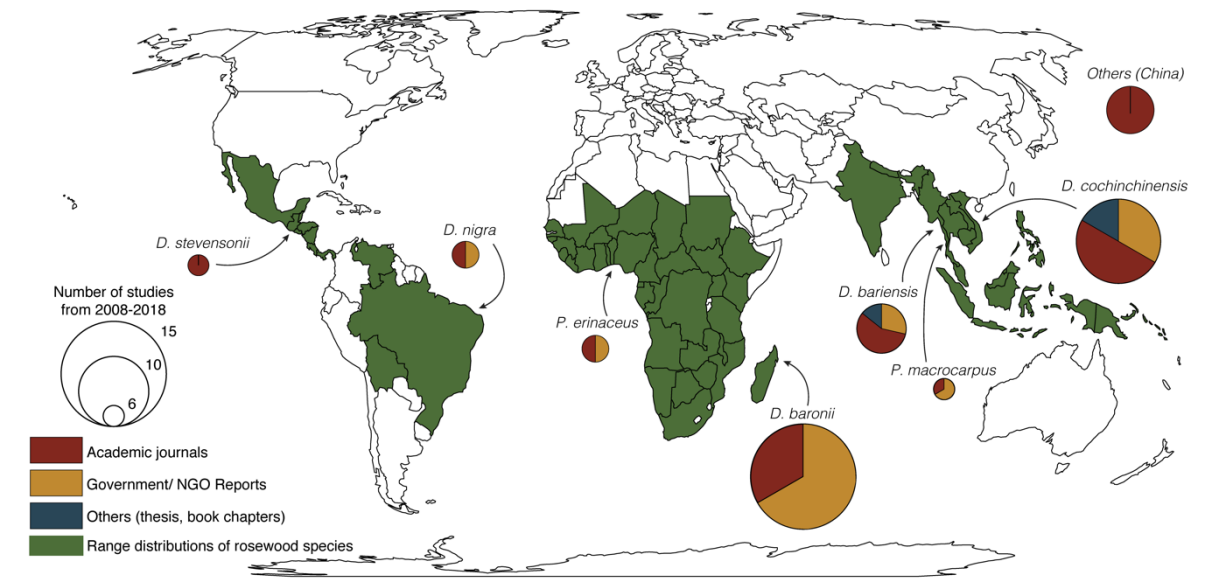

Figure 25. Published peer-reviewed academic studies in the past decade (2008 to 2012) that focused predominantly on the illegal rosewood trade. Shaded countries indicate where *hongmu* species have range distributions.

6.1.4 Study species and Thailand's timber laws

The three species included in the analysis of this chapter are Siamese rosewood (*Dalbergia cochinchinensis)*, Burmese rosewood (*D. oliveri)* and Burmese padauk (*Pterocarpus macrocarpus)* (Table 23). Despite being protected in its range states, the trade of Siamese rosewood has arguably had an impact on harvesting substitute replacement, especially, Burmese rosewood (*D. oliveri)* since both species share similar qualities and characteristics (Anonymous 2017d).

Table 23. Details on the three rosewood species studied in this chapter, including natural range states, IUCN listing, CITES listing, Domestic protection, and estimated market values.

Species	Range states	IUCN RL listing, CITES listing	Domestic protection	Price per cubic m^{3}, [a]
Siamese rosewood (*D. cochinchinensis)*	Cambodia, Laos, Thailand, Vietnam	VU, Appendix II (2013)	Forest Act Preserved Wood	$93,000
Burmese rosewood (*D. oliveri)*	Myanmar, Thailand, Laos, Cambodia, Vietnam	EN, Appendix II (2017)	Forest Act Preserved Wood	$9,200
Burmese padauk (*P. macrocarpus / P. pedatus)*	Myanmar, Laos, Cambodia, Thailand, Vietnam	Unlisted	Forest Act Preserved Wood	$6,300

[a]Source: Anonymous 2017d

6.1.5 Seizure data as a method to study illegal wildlife trade

In addition to the methods used in previous chapters to study and monitor both the legal and illegal wildlife trade, seizure data are also one of the approaches that are growing in popularity as a source of information to inform on illicit wildlife trade. Even with its inherent limitations (Rosen and Smith 2010; Underwood et al. 2013; Milliken et al. 2012), seizure data can perhaps offer the best starting point to identify and explain the illegal trade. The increased use of third-party monitoring approach further allows opportunities for studies which are not limited to government or organisational data, language, or geographic location. For example, seizure data collected from media reports offer a useful way to both complement government data by providing information on trade in species not listed in CITES or not on a priority watch (Gomez et al. 2016). Additionally, domestic trade is also not picked up by CITES. It is also an alternative to cross-check government data (Coston 1998; Phelps and Webb 2015). With this approach, limitations and inaccuracies can be minimised by extensive fact-checking and cautionary analysis (Nijman 2015).

6.1.6 Aims

The purpose of this chapter is to use online media-sourced seizure reports to investigate the trade of Siamese rosewood in Thailand quantitatively. Seizure data were first collected from national news agencies in the period from January 2013 to December 2019. Analyses were conducted to test spatial and temporal patterns associated with seizures, using the number of seizures and number of logs seized per year and for each species. Temporally, I test to see if there were any changes in the number of seizure over time for each species using a linear regression. Then, I test to see if there were any changes to the number of logs seized annually for each species using an ANOVA test. To explore spatial patterns, I use a χ^2 test to see regional correlations with the number of seizures. Furthermore, using Generalised Linear Model, economic, geographic and ecological factors were included to predict seizures and key active hotspots in the rosewood trade in Thailand.

Qualitatively, details on types of seizures, promised rewards, suspect details and agencies conducting the arrests were also collected from seizure reports and summarised to provide a more comprehensive understanding of the different elements of the illegal rosewood trade. Pathway information was also extracted from the reports to better illustrate the *modus operandi* of traders. The results demonstrate that online sourced seizure data can be used to provide an initial quantitative assessment of the trade network patterns of Siamese rosewood. Furthermore, changes to national legislation potentially impact future trade and current international regulations implemented for the protection of rosewood species are arguably lacking.

6.2 Methods

6.2.1 Seizure reports data collection

Media news reports related to rosewood seizures were searched on online news agency websites in a snowball sampling method (Goodman 1961; Martin et al. 2018). Snowball sampling is widely used as an approach in many methods, from finding interviewees (Lavorgna and Sajeva 2020) to surveying hunting efforts and illegal markets (Warchol et al. 2003), and to collect data on trade activity on social media (Martin et al. 2018; Hinsley et al. 2016). First, I focused on five primary websites in Thailand (Table 24). Searches were conducted in reverse chronological order until the database allowed. Search terms included 'rosewood' (*phayung / chingchan / pradu*), 'rosewood trade' (*kah phayung / chingchan / pradu*), 'rosewood arrests' (*chub mai phayung / chingchan / pradu*) or 'rosewood transport' (*khon mai phayung / chingchan / pradu*). Searches were carried out entirely in Thai language. For each year, seizure reports were collected at the end of each year, except for the first year of data collection in 2016 where reports were retrospectively collected for the previous three years (from 2013 to 2015).

Details of the seizures within the news reports were collected (Figure 26, p. 121). This included, where possible, date, location (district and province), number and/or volume seized, and intended destination. Each report was classified according to type. First, timber classified as 'storage' includes timber that was hidden in storage or stored within private properties, facilities or warehouses. Timber classified as 'en route' was defined as timber seized during transport whether in cars, boats, cargo containers, or seized beside roadside or riverbanks. The third category is 'protected areas', which is timber seized within or bordering government protected areas, wildlife sanctuaries, or government facilities. The final category is 'on-the-spot logging' which includes seizure reports of rosewood trees being cut down in non-protected areas, or public areas.

The species and volume or number of logs seized was also recorded. Each confiscated piece of timber is usually reported as a unit of 'log,' rather than in the volume. I also made a record of other species of timber seized on-site as reported in the news report. Details on arresting agencies were also recorded, such as the government agency leading or coordinating the seizure. Each seizure report was considered an independent case and checked for repetition. For any duplication, the report with the most details was selected (cf. Nijman 2015).

Table 24. News agencies used in collecting data of rosewood seizures in Thailand from 2016 to 2019.

No.	News agency (website)	Start date of monitoring
1	Manager (manager.co.th)	December 2016
2	Thairath (thairath.co.th)	December 2016
3	Daily news (dailynews.co.th)	December 2016
4	MCOT (tnamcot.com)	December 2016
5	Banmuang (banmuang.co.th)	December 2016
6	Post Today (posttoday.co.th)	December 2016
7	Sanook (Sanook.co.th)	December 2017
8	INN News (innnews.co.th)	December 2018
9	Siamrath (siamrath.co.th)	December 2018
10	Chiang Mai news (chiangmainews.co.th)	December 2019
11	Ejan (ejan.co)	December 2019

6.2.2 Statistical analyses

The primary unit of analysis used is the number of seizures. and the number of logs seized. Logs are referred to in Thai language as 'ton' and is often the term used in reporting the numeric unit of logs seized. It refers to timber in general, regardless of its form of whether it is in its raw logs or processed (or debarked), or size (whole trunks, part of trunks, or branches). Timber can also be referred to as sheets, but it is less common.

A direct linear regression was used to explore the temporal relationship between the changes in the number of seizures over time. An ANOVA test was implemented for each species using the year as a grouping to examine the detail further of changes within the number of logs seized over time. The differences in the number of logs in each year were compared to each other, and the changes according to the sequential year was used. All variables used were tested for normality and any variables which violated it was transformed and did not violate. Residuals and homoscedasticity were checked for using a Q-Q plot.

The provincial-level analysis was conducted to explain the number of seizures reported. Before statistical analyses, all data were log-transformed prior to analysis if it was not found to be in a normal distribution. After either a logarithmic or reciprocal transformation, all variables were normally distributed. In order to predict the provincial variation and to identify any possible pattern, I created a Generalised Linear Model (GLM) that included the variables representing geographic, economic, ecological factors (Table 25). Monetary values of timber seized and payments made were reported in Thai. In the monitoring period of 2013 to 2019, the US$ ranged from 29.93 to 36.04, so an

exchange rate of US$ 1 = 33.21 THB. In this chapter, statistical analyses were conducted on R Program (R Core Team 2019).

Table 25. Predictor variables included in the GLM to predict and explain the number of seizures per province.

Predictor variable	Proxy
Number of logs	Number of logs seized
Spatial	The distance to the closest land border from the district within each province with the highest seizure rates, using the shortest overland distance to a land border, using the district with the largest number of seizures as the centre point.
Temporal	Number of seizures overtime per annum
Economic	Gross provincial product - GPP per capita for 2014 (in Thai baht) (NESBD 2014)
Environment	Provincial forest cover (national parks and forest areas) - forest area (in km^2) for each province (DNP 2014)
Provincial	Population size of each province

Mapping pathways and networks of agency

Pathways were also mapped out to provide a glimpse of the various trade pathways used for the rosewood trade using the qualitative description from the content reported from the seizures. Key identifiers of where timber was seized, provinces though which the trade passed, key ports or exit points in the country and the ultimate destinations were recorded. A network of agencies was also recorded and included in the analyses.

6.3 Findings

6.3.1 General patterns

In the seven-year period from January 2013 to December 2019, a total of 2,274 seizure reports of the three rosewood species were recorded from ten news agencies. Approximately 78% (n = 1,771/2,274) of the seizure reports were related to Siamese rosewood, 7% (n = 166/2,274) were seizures of Burmese rosewood and 15% (n = 337/2,274) related seizures of Burmese padauk. Timber was seized and presented in many forms in the seizure reports (Figure 27).

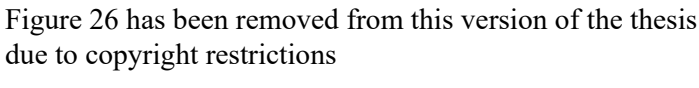

Figure 26. An example screenshot of the boilerplate structure of how a news article reporting on rosewood seizures is structured based on a news article from *Thairath Online* dated 29 May 2017. Details include the relevant government agencies involved in the arrest, transport method, date, time and location of arrest, number of logs seized and its form, further details on the direction of movement, suspects involved, and the source of news.

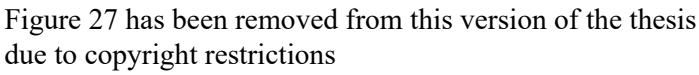

Figure 27. Rosewood seizures examples as reported in the media: (a) at home in Chantaburi province (thairath.co.th); (b) rosewood moving out of protected area in Srisaket province (posttoday.com); (c) in Pang Sida National Park (matichon.co.th); (d) en route on local highway (matichon.co.th); (e) on the Mekong using long-tailed boats for transport (komchadleuk.co.th); (f) port cargo container seizure by customs authorities.

The volumes of logs seized ranged from 1 single piece to 15,753 logs, totalling 182,397 logs seized reported in news outlets (Table 26). This number is strongly a conservative number, as at least 256 seizures reported did not state exact numbers of logs but were in large volumes of trees or cargo shipments. Siamese rosewood reported the highest total number of logs seized at 134,594 logs (mean logs per year = 19,228 logs/year; mean vol. per year = 219 m^3). Burmese padauk subsequently followed at 38,339 logs (mean logs per year = 5,477 logs/year; mean vol. per year = 169 m^3) and Burmese rosewood at 12,904 logs seized (mean logs per seizure = 1,843 logs/year; mean vol. per year = 47 m^3). Seizures predominantly reported the seizures in terms of 'logs', mostly referring to unprocessed raw logs; however, sheets and squares were also used as terms to report transformed logs.

Table 26. Summary of annual seizure statistics for the Siamese rosewood (SRW), Burmese rosewood (BRW) and Burmese padauk (BP) from 2013 to 2019, broken down by the total number of reports, the total logs seized, and the total volume of logs seized (m^3).

Measure	Species	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total (annual mean ± s.d.)**
Total reports	SRW	368	564	231	155	144	159	135	1,756 (251 ± 161)
	BRW	0	1	37	56	28	29	15	166 (24 ± 20)
	BP	10	59	62	76	42	43	45	337 (48 ± 21)
Total logs	SRW	34,062	47,478	33,048	6,958	5,312	4,296	3,440	134,594 (19,228 ± 18,374)
	BRW	0	7,547	610	2,805	831	819	292	12,904 (1,843 ± 2,673)
	BP	8,042	8,462	11,090	3,384	2,050	3,045	2,266	38,339 (5,477 ± 3,637)
Total vol (m^3)	SRW	260	862	258	93	39	19	NA	1,531 (219 ± 304)
	BRW	0	166	62	32	31	33	6	330 (47 ± 56)
	BP	19	120	112	94	84	691	61	1,181 (169 ± 233)

Overall, there was a fluctuation in the number of seizures reported over the monitoring year period (linear regression: $R^2 = 0.55$; $F_{1,5} = 6.14$, $p = 0.056$; Figure 28a). The number of seizures decreased over time was not statistically significant for Siamese rosewood, although there is a possible trend as it is close to significance (linear regression: R2 = 0.57; F1,5 = 6.56, p = 0.051). The number of seizures for Burmese rosewood not statistically significant (linear regression: R2 = 0.13; F1,5 = 0.71, p = 0.44). Likewise, the observed trend of number of seizures for Burmese padauk was also positive but not statistically significant (linear regression: R2 = 0.04; F1,5 = 0.20, p = 0.67).

The patterns for the number of logs seized (Figure 28b) is observably similar to the number of seizures (Figure 28a). Due to this reason, I took a different approach to statistically examine the changes over time. For the total number of logs seized in the seven-year period, an ANOVA test was used for each species using the year as categories to compare the means of the number of logs seized in each year as an indicator of trade activity. For Siamese rosewood, there was a statistically-significant difference in the annual number of logs seized in the seven-year period ($f(6) = 17.84$, $p<0.001$). The Tukey posthoc test revealed that consecutively from 2013 to 2019, the decline of the number of logs seized between 2015 to 2016 was the year with the most statistically significant drop ($p = 0.002$). Apart from that, chronological differences between each year were not statistically significant; however, the individual changes between the years for the entire time period from 2013 to 2019 were still sufficiently significant.

For Burmese rosewood, there was a statistically-significant difference in the annual number of logs seized in the seven-year period ($f(5) = 3.27$, $p = 0.007$). Post-hoc analyses showed that consecutive speaking, the difference between the year 2014 and 2015 was the only statistically significant year ($p = 0.007$). However, other sequential\ years did not show statistical patterns.

Finally, for Burmese padauk, there was also a statistically-significant difference in the annual number of logs seized in the seven-year period ($f(6) = 3.57$, $p = 0.0021$). Post-hoc analyses showed that chronologically, the annual differences between each consecutive year from 2013 to 2019 were not statistically significant.

Broken down into seizure types (Figure 28c), the most common category of seizure was caught in transport (37%; n = 862/2351), followed by storage based seizures (35%; n = 833/2351), protected areas (17%; n = 396/2351), and on the spot logging (11%; n = 260/2351). Looking specifically at the types of cases, storage, en route and protected area categories all showed significant decreases in trend. However, this was not seen for on-the-spot logging, which increased from 2016 to 2018.

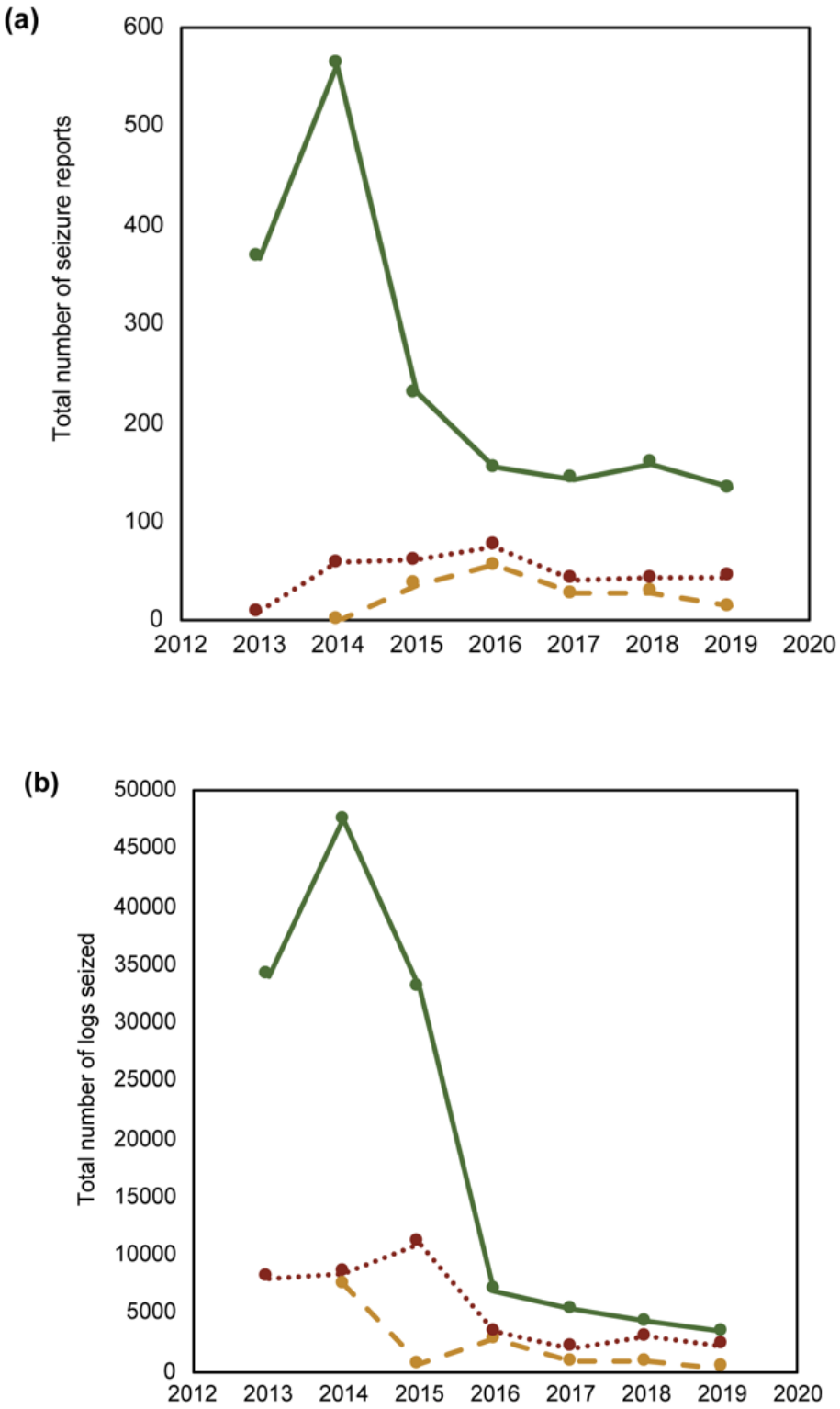

Figure 28. Breakdown of rosewood seizures obtained from news seizures from 2012 to 2019 based on species for (a) Number of seizures over time (b) Number of logs seized over time for Siamese rosewood (blue), Burmese rosewood (dotted) and Burmese padauk (dashed).

(**Figure 28** continued on the next page)

(**Figure 28** continued from the previous page)

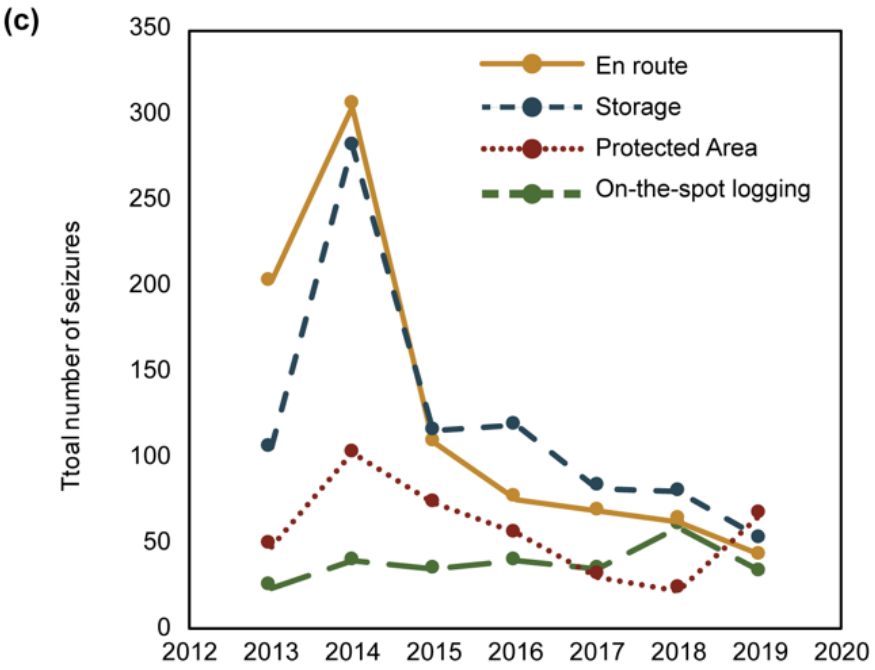

Figure 28. (c) The number of seizures broken down by type is also presented, including en route (solid), storage (dashed, blue), protected areas (dotted) and on the spot logging (dashed, green).

6.3.2 Spatial patterns

Rosewood seizure activity is distributed overall throughout the country, though there stronger geographical patterns based on particular species (Figure 29). Seizure reports occurred in 63 of 76 provinces in Thailand, with most of it originating in Ubon Ratchathani province (n = 363) followed by Mookdaharn and Srisaket province (both n = 224).

Siamese rosewood seizures (Figure 29b; n = 1754) are concentrated in the north-eastern and eastern provinces, especially in provinces bordering Cambodia and Laos and Bangkok. The Mekong River is an important location which is used as the main crossing point to smuggle logs across the border, where over 250 cases were directly referenced as being intended for boat crossing. Smugglers and traders use the motorised long tail-boats that do not necessarily require a specific pier or port to moor along the riverbank. Burmese rosewood seizures (Figure 29c; n = 268) showed a similar distribution to Siamese rosewood, whereas Burmese padauk (Figure 29d; n = 320) was much more broadly dispersed throughout Thailand.

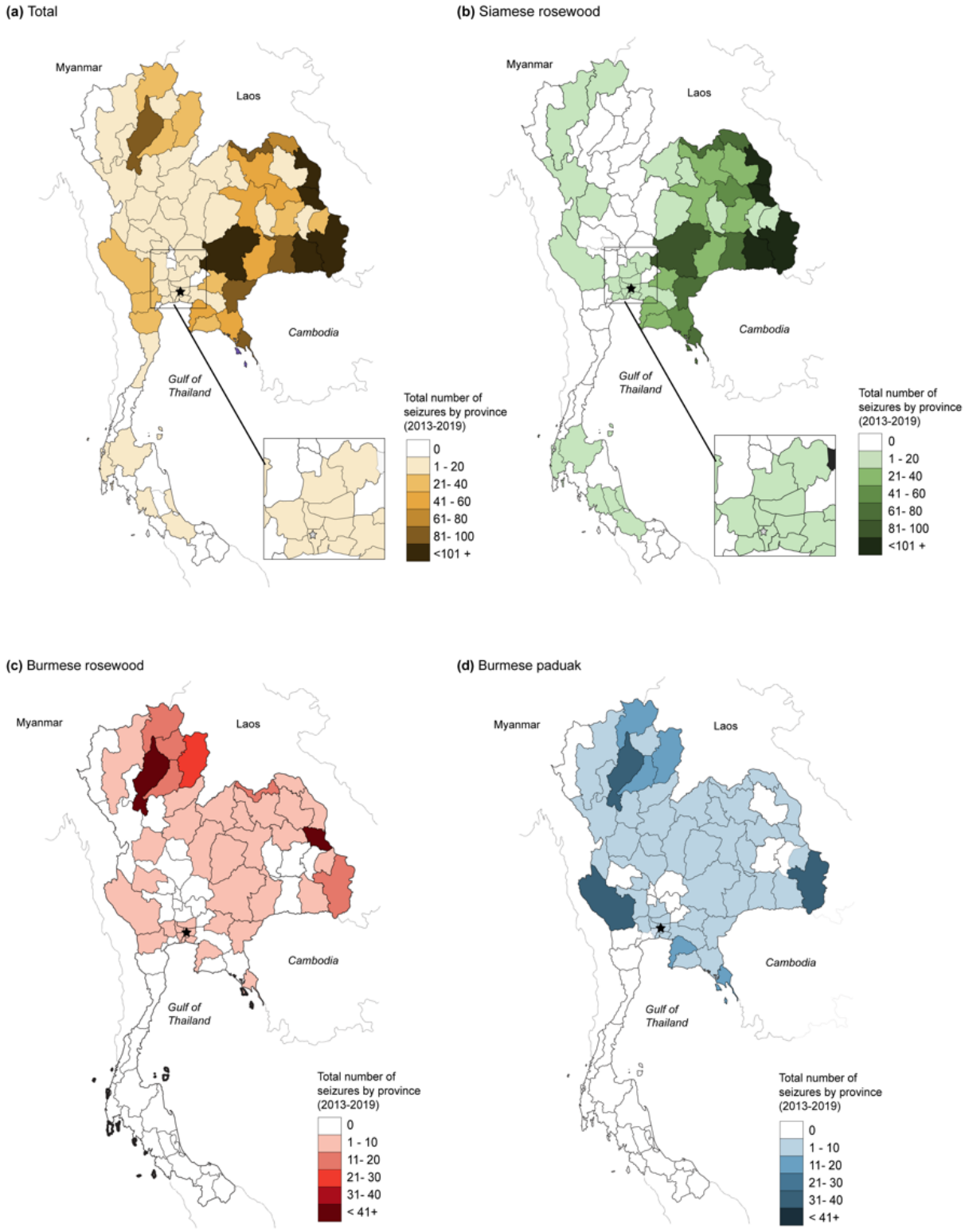

Figure 29. Map of the number of seizures for total rosewoods for (a) total seizures, (b) Siamese rosewood, (c) Burmese rosewood and (d) Burmese padauk from 2012 to 2019 as obtained from the online seizure reports.

The provinces were classified into one of 5 regions of Thailand: Central, East, Northeast, East and South (Table 27). A χ^2 test was carried out to test if there were any statistical differences in the number of seizure reports per region. As each region consists of a different number of provinces leading to a range of areas, the differences were corrected by dividing the total number of seizures by the total area of each region. The total number of seizures as reported with each region was statistically significant ($\chi^2(1, n = 37) = 17.43$, $p = 0.0016$).

Table 27. The number of provinces and the total number of seizures by region for all of the rosewood seizures combined.

Region	*n* province	Total area (sq km^2)	Total *n* seizures
Central and west	15	53,860	109
East	7	34,380	319
Northeast	20	62,000	1,414
North	16	93,691	260
South	4	70,714	9

6.3.3 Model to predict the number of seizure reports

First, a combined Generalised Linear Model was created to explain the number of seizures per province for all rosewood seizures. Independent predictor variables were selected on the bases to represent different areas (Table 28). The geographic border is represented by the distance to border variable measured in km based on the provincial district with the highest number of seizures. The economic variable is represented by the Gross Provincial Product (GPP) of each province that represents the annual income per person in the province. The variable that controls for provincial size and population is represented by the measure of population. Both the GPP and population were log-transformed to be normally distributed. Finally, the environmental predictor variable is represented by the percentage of natural forest, as there is no direct measure of rosewoods populations available for each province. In the combined model, the best predictor of seizures was the distance to the border ($T_{62,58} = -0.42$, $p < 0.001$). Other variables were not statistically significant in explaining the number of seizures.

For Siamese rosewood, the geographic variable was found to be the only statistically significant predictor factor (glm, $T_{45, 42} = -3.41$, $p = 0.0014$), where the more cases were explained closer to the border. However, for Burmese rosewood and Burmese padauk, the environmental variable was found to be the statistically significant predictor factor (BRW, glm, $T_{37,34} = 2.58$, $p = 0.015$; BP, $T_{48, 45} = 2.41$, $p = 0.02$). The geographic variable was found again to the only statistically significant predictor of the total number of seizures (glm, $T_{50,57} = -3.98$, $p < 0.001$).

Table 28. Model outputs and significances from the GLM model used to predict the number of seizures per province, for the total number of cases and individually for each species.

Model	Population	Economic (provincial GPP)	Environmental (% natural forest)	Geographic variable (distance to the border)
Total	$T_{62,58} = 0.79$, $p = 0.43$	$T_{62,58} = 0.059$, $p = 0.95$	$T_{62,58} = -0.077$, $p = 0.94$	$T_{62,58} = -4.25$, $p < 0.001$ ***
Siamese rosewood	$T_{48,44} = 0.77$, $p = 0.47$	$T_{48,44} = 0.40$, p 0.69	$T_{48,44} = -1.97$, $p = 0.056$	$T_{48,44} = -4.25$, $p < 0.001$ ***
Burmese rosewood	$T_{40,36} = 0.36$, p= 0.74	$T_{40,36} = 0.81$, $p = 0.42$	$T_{40,36} = 2.92$, $p = 0.006$ **	$T_{40,36} = -1.87$, $p = 0.068$
Burmese padauk	$T_{51,46} = 1.77$, $p = 0.082$	$T_{51,46} = 0.69$, $p = 0.49$	$T_{51,46} = 4.24$, $p = 0.0022$ **	$T_{51,46} = -3.05$, $p = 0.0037$ **

6.3.4 Suspects

Suspects were reportedly apprehended at the scene as reported in 44% (n = 1,002/2,274) of seizures reports. Where information was available on the nationality of the suspects, 69% of suspects were Thai (n = 1,176/1,689). Suspects were also be found from other bordering nations including Cambodia (25%, n = 427/1,689), Laos (4%, n = 72/1,689) and Karen ethnic community (<1%, n = 2/1,689). Though not directly neighbouring Thailand, apprehended suspects were also from Vietnam (<1%, n=5/1,689) and China (<1%, n = 5/1,589). There is currently no database in Thailand that reports on prosecution and conviction rates related to environmental crimes.

Authorities gathered details on financial rewards from the apprehended suspect. Information was mainly about promised payments, and in some cases, the deposit amounts. Where payment information was available (n = 183), suspects were also found to carry cash-in-hand upon arrest, rewarding from the amount of financial payment ranged from 500 Baht to 40,000 Baht. The reported mean for payments offered for 'cutting wood' and 'storage' was found to be lower than payments offered for going into 'protected areas' and 'transporting' logs both around the Mekong and throughout Thailand (Figure 30). In an ANOVA test using the promised rewards for each category as groupings showed that the means were not found to be statistically significantly different ($F_{4,178} = 1.058$; $p = 0.37$).

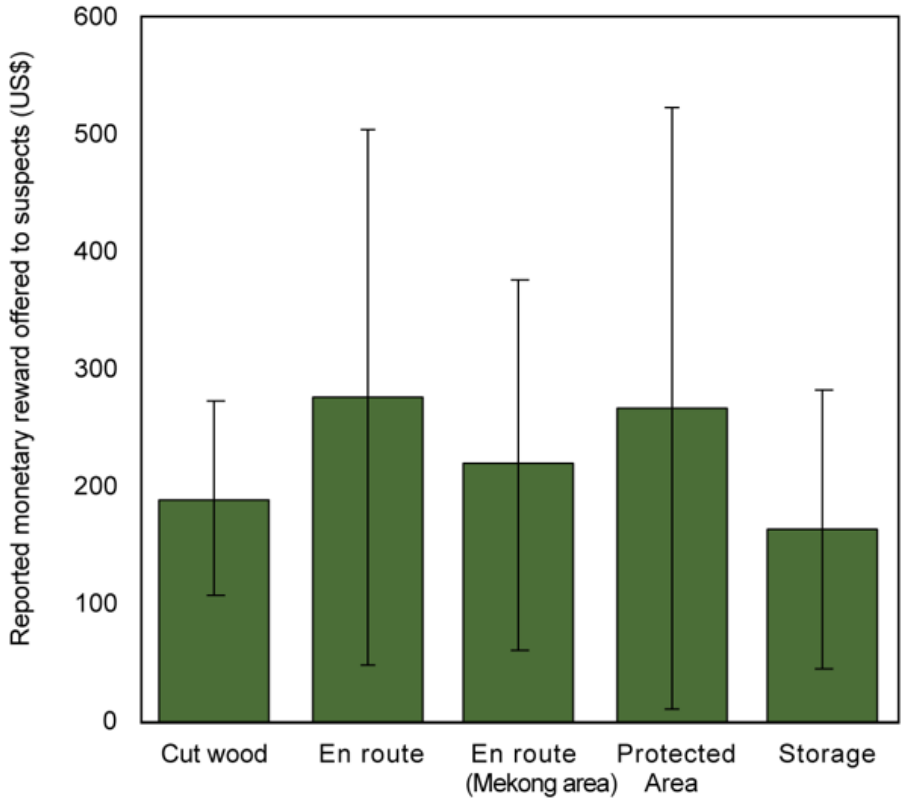

Figure 30. Monetary rewards offered (in US$) as reported by suspects, broken down by the type of illegal activity (n = 183).

6.3.5 *Modus operandi* and trade pathways

Trade pathway information was also obtained from the seizure reports, for example, specifically where the timber shipment was logged from, where it was travelling from and to, or the intended destination (n = 487; Figure 31). Fewer than 20 seizure (n = 18) reports reported timber for domestic consumption. In cases where timber is removed from a protected area, there can be a range of *modus operandi*. For example, there can be one or two loggers who crossed the protected area border, and sometimes the natural borders between Cambodia and Thailand in order to come into the protected area to log. In contrast, it can also appear that it is much more strategic and planned where organised groups come into the protected areas in large groups of 30 to 40 people. During my experience working with park rangers, this was indeed consistent with the details reported in the seizure reports. Similarly, groups of smugglers would bring in a monthly supply of food in order to camp out and produce a system of logging from inside the protected area and smuggle the wood out.

Concerning transport, vehicles were modified to carry and conceal large loads of timber. In some cases, there were also networks of teams working where the front and/or back vehicles were present to scout for the central vehicle of roadside checkpoints and/or serve as escape vehicles. Large trucks

were not as frequently used for transportation as they are quite conspicuous. In some cases, it explicitly stated that logs were illegally harvested from certain national parks, such as the Dong-Phayayen Forest Complex that encompasses one Wildlife Sanctuary and four National Parks. Though many more seizures report the direction of movement outwards towards international borders, a few report movement inwards, mainly to Bangkok or Chonburi province. This is because of the large city may be easy for more concealment, but also, large ports in the cities or towns which may be used to ship the logs out of the country in large volumes.

In the outbound pathway, it is anticipated that most of the rosewood is destined for the Chinese market, and Cambodia and Laos act as transit countries rather than end destinations. The different key methods that wood is transported out are crossing the Mekong River, through cargo shipments, or sea paths in the Gulf of Thailand. However, not all wood seemed to be intended for international consumption. Domestically, there are different uses for these rosewoods. The direct translation of the term Phayung or 'Siamese rosewood' in Thai is to support or raise; therefore. it is nationally renowned and associated as an auspicious timber to enhance and support one's status. Despite its positive association, it is not as in demand for use in Thailand by locals. In contrast, Burmese padauk is much more commonly available in commercially regulated domestic furniture and homebuilding markets, akin to other hardwood species such as Teak (*Tectona grandis*), Iron wood or Mai daeng (*Xylia xylocarpa*) and Makha (*Afzelia xylocarpa*). In rural provinces, it is used to build houses and is associated with status in the village (Pers. comm. Siriwat 2020).

Figure 31. Pathways mapped based on the information that is able to be extracted from the news seizure reports (n = 487). The lines represent the direction of movement – inwards (dashed red line for domestic movement, solid blue line for international movement) and outwards (dashed red line for domestic movement, solid red line for international movement). Symbols at the border represent the intended mode of transport used to move logs out of the country.

6.3.6 Arresting agencies and relevant laws

In total, 20 government agencies reporting to 6 ministries or major government bodies were involved in rosewood crimes and arrests (n = 2,187; Figure 32). Within the news reports which reported single-agencies carrying out (38%), the Royal Thai Police (RTP; which includes the police, traffic police, Royal Thai Immigration, Border police, NRECD) solely led 23% (n = 504/2,187) of reports. While Environmental government agencies (Department of National Parks, Wildlife and Plant Conservation and the Royal Forestry Department) solely led 6% of reports (n = 132/2,187). Considering seizures that were led by two government agencies, this comprised of 31% of all seizures. Seizures between the police and DNP/RFD accounted for the most at 8% (n = 207/2,187), followed by seizures of army and police at 7% (n = 159/2,187). While seizures carried out by three or more agencies accounted for the remaining 31% with the highest cooperation between the police, the army and the DNP/RFD (12%; n = 256/2,187). Most government agencies operate throughout Thailand, while others are more fixed geographically. The Mekong Riverine unit works specifically in the Mekong region, while the Water police (harbour police) deals with both Mekong region and gulf of Thailand.

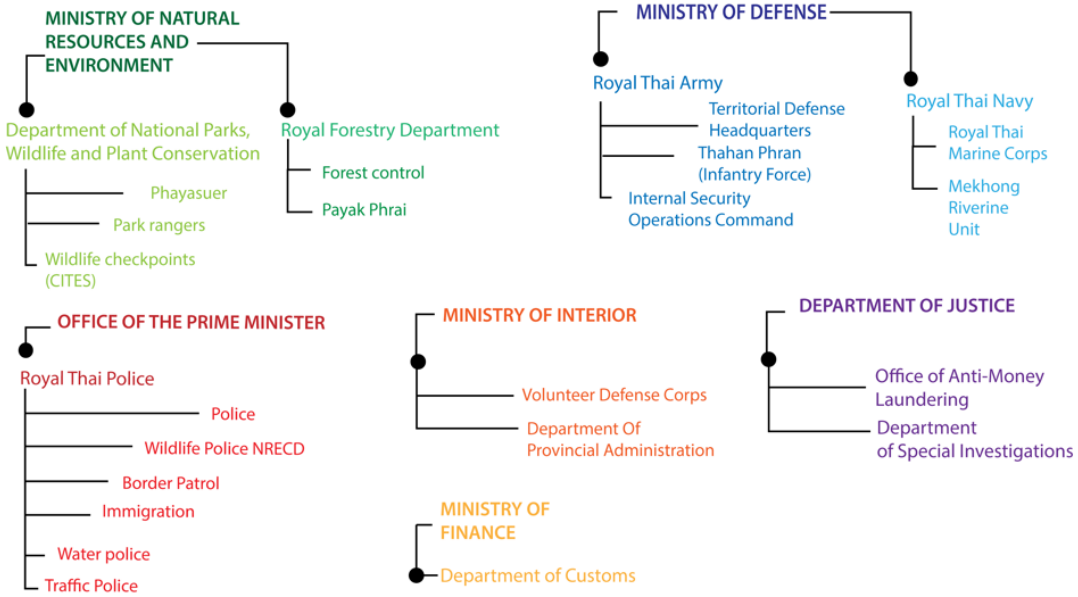

Figure 32. The different constituents of government agencies involved in the rosewood seizure reported from 2013 to 2019.

Often, seizure reports refer to the legal penalties associated with the possession of prohibited timbers, mainly, references to the domestic articles within the Thai constitution in the timber laws (n = 551). This mainly includes the Forest Act, B.E. 2484 (1981), now reformed as Forest Act B.E. 2562 (2019), the Wild Animal Reservation and Protection Act, B.E. 2535 (1992), now reformed as Wild Animal Reservation and Protection Act, B.E. 2562 (2019), National Park Act, B.E. 2504 (1961), as well as other legal acts which relate to the processing and transport of timber such as the Chain Saws Act, B.E. 2545 (2002) and the Factory Act B.E. 2535 (1992).

More concerningly, in less than ten seizure reports, CITES regulations and/or penalties were mentioned. In a few reports, it was mentioned that Thai agencies had contacted Cambodian enforcement authorities regarding suspects that crossed over the border. However, there was no clear follow-up statement on the result of the communication or further action. There was only one single instance that reported a cooperative, coordinated enforcement action between Thai and Cambodian officers.

6.4 Discussion

6.4.1 *Modus operandi* of rosewood traders

Open-source online seizure data from 2013 to 2019 in over 2,000 seizure reports show that rosewood seizures occur throughout Thailand. Even though there was no clear statistically shown trend in the changes in the number of seizures over the seven-year period, there were significant differences of the number of logs seized that could be used as a proxy for seizure activity. One of the remarkable differences was observed between the year 2015 and 2016 for Siamese rosewood that a statistically significant sharp decline in the number of logs seized. There was also a sharp increase in the number of logs seized from 2014 to 2015 for Burmese rosewood. The reason for this could be due to the spike in trade for Siamese rosewood, as the trade of both rosewood species are closely associated and often found traded together using the same channels.

There are also evidently regions that are clear hot-spots for trade, although qualitative pathway analyses show that trade happens in all directions, and Thailand is both a principal source and transport country. The consumption of Siamese rosewood and Burmese rosewood is consistently directly for international markets; however, this was not the same across all species, such as for Burmese padauk. Burmese rosewood was cited multiple times as the replacement species for the Siamese rosewood. The key areas of transport out of the country predominantly remain in the north and northeast region of Thailand along the Mekong River, and this is consistent with previous findings from NGO compiled investigative reports (EIA 2014, 2016; Treanor 2015). On paper, Thailand is not a major exporter of Siamese rosewood; however, its neighbours appear to be. Timber illegally smuggled to Laos and Cambodia can, therefore, become ‘legal’ rosewood in international markets (Innes 2010; EIA 2014). In 2014, Laos and Cambodia were ranked 1st and 10th in exporting rosewood logs by volume to China through official trade channels, while Thailand’s official exports were none at all (Treanor 2015).

Overall, the decrease in the number of seizures could also be potentially credited to enforcement efforts by the Thai government in combating of rosewood crimes. However, the information obtained from the suspects and seizure reports reflects that the scale and impact of the illegal rosewood trade

are not limited domestically to Thailand and the Thai government, but is an international issue that requires further regional cooperation. Illegal loggers and wood smugglers cross through natural borders, with few cases reporting successful arrests of suspects, or more importantly, successful investigation of kingpins or financial backers. There is also a lack of information available about successful prosecution rates and follow up news articles about what happens subsequently after arrests; only approximately 1% of news reports offered information on follow up arrests or cases. At a global level, the number of rosewood seizures has decreased over time since its peak in 2013, where between 2014 and 2018 the dominance of global seizures decreased with the reason cited as the market shifted to new species (UNODC 2020). It does show consistent patterns as what was found in this study.

The official Thai government reports less than 10% of suspects arrested with Siamese rosewood related crimes in 2016 (Anonymous 2016). With the porosity of the Mekong border, the proximity to Laos and Cambodia, and the convenience of escape makes it incredibly preferential as an exchange location. It is indicated that the final destination of timber logs is China, transiting through Cambodia or Laos. Though the market is driven predominantly by external outside demand, the pathways of removing the timber out of the country are not always direct. In some cases, timber logs are directed into towards Bangkok in order to use other discrete transport methods. The various modes of transport reiterate the trade is within a complicated large-scale network, both domestically and trans-regionally. Similar *modus operandi* is evident in conducting wildlife crimes in the region. In Vietnam, poor locals are often hired to carry illicit goods across the border, and wildlife traffickers often use vehicles with expired licenses which can be quickly untracked or easily abandoned when escaping the police (Cao Ngoc and Wyatt 2013).

This study shows that geography and environmental factors can be predictors for seizure activity. Areas of forest are targeted as timber are being logged in those areas. Importantly, forest and population census should constantly be updated to prioritise areas of enforcement. Geography is a clear factor as there is evidently more seizure activity closer to the border. When used in combination with qualitative information provided on *modus operandi,* seizure data can offer a complete picture of the trade and allow enforcement agencies a guide to predict and prioritise future areas of trade.

6.4.2 Enforcement, domestic legislation and CITES

In the past decade, there have been domestic legislative changes related to the rosewood trade. In Thailand, the trade in rosewood is regulated under Thailand Forest Act B.E. 2484 (1981). Under Thailand's military government, a revised version of the forest law was drafted and passed into effect in November 2019. Thailand's previous legislation covered the trade in rosewoods where all three species are listed under the tree protection act where the possession and selling of several 'precious'

wood species, including the three *hongmu* species are prohibited unless approved by local governments (Anonymous 2018i).

A significant change was in regards to Section 7 of the 1941 Forestry Act, that addresses 171 'reserved' timber species, including Siamese rosewood and Burmese rosewood, are among 13 rare species of timber to become able to be legally felled and traded under the condition that it is grown on privately owned land (Anonymous 2018i). The purpose of the law reform is to create jobs and generate income for farmers who may possess several of economically valuable species such as teak, Siamese rosewood and Burmese rosewood, with the hopes that people will grow commercially viable trees for sustainable logging. Furthermore, as part of the governments' 20-year National Strategy environmental plan, the government is also pushing forward to create more economic incentives to encourage people to conserve precious wood species. For example, commercial banks have endorsed a new policy which allows precious trees to be recognised as tangible assets and thus can be used as collateral for procuring loans in a programmed called 'Tree Bank'.

In an ideal situation, the new law will address issues related to sourcing timber illegally and pushing them through legal channels. Under the correct system, a timber product will have traceability from when it is grown, when it is cut, to when it is shipped out through legitimate channels. However, the effectiveness of the program is not yet known as it is too early in its implementation. Furthermore, the subsidiary laws that explains in detail exactly how the plan should unfold are also not yet drafted or pushed through. It should also be noted that to 'legitimately' cut timber to be processed and sold is, in fact, a very difficult situation as it is now as it involves different laws, for example, a legal statute in using the correct chainsaw, a legal statute in transporting timber out of the personal property, a legal statute in selling timber. With these legal restrictions, ordinary people usually may not be aware or have access to equipment to do everything legally, and this is seen as a loophole that serves wealthy business people or investors.

At the present time, this seemingly progressive action raises potential issues of concern, especially regarding the effectiveness in current enforcement on the illegal trade situation. As evident in Madagascar, gaps in legislation and the ineffective implementation of those laws provide rosewood timber species result with unintended consequences which may bode negatively (Reeve 2015). With the current legal infrastructure in place, law enforcement authorities still report difficulty species identification and tracking the legitimacy of wood in commercial market species, for example, in 2016 where over 100 cases of Siamese rosewood seizures reported in Thailand were due to misdeclaration (UNODC 2016). While looking ahead to a growingly legal area for cutting and logging precious woods, it will be just as important to strengthen the enforcement and to ensure that populations in natural range forests are not driven to extinction.

Furthermore, although CITES is one of the key regulating bodies of wildlife trade (Amilien 1996; Challender *et al.* 2015b), there are inadequacies in protection, especially for certain flora species (Brack 2003; Innes 2010; Phelps and Webb 2015). High-value timber species do not grow fast enough to compensate logging rates and commercial trading volumes, and post-process identification of timber products is still lacking (Winfield *et al.* 2016). Currently, the trade in 12 *Pterocarpus* species (which are considered rosewoods), are still allowed commercially (Winfield et al. 2016). it is also possible that stockpiles of timber felled prior to a logging ban may be introduced into trade later. As such, once logs are exported to destination markets, local regulations in the source country may become irrelevant (UNODC 2016). As a result, illegally sourced or logged timber can ultimately become legal hardwood furniture due to the ambiguity in the global timber trade. Issues of regulating timber under CITES with correct identification have been highlighted in case studies of Brazilian rosewood (*D. nigra)* (Ferriss 2014; Ugochukwu et al. 2018) and broad-leaf mahogany (*Swietenia macrophylla*) (Innes 2010). In combination with Thailand's newer flexible legislation of trade, this may undermine controls implemented to protect all rosewood species and impose complexities in enforcing CITES.

All in all, the effectiveness of Thailand's new timber commercialisation is not reviewable at the moment. Therefore, the development of the legal framework and the effectiveness of implementation will need to be closely monitored in the coming years. Transparency of regulation pathways at the domestic level will be pertinent for it any international trade to be legitimate. Technically, Thailand's role in the global rosewood trade should also be unchanged with this new regulation. The implemented program does not yet allow and include international trade. Therefore, it will be interesting to monitor how legal trade activity, as well as illegal activity via seizures, changes over the coming years.

6.4.3 Usage of seizure data

This chapter introduces the utility in using publicly available seizure reports to track wildlife trade using the illegal trade of rosewood species as an example. Seizure data offer valuable insights into the specific nuances, patterns and complexities of illegal wildlife trade networks, as has been demonstrated in other wildlife trade as well (Nijman 2015; D'Cruze and Macdonald 2016; UNODC 2016; Cheng et al. 2017; Gomez et al. 2019). Seizure reports related to rosewoods in Thailand are reported openly as timber crime is not as negatively viewed in Thai society, compared to other wildlife crime. Since the topic at hand does not carry a social stigma, authorities are relatively less sensitive in guarding and reporting crime, and even appears to be encouraging to report the successful seizures. The only comparable dataset is one released by the Department of National Parks, Wildlife and Plant conservation for the seizures of Siamese rosewood from 2008 to 2017. Though the time

frame of the study and the species studies does not coincide directly with the data presented here, there showed similarities in the patterns of peaks and declines that could indicate that the reporting patterns coincides or is a proxy of reality.

As illustrated in each of the three previous chapters that examine publicly available databases such as the CITES trade database, or surveying and monitoring of online marketplaces, and including this chapter's use of seizure data, there are obvious inherent biases in the dataset used due to the nature of the topic studied. Underwood et al. (2013) examined the use of seizure data to much more detail in order to explain the illegal ivory trade and developed methods to identify sources of bias and thus correct for them. This starts by acknowledging blind spots, starting from identifying the fact that not all illegal ivory transactions within a country are seized, the proportion rates of what is seized is often unknown, and the reporting rates of seizures made by law enforcement to the global database for elephant trade seizures is unknown. From there, statistical models were used to provide estimates of illegal ivory activity over time and the origin countries of the seizures (Underwood et al. 2013). Even with a progressive model as theirs, there are still assumptions that need to be made regarding stages where there is a clear lack of data. In the same way, this study finds that there are still clear unknowns, especially to do with seizure frequency, and reporting rates however future works can be seen to look into ways that can better identify and correct for these inherent biases.

The nature of fluctuation in the number of seizures is found for other studies that use seizure data (UNODC 2016). Boom and bust cycles are also seen in other trades of timber (Rodrigues et al. 2009). The UNODC (2016) reports that seizures of individual species are volatile; the yearly variation in the total weight of ivory seized reaching a range of up to 33% (UNODC 2016). This is due to the fact that there are multiple external factors which may influence seizure, both national and international, for example, stricter domestic regulations or enforcement imposed may lead to higher seizure rates. While changes in trends in the market may also influence the movement of products and thus impact seizure rates, and this may also vary on a species basis.

With multiple potential sources of seizure data, the use of online media as a source has an array of benefits. Firstly, and most clearly, is that there are large amounts of data available on the Internet. Researchers also have flexibility in conducting research in different languages with minor geographic limitations (Nijman 2015). Local and national news are updated daily; therefore, it reflects real-time trends of trade patterns and addresses the issue of periodical delays released by monitoring agencies highlighted in the earlier chapters such as through the CITES UN Comtrade database (Phelps *et al.* 2010).

Another limitation raised through using CITES trade database in chapter 3 is that only international trade of CITES-listed species is included. Even though the rosewood species highlighted in this chapter are CITES-listed as Appendix II species, there is a lot of movement in logging and trade at the domestic level, which may be overlooked and underreported. Even within seizures reported to the UNODC, it is assumed that it is an underreporting as not all countries class timber as 'wildlife' (UNODC 2016). Publicly available seizure data can, therefore, be used in conjunction, and in complementary, with official government trade data to offer a more comprehensive complete view of the trade. The records can also be used to monitor gaps in conservation and enforcement efforts proactively and to reveal ambiguities in the legal systems.

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Chapter 7: General discussion and recommendations

7.1 Introduction

The Internet and the digital age have reshaped the way wildlife is traded and monitored. Trade has accelerated as a result of globalisation (van Uhm and Moreto 2017). Although significant parts of trade may be legal, the illegal and unregulated component threatens population to decline and ultimately drives species to extinction (Scheffers et al. 2019). Comparably to other species, well-document populations of tigers, elephants and rhinos have seen pronounced loss in wild populations globally (Bennett 2011). Several bird species in Indonesia was assessed to be on the cusp of extinction as a diret result of trade (Eaton et al. 2015). The Internet has also changed how people can monitor and better understand market dynamics (Sung and Fong 2018). In addition to directly tracking what is being traded in physical and virtual markets, there are also other methods of monitor trade. For example, publicly available datasets such as the CITES trade database (Nijman and Shepherd 2011; Vall-llosera and Su 2017; Robinson and Sinovas 2018) or seizure data collected through media and reports (Rosen and Smith 2010; Underwood et al. 2013; Wasser et al. 2015; Petrossian et al. 2016; Cheng et al. 2017). By analysing the trade in a range of taxa, I have illustrated how the role of the Internet has changed wildlife trade either through means as a platform for sales or as tools which can be used to monitor and track wildlife trade.

Moreover, my findings demonstrate that though Thailand has a role in the legal and illegal wildlife trade as a source, transit and consumer, it is not alone in its difficulties in regulating the trade. Within Southeast Asia, Thailand has high levels of biodiversity and challenges in enforcing regulations in wildlife trade and governance issues (Wilcove et al. 2013; Wyatt et al. 2018). I later discuss the inadequacies in the regulation of domestic and international trade impacting a range of species from harvested for exotic pet trade to plants and timber products.

7.2 Internet as a direct tool for trade

The Internet has accelerated the speed and accessibility of wildlife trade and decentralised the traditional trading model for the trade in wildlife. As evident from findings in chapter 3 and 4, there is no longer a requirement for sellers and customers to meet face-to-face. The Internet has removed many barriers that once may have impeded or limited certain trafficking. Any individual can become a poacher or hunter and advertise the wildlife for sale on a relatively accessible platform that reaches out to a wider consumer base which does not need to a central market place to ‘shop’. These individuals are no longer bound to traditional shop-fronts or physical markets. As a result, there is a range of environments where one may see the animal; often the animals are seen in small makeshift

trapping cages, but they can also be seen chained to resting perch in the case of some raptors, or pictures are taken from larger enclosures for some larger monkeys. Humanising animals, for example, close to children to show that they are friendly, or wearing of diapers and children clothes is also a key advertising factor. Furthermore, financial transactions can be done either directly or through a third party. Logistically, the exchange of goods can be conducted via private domestic shipping or transport companies, despite regulations in most companies that prohibit it. In 2018, the Thailand Post regulation that prohibits the sending of live items, however, later that year heavily promoted a campaign to send 'fish and live aquatic animals' (Anonymous 2018j). As a result, the unclear policy from the national postal service may send mixed messages to the Thai population about allowances in regards to sending live animals.

Still, elements of online trade of animals and plants remain a mirror to conventional trade. As such, the issue of illegal items being laundered through legal trade platforms are still evident even among online market platforms, as is found in physical markets (Gao and Clark 2014). Operating platforms on social media have presented new challenges in the regulation and monitoring of legal and illegal wildlife trade (Lavorgna 2014). Although our study considers just a fraction of the visible trade online, the Internet can be used to gain potential insight into patterns of wildlife trade and provide crucial evidence-based for informed interventions in several ways (Martin et al. 2018; Sung and Fong 2018). As one of the main social media platforms, Facebook is an operator of trade and is one of the examples. The key difference is that law enforcement actions differ between the physical and online markets. In many places, current legislation may still be conservative and not include legal penalties of online trade. The scenario should also be considered that when law enforcements choose to crack down on online trade, there is the plausible potential that traders will be driven underground into a 'dark web'. This will impose a new array of challenges for law enforcement agencies (Harrison et al. 2016).

7.3 Online trade drivers

As highlighted in Chapters 3 and 4, there is evidence that an increasing number of places, wildlife trade are shifting from physical markets to online markets, both in Thailand and beyond (Izzo 2010; Yeo et al. 2017; Vaglica et al. 2017; Phassaraudomsak and Krishnasamy 2018). There are many drivers behind the domestic market. Based on the groups available on Facebook, the main findings for domestic consumption is driven primarily for the exotic pet trade. The groups that are targeted are both domestic species and non-native species.

Results show consistent preferences for non-native species across a range of taxa from birds, mammals and reptiles, and this has been linked to the high drive of prices for non-native species. In physical markets, these patterns were also consistent; in Chatuchak market where 44% of bird species

offered for sale were non-native (Chng and Eaton 2016), and 97% of the turtles and tortoises belonged to non-native species (Nijman and Shepherd 2015). The non-native statuses of species are linked to rarity of species and the Anthropogenic Allee Effect. This was consistent with other exotic pet trade in other places around the world (Lyons and Natusch, 2013; Sung and Fong 2018), but also among other avenues of wildlife consumption such as trophy hunting (Palazy et al. 2011) and luxury food items (Sadovy et al. 2018).

However, whilst non-native species drove up prices, native species were more frequently, accounting overwhelmingly more by volume. There was a mixture of legal and illegal activity; however, more occurrences of illegal sales rather than legal. The lower prices offered for Thai native species means they are more accessible and turnover rates were higher. There was also a lack of information provided on the other details related to the wildlife individuals traded, for example, on the origin or how it was sourced, import paperwork, or how to care for the animals sold. This reflects that there is insufficient protection for native species and a lack of regulation for non-native species.

The conclusions from the Anthropogenic Allee Effect draws attention to an area of future work. It is clear that more detailed studies on aspects of market prices, harvesting costs, the population of species in the wild, all overtime, will be required to fully understand the extent of the AAE. As now, it can definitely be said that elements of 'rarity' whether from a protected animal, a non-local animal, or an endangered species of tree, do indeed have some influence on-demand, as well as price where information may be available. With the level of wealth increasing throughout the world, the risk of extinction for rare species, or those that are perceived as rare or as a luxury item, will in turn increase (Tournant et al. 2012).

7.4 Domestic legislative framework to address online wildlife trade

Due to Thailand's conservative wildlife legislation, concerns have been raised regarding the loopholes in legislative gaps and the rigid list of protected species (Moore et al. 2016; Nijman and Shepherd, 2007; Chng and Eaton, 2016). As highlighted in the previous chapters, the push for a revision of laws was to respond to the fast-moving nature of the online platforms, including regulation of domestic trade of non-native species, and overall for laws to be harmonious to agendas proposed by CITES (Moore et al. 2016).

In specific response, the Department of National Parks Wildlife and Plant Conservation in Thailand has established a dedicated task force called 'Wild Hawk Unit'. This task force focuses on tackling online wildlife crime through investigations and sting operations (Phassaraudomsak and Krishnasamy 2018). However, considering the high volume of cases and geographically widespread nature of Internet crimes, this poses challenges to government agencies which may already be limited in terms

of resources and personnel. These limitations in enforcement are not found just in Thailand but throughout many countries dealing with the emergence of online wildlife crime (De Magalhães and São-Pedro 2012).

In April 2019, a cooperative effort of NGOs, Facebook and relevant government agencies pushed a Coalition to End Wildlife Trafficking Online with Facebook to introduce a policy to ban live animal trade from non-verified physical businesses across the platform suggests a positive step towards collaborative interagency effort to address the issue. More significantly, in 2019, Thailand's environmental laws underwent a major reform, resulting with new Wildlife Preservation and Protection Act B.E. 2562 (2019), National Park Act B.E. 2562 (2019), Community Forest Act B.E. 2562 (2019) and the Forestry Act B.E. 2562 (2019). In particular, WARPA, as discussed heavily in the previous chapters of the thesis, was replaced and the new legislation came into effect on November 25, 2019.

The main changes are highlighted as follows:

- From the three categories: reserved species, protected species and species permitted for breeding, wildlife species will be distinguished into five categories that now include: preserved wildlife, protected wildlife, controlled wildlife, dangerous wildlife, and wildlife carcasses.
- The definition of the term 'trade' of wildlife now includes online advertisements in order to address online sales.
- The following actions also now have substantially stricter penalties, including increased prison terms, fines, or both
    - Import, export, transport, possession of reserved, protected, controlled and dangerous wildlife, including products and carcasses;
    - Regulation of breedable species to be determined by the ministry (by ministerial notification)
- Included the regulation of CITES listed species through the new category: 'controlled wildlife'. Species on the list is determined by a Minister's order. It will regulate the possession, breeding and trade of select species.
- For the first time since 1992, new species to the list of preserved wildlife, including, Bryde's whale (*Balaenoptera brydei*), Omura's whale (*B. omurai*), leatherback turtle (*Dermochelys coriacea*), and whale shark (*Rhincodon typus*)
- More government agencies and ministries are being incorporated into the revision of the law and the committee regulating the law. This reflects the recognition that it is an interagency problem.

This changes mean that upon a ministry declaration, the import, export, and possession of CITES species will now be protected (Anonymous 2019h; Anonymous 2019i). In general, the aim for the revision is supposed to coincide more under CITES. However, it is important to note that the exact details and mechanism of how all of the aforementioned reformed laws will be implemented are yet to be fully laid out. All the relevant laws, including wildlife and forests, were pushed through rapidly by the National Council for Peace and Order (NCPO). At the present time in 2020 after the elections were held, the process for pushing the subsidiary laws are still in process but as they are under 'regular' conditions, will take a much longer time to pass through.

Lastly, on the note of bigger picture of domestic legal framework, is the issue of National Strategy plans. In a legal review, Pucharoen (2019) assessed the current restraints and demonstrated that Thailand's messages at the national level do not encapsulate relevant issues related to pet keeping and online wildlife trade. As mentioned in the Introduction, the Thai government has implemented a new National Strategy from the year 2018 to 2037 comprising of a strategy for 'environmental-friendly development', as well as a National Economic and Social Development Plan from the year 2016 to 2021, that includes the 'Thailand 4.0', a policy to enhance digital economy of Thailand. The country's National Strategy from 2018 to 2037 has a strategy for environmental-friendly development that acknowledges animal welfare, but does not have an agenda to address zoonotic diseases, or endangered species all issues that address national biodiversity. Whereas, the National Economic and Social Development Plan in theory encourages and enhances online wildlife traders for a 'digital economy', but does not address animal welfare and impacts of online wildlife trade. As a result, they effectively mislead policies at lower government level.

At the lower level, Pucharoen (2019) evaluated that the national legislation in regards to importing animals, breeding animals, possession or pet keeping and transport is fundamentally flawed in the definition of of 'wildlife'. For example, some traded wildlife do not fall under the protected, reserved species, or controlled species, but also not under the list of breedable animals. For example: sugar gliders, hamsters, and hermit crabs, which are completely unregulated and can be freely imported, bred, and sold. As a result, these unlisted species will also not subject to any zoonotic disease screening. Furthermore, Animal welfare policy are vaguely specified, and there is not a clear discrimination of welfare requirements by species, type, condition and age of wildlife, therefore, management specifications like breeding are unregulated. Finally, the list of controlled species is yet to be determined by the ministerial order. As long as the subsidiary law is not approved and enforced, it leaves a time gap where wildlife species, including non-native CITES listed species can be bred, traded and transported freely (Pucharoen 2019). While the legal reform is one to be applauded, there is also grave concern to the 'limbo' state that the legislation framework is currently stuck in.

7.5 CITES enforcement, and regulation of trade

When wildlife and money are moved across borders, illegal wildlife trafficking moves beyond domestic issues involving national legislative laws (Wyatt et al. 2018). The transnational nature of the illegal wildlife trade utilises loopholes which enable illegal harvested wildlife and products, to become legally traded items if no proper system is enforced to regulate international trade (UNODC 2016). Similarly to how the northeast region is a key area of activity for timber to be smuggled across the borders by land or on water, the south of Thailand is a key activity area for a significant amount of wildlife posts. There is a strong likelihood, based on the descriptions offered from the seller, that wildlife is taken from Thailand and Malaysia. Hunting and sourcing of wildlife from across the border are likely considering the minimal enforcement and porous borders in the region as found by Phelps et al. (2010) for the orchid trade. Furthermore, recent evidence of overwhelming trade of seahorses from Thailand to Hong Kong, despite export bans being implemented since 2016 reflects that there is a pervasive lack of enforcement of trade quotas by Thailand (Foster et al. 2019).

The cross border movement of wildlife, as well as CITES-listed timber species, highlights the inadequacies in the enforcement trade regulations by the CITES authorities. The lack of accountability impedes the ability of law enforcement to control or reduce the illegal wildlife trade (Rosen and Smith 2010). The impacts of exploitation of natural resources in developing countries are further exacerbated by political instability, poor governance and ill-conceived environmental policies (Innes 2010; Douglas and Alie 2014).

In this study, issues related to the use and interpretation of the CITES trade database were also encountered. Limitations in the CITES trade database have been highlighted by previous researchers in their methods (Challender et al. 2015; Foster et al. 2016; Luiselli et al. 2016). to date, though there is growing information to be entered into the data base, there is still no standardised way to interpret counts of volume. As such, there remain discrepancies in reporting of trade and the overall understanding of the degree and scale of trade. This is a potential concern as it could misinform wildlife trade trends, conservation agendas and priorities (Pavitt et al. 2018). It will be necessary for the CITES Secretariat authority to remove common sources of discrepancies and TO stress the need for accurate reporting by Parties. For researchers who utilise and analyse the database, researchers need to acknowledge and consider the limitations and explicitly indicate their methods and approaches (Vall-llosera and Cassey 2017).

7.6 Social media and the perception of wildlife

In addition to providing a platform for trade, social media also reshapes the perception of wildlife and wildlife trade through exposure and amplification of popularity via videos and clips (Kitade and Naruse 2018; McMillan et al. 2020). The exposure of elements of wildlife trade fuelled by direct

human-wildlife interaction in exotic pet cafes may be normalised and shared harmlessly stimulating exotic pet ownership. The link between social media and exploitation of threatened species for the pet trade has also been discussed for the trade of raptors and owls (Kitson and Nekaris 2017; Panter et al. 2019), and otters (Harrington et al. 2019).

Only a few studies have systematically analysed the impact of social media platforms on wildlife demand and perception (Nekaris et al. 2013, Clarke et al. 2019). Findings from platforms such as YouTube and Twitter found that interest and preference to have exotic pets respond correspondingly following viral videos of animals. In 2009, a YouTube video of a pet pygmy slow loris (*Nycticebus pygmaeus*) being tickled went viral, and researchers found that the video content incentivised people to want slow lorises as pets. The post was shared, without any accompanying note to show that slow lorises were an Appendix I listed species and classified as Vulnerable on the IUCN Red List (Nekaris et al. 2013). Another case study was in 2016 when a clip of a habituated ring-tailed lemur (*Lemur catta*) was circulated, reaching over 20 million viewers within a few weeks. In response, the post resulted with a marked increase of search trends for 'lemurs' directly related to 'wanting a pet lemur' (Clarke et al. 2019; Reuter et al. 2018). These are examples of how the perception of wildlife, concerning with desire to have wildlife as pets and thus links to the accessibility of wildlife trade, have been influenced by the social media in recent times. Furthermore, monitoring of exotic pet cafes as a key mechanism that may influence exotic pet trade and exotic pet ownership will also be vital. In particular, assessing changes in perception via interviews and questionnaire approaches can also be used to better understand attitudes and drivers of exotic pet ownership (McMillan et al. 2020).

Extending beyond the perception of wildlife into actual implementation and integration into society, wildlife, as portrayed in digital media, influences social media and culture. An example of this is the 'Harry Potter effect' or the increased popularity or exposure of owls as pets, creating a phenomenon in 'themed' cafes. Despite strict legal constraints in Japan, this has led to an increase in imports of captive-bred owls for domestic use (Vall-Llosera and Su 2018). The association of the film and owls have become normalised. Even after years of the release, the impacts of film and associated wildlife trade is still worthy of exploring (Militz and Foale 2018). Continual monitoring of trade, both in physical and online markets is essential to ensure regulation of trade, and inform wildlife regulations and policies.

The links between the influence of social media and wildlife trade is also an idea worthy of exploration in the future. In the qualitative observations in chapter 4, Facebook users discussed the legality of buying wildlife, while some even acknowledged the illegality and proceeded to ignore it. In comparison to other illegal online markets which may require further steps in masking one's identity (Wehinger 2011), the current platforms are open and accessible such that one may even not

realise the illegality of buying certain wildlife. The intangible nature of the online market space facilitates seemingly unmonitored economic exchange. As the trade has moved online, this has reduced the action of buying a 'living item' on the same level as regular online shopping. Therefore, the relationship between social media and wildlife trade is recommended as a future study.

Furthermore, in addition to the operators' responsibility to track and shut down groups, there have also been suggestions to operators to utilise more creative tools to inform users. For example, in 2017, the photo-sharing platform integrated a new alert system to combat animal abuse by delivering messages to users who search for a range of wildlife hashtags (Anonymous 2017e). Though it is indeed a widespread tool to spread an awareness message, there has not much follow-up information measuring the effectiveness of the tool, or how and when the content or targeted wildlife may evolve over time.

Nevertheless, the relationship between social media and wildlife is not always negative. Social media platforms, such as Facebook, Twitter and Instagram, provide a virtual space where users can share media and text privately and publicly (Toivonen et al. 2019). Social media can be used in a positive manner, for example, to educate consumers on threats, conservation statuses and legality of the trade. By raising awareness on welfare issues, associated disease risks, implications and consequences to biodiversity and invasive species, and legal penalties should be communicated to potential consumers (Moorhouse et al. 2017). Given the situation of SARS COVID-19 pandemic, zoonotic diseases and susceptibility of domesticated pets will be an important point for discussion (Shi et al. 2020).

Beyond social media, digital media can be generally used positively for conservation purposes, where films can offer an opportunity to address wildlife perception and encourage audience engagement for conservation issues (Yong et al. 2011; Silk et al. 2017; Fukano et al. 2020). It could be argued that wildlife experiences, whether it is in zoos, aquaria or even cafes can positively foster biodiversity education and conservation (D'Cruze et al., 2019; Fernandez et al. 2009; McMillan et al. 2020), though results regarding the direction of impact are inconclusive and require further evaluation. Whether on social media or in the form of digital media, it will be important to stress the responsibility of people to conscientiously consume digital content. At the very least, to make the distinction or awareness of conservation issues involving wild animal content (Nekaris and Campbell 2012).

7.7 Social media as a tool for monitoring

There is also an increasingly larger body of researchers who recognise the potential of social media data and are developing tools to track wildlife trade on social media (Toivonen et al. 2019). As briefly mentioned in passing in chapter 2, machine learning techniques are becoming more integrated with

wildlife trade studies. In addition to the framework first introduced by Di Minin et al. (2018), Xu et al. (2019) carried out a machine learning study on social media platform Twitter. The researchers detected and classified suspicious wildlife trafficking using elephant ivory and pangolin as a case study. Results showed that in a mere 2-week period returned over 138,357 tweets from 38 individual users promoting the sales of these prohibited items (Xu et al. 2019). The results demonstrate the potential for integrating technology into tracking wildlife, though will depend on what kinds of social media platforms are used in each particular country and more importantly, require addressing Internet security and privacy laws in each respective country.

7.8 Evaluation of methods and next steps

The clandestine nature of the illegal wildlife trade means that the true extent of the trade is often unknown. However, each of the methods utilised should also be considered with a degree of caution, given its separate sets of limitations. Overall, the findings provide a step towards better understanding the trade that would otherwise be lacking. Though the trade of illegal species in physical markets was found to be decreasing, the next step in the research is to continue monitoring, on all avenues and platforms. Despite seeing a decrease in trade, the physical markets still continue as a vital location for trade. Physical markets are important areas for online traders to meet and exchange product under the veil of legality. More data, on price, availability, composition, turnover rates can increase avenues for further research. Furthermore, seizure data for other species can also be used to inform on more information.

7.9 Specific recommendations

There are specific recommendations that can be made for policy and legislation (Table 29). At the regional and provincial level, government officers need to be vigilant in areas that can be deemed to be key trading areas. For example, in the city of Bangkok, there are hot spots that we can determine of trade and exchange areas based on the texts. In other provinces, the key trading area may be locations next to border locations, national parks or protected areas.

At the national level, the government must be clearer about the new legislative change and explicitly enforce CITES implementation and protection of CITES species. Based on the feedback and discussion between traders on the Facebook groups, it is evident that there is a lack of communication to the consumers and pet traders regarding the laws around exotic pets. There is a combination of potential consumers who are unaware of the legality of trade, but also consumers that are blatantly aware of the illegality. Governments need to use the Internet to target these interested individuals to communicate this information, make users and consumers aware of these illicit activities (Vaglica et al. 2017).

With the legal reformation in November 2019, it will be important for the government to inform the public about the clear steps of the law and exactly what it entails. It would also be worthy for the Thai judicial system to have a platform which publishes news on successful prosecution in order to inform the public as well as potentially deter individuals from getting involved in the future.

The government will need to continually monitor trading grounds, physical and virtual. The increased popularity of using social media platforms to trade wildlife presents new challenges to regulation and enforcement (Di Minin et al. 2018). The Thai government will need to work closely with operators of social media such as Facebook. As the operator, Facebook should be responsible for discriminating legal and illegal wildlife trade on their sites (Izzo 2010). Facebook has stated that the platform does not allow the sale or trade of endangered species or parts. Illegal wildlife trade should be addressed with urgency as to how content on violent criminal behaviour or intellectual property content is regulated- perhaps appointing more resources to monitor wildlife trade in the same intensity and degree as their drug or nudity community standard policies may also be useful dealing with illegal activity on the platform.

Facebook is not the only social media platform used for trade or sharing content of exotic pets (Di Minin et al. 2018; Nekaris et al. 2013). However, the approach should also be strategic in its combating as groups that are removed from Facebook will ultimately remerge and appear. Traders are aware of the algorithms used and will use techniques to bypass the detection of Facebook. For example, many groups now have rules that state clearly not to list words like ‘buy’ or ‘sell’, not to write out prices in numerical form. Rather, the sellers will use code names related to the colour and number of each bill (for example, ‘red’ refers to 100 baht bill, ‘purple’ refers to 500 baht bill and ‘grey’ refers to 1000 baht bill, so ‘one purple three red’ means 800 baht).

As there is both legal and illegal trade present on these platforms, it will require manpower to go through to distinguish. Even machine learning tools and data scraping techniques may not automatically pick up on changing slang and codes. This is where university and independent researchers and non-governmental organisations may come in to assist the tracking and monitoring of trade where necessary. Though it is a popular platform in Thailand, Facebook is not the only social media platform that should be held accountable for its role in the trading of wild plants and animals. Other platforms, such as Instagram and Twitter, should also follow similar guidelines in cooperating with governments to combat wildlife crime.

At the international level, Thailand will need to work closely with neighbouring countries to combat wildlife crime. For example, Cambodia and Laos are key partners when dealing with seizures of long-tail boats along the Mekong River. Thailand should also work with Malaysia, to deal with exchanges

of wildlife along the southern border. This will require consistent coordination with authorities to achieve more than just an attempted seizure and arrest. Strengthen regional cooperation initiatives such as Wildlife Enforcement Networks (or WENs) within the region can increase the capacity of law enforcement officers in response to wildlife and environmental crime. For example, the WWF Foundation hosted a training to combat illegal wildlife trade for authorities in the Golden Triangle region that included enforcement agencies from Laos, Myanmar and Thailand. Each key province in the region, therefore now possesses relevant officers that are aware and have developed a skillset in particular to address wildlife crime issues. Consistent sharing of information of best practices of enforcement could also be an important first step fostering working relationships as well as developing a level of trust across national and border agencies. Based on case studies on ivory trade, there is strong evidence for the need to improve law enforcement capabilities transnationally along all stages of the supply chain (Wyatt et al. 2018).

Table 29. Summary of recommended actions to be taken at local, domestic and international levels to combat the online trade in wild plants and animals in Thailand.

Level	Actions needed
Local	• Build capacity for law enforcement officers to prevent poaching and logging of wildlife resources from its natural sources (i.e. national park rangers, forest police etc.) • Build capacity for law enforcement officers to prevent the transport of wildlife resources across the border (i.e. law enforcement officers in high-activity areas) • Enhance interagency cooperation within local agencies to develop a shared responsibility and better understanding of roles to combat illegal wildlife trade and to regulate legal wildlife trade
Domestic	• Build capacity for law enforcement officers to 'catch up' with the traders online without waiting only for conducting sting operations • Putting an emphasis on the judicial system to priorities wildlife crimes as a serious office. After judgement, to publicise enforcement and successful prosecution of online cases in order to deter future crimes. • Work with Facebook, as the main platform for trade, to crack down on the new groups which reappear. • Work with transport companies, including national bus service and private companies to enhance surveillance on transporting 'live' animal packages.

(**Table 29** continued on the next page, 1/2)

(**Table 29** continued from the previous page, 2/2)

Level	Actions needed
Domestic (continued)	• Clearer communication of changes in the new law reforms, and to present accessible and comprehensible content for the general public and raise awareness of exotic pets. • Address the issue in regards to the demand for exotic pets as well as wildlife perception within Thai society (misrepresented messages of normalisation for Tiger farms and exotic pet keeping).
International	• Cooperation of law enforcement officers and agencies between neighbouring countries. • Strengthening the legal framework between all countries in the region to be congruous. • Shared data and communication between countries to develop cooperation, trust and shared sense of responsibility between countries.

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Illegal pet trade on social media as an emerging impediment to the conservation of Asian otters species

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ABSTRACT

Social media has become an increasingly popular platform to trade legal and illegal wildlife. Here, we evaluate the online trade of otters, a group of globally threatened taxa in Thailand, a country of high global social media use. During the 14-month period, we monitored five Facebook groups to establish a primary understanding of the scope and scale of the trade. We recorded 160 sales posts (337 individual otters) of two species, the Asian small-clawed otter (*Aonyx cinereus*) (81%) and the smooth-coated otter (*Lutrogale perspicillata*) (19%). Newborn otter pups accounted for 53% of the offers, whereas young otters accounted for 35%. Prices averaged US$78, where the smooth-coated otter was offered at a significantly higher price than the Asian small-clawed otter. Juvenile otters were also significantly more expensive than newborns. Trade appears to be domestic; however, the potential for international trade cannot be overlooked. Although otters are protected domestically, we find that the trade is easily accessible and prevalent. The results reflect current inadequacies in enforcement and legislation in keeping pace with the rapidly shifting nature of the Internet in Thailand and throughout the global Internet community. A consistent collaborative effort from consumers, enforcement agencies, and operators is required to address this illicit trade.

Introduction

The global legal and illegal trade in wildlife is an increasingly growing threat to global biodiversity and species conservation (Challender et al 2015). One key driver of the global wildlife trade is the demand for pets (Baker et al 2013; Tingley et al 2017). Wildlife consumption for the pet trade has multiple inevitable consequences, from species population loss (Bush et al 2014), nonnative species introductions (Fong and Chen 2010), zoonotic risks and implications (Palvin et al 2009), as well as welfare issues (Baker et al 2013).

Developments in factors that influence modern-day market structures, such as increased accessibility to wildlife, exposure of trade, and enhanced infrastructure of transport have reshaped the modern pet industry (Lavorgna 2014). As a result, increased numbers of species are at risk of overharvesting or extinction (Bush et al 2014). Accessibility to and the exposure of the exotic pet trade have amplified due to the growth of the Internet, which has massively expanded both the legal and illegal wildlife markets through the creation of novel hybrid marketplaces (Lavorgna 2015). This dual platform combines traditional social and economic opportunities within the new virtual Internet marketplace (Lavorgna 2014), offering alternative distribution channels with endless destinations not limited to just traditional pet stores (Baker et al 2013).

In the past decade, the Internet has become a key platform for the trade of legal and illegal wildlife where products from high-profile species such as elephants, rhinoceroses, and tigers, as well as live reptiles, amphibians, and birds, were reported on platforms such as eBay and Amazon (Derraik and Phillips 2010; IFAW 2008; Todd 2011; Wu 2007). In addition to these traditional platforms, social media has also played a novel influential role on the modern pet trade (Morgan and Chng 2017). Directly, social media has been used as a tool for advertising, sourcing, and the online trade of animals and plants alike (Hinsley et al 2016; IFAW 2018; Vaglica et al 2017; Yu and Jia 2015). It has also been an indirect stage for the spread of viral exotic pet videos on social media (Nekaris et al 2013), as well as an area for comments that often entice more

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people to acquire illicit exotic pets themselves (Morgan and Chng 2017).

The growth of the Internet and the role of social media platforms in the trade of exotic pets have posed challenges in regulation of trade (IFAW 2008). Law enforcement officers constantly require new tools and methods to monitor and regulate these virtual markets (Vaglica et al 2017). However, the fast-moving nature of these e-commerce platforms often mean that international and domestic laws implemented in many countries are outdated (Wu 2007). Previous investigations into the scope and scale of the role of social media have shown growing volumes of wildlife trade after increased Internet accessibility; however, they have predominantly been limited to short-term immersive monitoring sessions of a few weeks with a focus on key high-profile species (IFAW 2018).

To review the characteristic of the exotic pet trade on social media platforms, we use otters as a case study. In recent years, otters have been traded online in Southeast Asia (Aadrean 2013; Gomez and Bouhuys 2018; Gomez et al 2016; Krishnasamy and Stoner 2016). Otter species are threatened worldwide from habitat loss, as well as legal and illegal trade including the fur trade, the exotic pet trade, for traditional medicine, and trophies purposes (Duckworth 2013; Melisch 1998; Shepherd and Nijman 2014). Five otter species are found in Asia, including the Eurasian otter (*Lutra lutra)*, the hairy-nosed otter (*L. sumatrana)*, the Asian small-clawed otter (*Aonyx cinereus)*, the smooth-coated otter (*Lutrogale perspicillata*), and the sea otter (*Enhydra lutris)*. All these five species are considered globally threatened according to the International Union for Conservation of Nature (IUCN) Red List criteria, and their international trade is regulated under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (IUCN Otter Specialist Group 2016). In the past 35 years, seizure records reveal that otters are traded in around 15 Asian countries, the majority being in China, India, and Nepal (Gomez et al 2016). However, in recent years, there have been a growing number of seizures of "live otters" in Southeast Asia which suggested an emerging trend of otters being caught for the commercial pet trade in this region (Gomez and Bouhuys 2017).

Here, we review the otter trade on Facebook in Thailand, a key hub for the illegal wildlife trade (Nijman 2011). Thailand has a very strong global social media presence, ranking among the top 10 nations in the world for social media use, increasing an average of 20% year on year for users on Facebook, Instagram, and Twitter (Leesa-nguansuk and Fredrickson 2017). With the exception of the sea otter, four of the Asian otter species are recorded in Thailand (Mason et al 1990). The range of the Asian small-clawed otter and the smooth-coated otter is distributed across Thailand, whereas the other two species are rare and are limited to isolated populations in the north of Thailand (Conroy et al 1998; Kanchanasaka 2001). In Thailand, possession of otters is prohibited; all native otters are domestically protected under the National Wildlife Protection Act of 2535 B.E. (Gomez et al 2016). However, despite the legislation in place, domestic and international trade exists. For instance, in 2017, there were two separate airport seizures resulting from attempts to smuggle more than 20 live otters out to Japan (Gomez and Bouhuys 2017). We conduct a 14-month analysis of the otter trade on social media platforms in Thailand. We aim to establish a primary understanding of the extent of the trade through factors which focus on the species sold, the vendors, and geographic location of the trade as well as highlight challenges in management policies and regulations of the trade.

Material and methods

Five Facebook groups were monitored from 1 March 2017 until 30 April 2018. All groups monitored were listed as "Buy and Sell Groups" and thus acted as public virtual marketplaces. The search for exotic pet groups was made in Thai and English using search tags for "exotic pets". There were many groups with Thai names; anyone with access to Facebook is able to find these groups, and the request for access to join the group is instantly approved within a day. Each group clearly describes itself as a market platform, with public sales posts, and displayed interaction between seller and buyers, all of which was carried out in Thai. We approached each monitoring session as a typical economic market approach without direct interaction and followed common market survey protocols as interactions between sellers and buyers can be freely observed by anyone in the group (cf. Barber-Meyer 2010; Nekaris et al 2010). To ensure anonymity of group members and to minimize any resulting increase in trade due to our research, we followed the guidelines from the Ethics Working Committee of the Association of Internet Researchers (cf. Markham and Buchanan 2012).

Each monitoring session consisted of browsing through all items listed for sale, and posts related to otters were recorded. Where available, details were collected on the date, number of otters sold, species, price, age category, location of post, delivery methods offered, and when or if the sale ended. Usernames and URLs were anonymously coded, and pictures were saved for future reference. Compared to other retail platforms, Facebook can be challenging to monitor as there is no comprehensive approach to conduct an automatic search within groups (Hinsley et al 2016). Therefore, we used the group photo limit approach to define our monitoring sessions, which uses Facebook's 5000 photos cap as a marker to end each monitoring period (cf. Iqbal 2016). Each group was monitored every 4–6 weeks.

Cases of otters being readvertised or resold may inevitably lead to some amount of double counting, but to avoid duplication, all posts were compiled in this study and cross-checked for date of post, the vendor's username, and approximate age of otters listed for sale, and cases of the same username reposting similar-aged otters within 3 days were removed. Repeat posts across different groups were also monitored for duplication. In any case in which there is a lack of information or a clear duplication of items being sold (such as the same photos used), the entry was removed from further analysis.

Otters were listed for sale only by their common name. The Asian short-clawed otter was also referred to as "small otter" and the smooth-coated otter as the "large otter". We identified the otters for sale on the basis of single or multiple photographs posted; 34 photographs of unidentified otters were identified with the help of members of the IUCN Specialist Otter Group. Otters listed for sale were often in their early life stages, therefore classified as newborns (eyes yet to open) and young (eyes opened, usually around 6 weeks). For very young newborn individuals, species identification was often not possible.

Using the data available, we analyzed the overall trade through content of the sale posts in terms of the number of independent posts and total number of otters posted for sale over time. Batch size averages were also analyzed, for which prices of individual otters were taken into account in cases in which there was more than one otter posted for sale in a single post (cf. Nijman and Bergin 2017). We incorporate spatial factors such as distance to an international border and regional analysis to further explain the distribution of the trade. As trade is evident in other countries in the region (Gomez and Bouhuys 2018), distance to an international border was included as a proxy for trade activity that may be intended to cross to other countries. Data were log transformed before analysis. Statistical analysis was conducted using simple linear (lm) model and t test functions in R (R Core Team 2018). A χ^2 test was carried out to for spatial analysis to compare observed regional outcomes. The prices reported in this study is US Dollars,

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converted from Thai baht with the exchange rate of 1 US Dollar = 33.2 Thai Baht (rates ranged from 31.5 to 34.9 Thai baht within the monitoring period).

Results

From March 2017 to April 2018, 160 sale posts from 59 individual sellers were recorded in the five market groups, with a total of up to 337 individual otters posted for sale (Table 1; Figure 1). Each group was monitored 8–10 times, with the exception of one group that was only monitored once as it shut down within the study period. All the trading was carried out in Thai, and in the 111 posts in which information was available, 81 posts originated from the south of Thailand, followed by 27 posts in the central region, including Bangkok the capital, and a single post each from the north, east, and west (Figure 2). There was a statistically significant skew in the number of posts concentrated in the southern region of Thailand (χ^2=217.51, df = 4, p<0.001). However, there was no statistically significant relationship between the number of sales posts and the distance to an international border (linear regression, $F_{1,16} = 1.61$, $p = 0.22$). In addition to otters, groups also sold other animals, ranging from domestic cats, dogs, and birds to exotic wildlife including small carnivores, primates, and reptiles.

Only two species were specifically listed for sale, the Asian short-clawed otter and the smooth-coated otter. The Asian small-clawed otter attributed to 57 posts (127 individuals), and smooth-coated otters contributed to 15 posts (29 individuals). There were 88 posts (183 individuals) that were unidentifiable as the photos posted were unclear or the otter were too young to identify them as the species level. Based on their geographical origins of the posts, the unidentified otters are most likely either the Asian small-clawed otter or the smooth-coated otters. The other two species (Eurasian otter and hairy-nosed otter) are rarer and have a distribution limited to the north of Thailand.

Newborn pups accounted for the majority with 77 posts (179 individuals) compared with young otters with 67 posts (117 individuals). Two posts offered adult otters for sale, stating that the otter pet required rehoming, and there were 16 posts (48 individuals) in which otters could not be classified by age. Newborn pups were frequently sold within a litter with up to six pups in one post; this was statistically significant when compared with young otters that tend to be sold individually [t test, t (142) = 2.78, $p = 0.0061$].

Price information was stated in 132 of 161 posts, in which the prices of otter ranged from $39 to $203, with an average price at $78 per otter when calculated by individual posts and when considering the batch size. The average price of the Asian small-clawed otter ($97; batch size average $94; S.D. $30) was found to be lower than that of smooth-coated otters ($112; batch size average $109; S.D. $23), but this difference was statistically significant [t (130) = 2.40, $p = 0.018$]. Juvenile or older otters were listed at a higher price ($99; batch average $98; S.D. $27) than newborn pups ($89; batch size average $88; S.D. $26); there was also a significant statistical difference [t (303) = 3.70, $p = 0.0003$]. Overall, there was no significant change in the average price for the otters over time (linear regression, $F_{1,12} = 0.098$, $p = 0.76$). There is a negative nonsignificant relationship between the number of otters posted and the average batch price (Figure 3; linear regression, $F_{1,12} = 2.90$, $p = 0.11$).

Where stated (n = 32 posts), turnover rates observed were within 48 hours within the post date, where sellers would comment on the post as "end of sale". In five posts, young otters were described as "guaranteed to live;" this assurance was not seen for newborn pup posts. Other common descriptive terms in the sales posts include "cute/good size," "friendly," and "converted to cat food diet". In nine posts, the otter on sale was advertised as "resell" from previous buyers, citing reasons such as "insufficient time to raise the pet" or "the otter was too loud for a small condominium". In regard to transporting of live otters, 101 posts offered guaranteed delivery methods throughout the country; the most common delivery method stated is via bus transfers and often excludes any face-to-face exchange. Further transaction details with serious buyers were often taken privately via direct messaging.

Discussion and conclusions

General findings

Social media has become a popular platform used to openly sell exotic pets, as seen here for otters in Thailand, as previously reported in many countries in Southeast Asia (Aadrean 2013; Gomez and Bouhuys 2018; Gomez et al 2016). The fluctuation in numbers of otters posted for sale over time reflects that the acquisition of otters were opportunistic as found in previous reports (Aadrean 2013). Chances of survival for newborn otters in the trade appear to be low; this is reflected from the juvenile otters which that offered at a higher price as a result of increased survival chance. However, the much higher volume of newborn pups supplied in the trade indicates that otters are indiscriminately extracted from the wild, even as a newborn, despite the risk of death. While each trader individually sells a small number of otters each time, the overall volume of the trade itself is significant, raising concerns for the wild populations of smooth-coated otter and Asian small-clawed otter, both of which are already recognized by the IUCN Red List as Vulnerable (Gomez et al 2016).

From the four species found in Asia, the two species found traded are the *Lutrogale* and *Aonyx* otter species. The other two species, the Eurasian otter and the hairy-nosed otter, are rare, distributed limitedly, and are even locally extinct in some previous ranges (Conroy et al 1998; Kanchanasaka 2001). As a result, it is not expected that they are traded in large numbers as the two species in the study. Nevertheless, these species are all globally threatened populations and of international conservation concern (IUCN Otter Specialist Group 2016). Otter trade as observed here in the Thai market is mainly for exotic pets, rather than traditional medicial purposes as observed (Aadrean 2013; Gomez and Bouhuys 2018).

Despite the fact that all locally found otter species are protected under Thai legislation prohibiting hunting, possession, and trade, we find that the sales advertisements were very much targeted

Table 1. Wildlife trade groups monitored on Facebook from March 2017 to April 2018, with details of poster, species, and age composition of otters posted for sale.

Group number	No. members (date updated)	No. times monitored	No. posts (no vendors)	Total# of otters posted for sale	No. posts by species (small-clawed/ smooth-coated//unidentified)	No. posts by age (new-born/young/ undetermined)
1	9,810 (04/2018)	9	4 (3)	12	2/0/3	2/1/1
2	14,216 (04/2018)	8	21 (5)	47	13/2/7	11/8/2
3	28,617 (04/2018)	10	46 (21)	102	13/3/29	24/15/7
4	14,619 (04/2018)	9	88 (30)	181	28/10/49	40/42/6
5	64,800 (05/2017)	1	1 (1)	1	1/-/-	-/1/-

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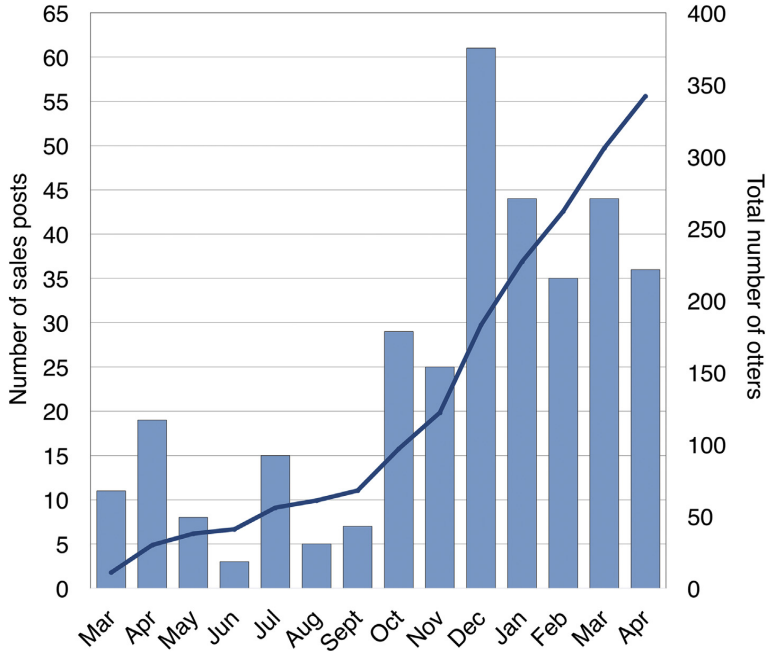

Figure 1. The number of sales posts advertising otters (bars) over time and the cumulative number of individual otters posted for sale (line) over the period from March 2017 to April 2018.

toward a domestic clientele. All correspondence was in Thai language, prices were offered in Thai baht, and shipping or transport was offered across Thailand. When asked about the legality of the trade, replies all acknowledge that pet otters are indeed illegal; however, "one or two are usually not a problem" (P. Siriwat, pers. observ.). The regularity of the sales posts and the very quick turnover rates reflect that the market is very active and that there is still a very high demand.

The geographic location of the posts clearly originated in the southern region, especially in the provinces that directly border Malaysia such as Yala and Pattani. Online otter trade in Malaysia has also been reported, especially in the northern region of Kelantan which borders Thailand; this suggests a potential link in trade which needs to be further explored (Gomez and Bouhuys 2018). This aspect of potential international trade should not be overlooked as it has implications to the implementation of CITES, with a possible likelihood that the otters could also be sourced from Malaysia and also transported across to satisfy the rampant pet trade across the border (Krishnasamy and Stoner 2016).

Enforcement and legislation

This research is a preliminary analysis as the five Facebook groups are only a representation of entire online trade in otters. Importantly, beyond otters, other wildlife species were also found to be traded on the Internet (IFAW 2008; Smith et al 2016; Todd 2011; Wu 2007). This research highlights the potential of monitoring social media sites to inform management and conservation. Most traders of illegal wildlife do not need to venture to the dark web as most of the trading is freely carried out and loosely monitored on the clear web (Roberts and Hernandez-Castro 2017). Investigations into the potential of social media as a commercial trade platform is increasingly acknowledged, albeit current studies have been limited to monitoring periods of a few weeks (Hinsley et al 2016; IFAW 2018). Therefore, it is pertinent to conduct long-term monitoring to gain information to better regulate and enforce trade on these platforms (Vaglica et al 2017), and this should be considered a conservation research priority (Yu and Jia 2015). Analytical methods to better understand trade networks (Patel et al 2015) and the development of novel technological tools (Hernandez-Castro and Roberts 2015) are also applications that can further detect and monitor trade.

To the credit of the Royal Thai Government, cyber taskforces have been established by the Royal Thai Police and Department of National Parks, Wildlife and Plant Conservation to combat this issue. Publicized sting operations mainly targeting individual sellers have led to increased private settings and shifted discussions to private or direct messaging rather than public comments. The shut down and constant displacement of groups is a common practice once the marketplace is exposed or gets too large (Krishnasamy and Stoner 2016). Therefore, it is essential for enforcement officers to quickly crackdown on sellers before groups become even more exclusive and secretive. It is also necessary for countries to strengthen legislation; within this region, countries vary in protective regulations, and not all countries have protection of otters (Gomez et al 2016). It may be more difficult to trace the offender on these virtual networks as many may hide behind relatively anonymous profiles (Lavorgna 2014) as well as use closed groups as cover (Yu and Jia 2015). Given their current ability to monitor this trade, movement to the dark net will undoubtedly create further challenges for law enforcement officers (Roberts and Hernandez Castro 2017).

Cooperation between law enforcement, operators, and consumers will be the key priority (de Magalhaes 2012). A growing

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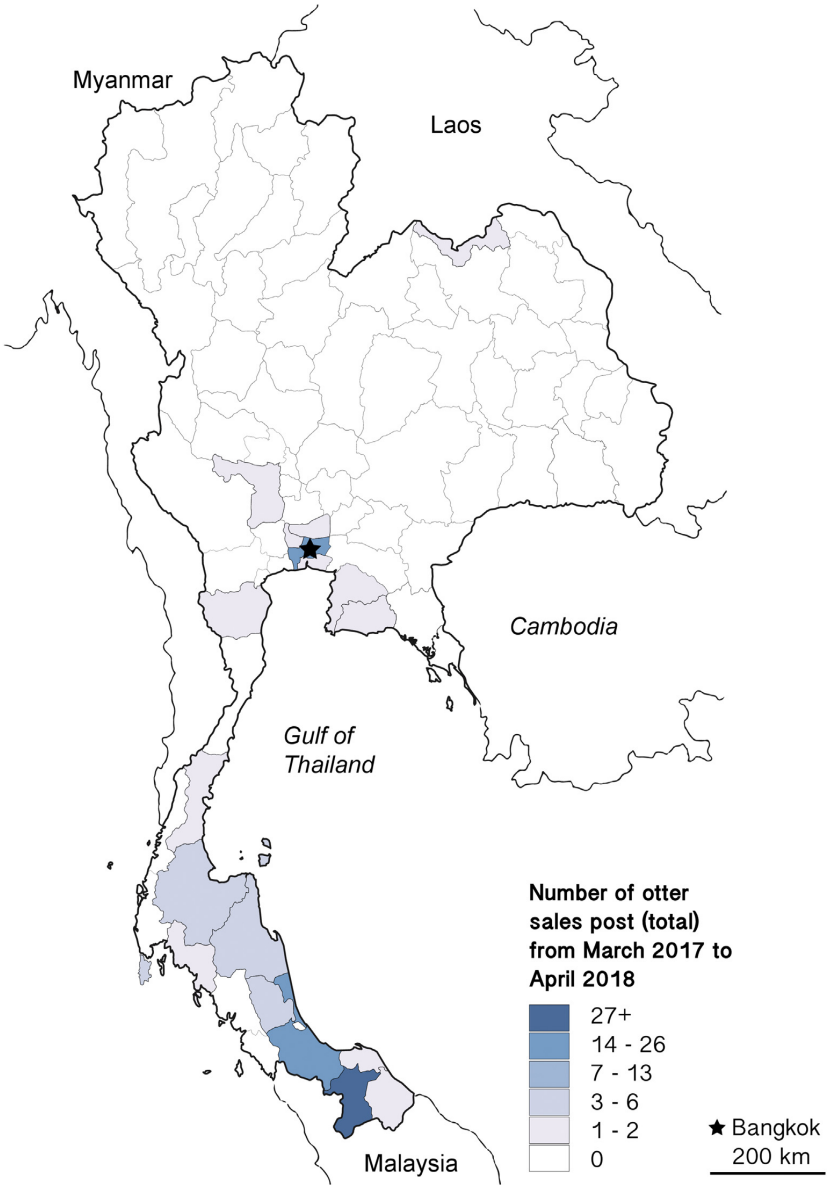

Figure 2. Spatial distribution of otter sales posts (n = 111) based on originating provinces recorded from 5 Facebook market groups from March 2017 to April 2018.

number of traditional online retailers such as eBay (Anonymous 2008) and Alibaba (IFAW 2009) are committed to preventing the sales of wildlife products on their platforms, albeit the enforcement of such policies is a work in progress (Anonymous 2015). Social media platforms such as Instagram and Facebook have started to follow suit; Facebook is has voiced its support to remove illegal trade and has generally been responsive and cooperative in receiving tips on illicit activity (Krishnasamy and Stoner 2016), and Instagram has recently launched their new Wildlife Alert System that warns behavior of users which harms wildlife (Anonymous 2017). Thailand's recent dealings with Facebook have received certain criticism due to contradictory legislative interpretation; this case study provides another opportunity for the Thai state to work alongside Facebook in regulating these markets through enforcement of the Wildlife Protection Legislation.

Internet consumer awareness

The Internet provides an additional platform for national and international wildlife trade through users which create and share content (Lavorgna 2014). On social media networks, likes and comments can potentially increase desirability and thereby entice more people to purchase exotic pets, despite its illegality (Morgan and Chng 2017). The "cute" factor is a key marketing point for the

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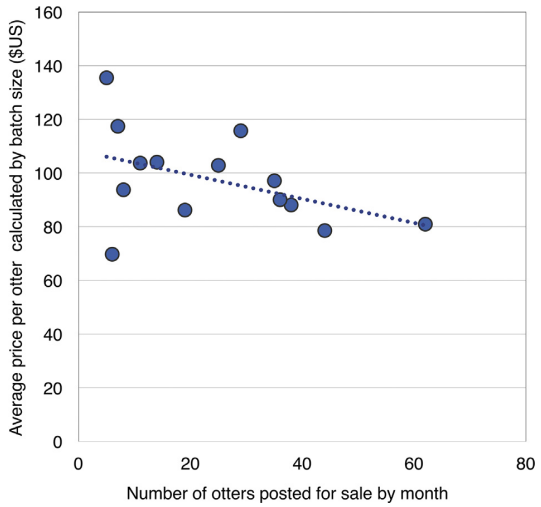

Figure 3. The price of otters posted for sale calculated by batch size average. Each data point is the number of otters posted for sale in each month.

otter pups for sale; this has also been evident for other cases such as slow loris videos on YouTube influencing uninformed consumers (Nekaris et al 2013). Providing more information on legal penalties, welfare issues, disease risk, and biodiversity implications may deter potential consumers from purchasing illegal wildlife as pets and engaging in illegal trade (Moorhouse et al 2016). Furthermore, raising consumer awareness for sharing viral Internet content on illegal pets or wildlife makes a difference in managing the online wildlife trade (Challender et al 2015).

The responsibility for law enforcement agencies to take on and monitor social media in its entirety is not realistic. Whilst the impact of social media platforms has increased accessibility and exposure to the illicit pet trade, in a way, it also provides an opportunity to shine light on this issue considering the wide range of audience (Waters and Harrad 2013). For example, it provides an opportunity for more eyes to monitor and report such illicit activity and inform local government authorities and conservationists (Waters and Harrad 2013). When combined with increased awareness and cooperation between enforcement agencies, operators, NGOs, and consumers, social media can in fact become a powerful tool for social change and a key platform to advocate for tackling the illegal wildlife trade.

Conflicts of interest

The authors declare that there is no conflicts of interest.

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Digital media and the modern-day pet trade: a test of the 'Harry Potter effect' and the owl trade in Thailand

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ABSTRACT: We explored the influence of film and media on the exotic pet trade using the context of the 'Harry Potter effect' and the owl trade in Thailand as a case study. We compared the owl trade between market surveys dating from 1966 to 2019 in Bangkok's Chatuchak market, to online surveys from 2017 to 2019. Using generalised linear models, we examined whether prices offered for owls could be explained by variables linked to whether the species are featured in the Harry Potter franchise, body size, tameness and temporal/seasonal harvesting. We also tested for an anthropogenic Allee effect by examining the relationship between the availability of owls and asking price. Owls never exceeded 1.3% of the total number of birds for sale in Chatuchak animal market, and we did not observe any owls during our visits in 2011, 2018 and 2019. In contrast, we recorded 311 individuals of 17 species from 206 posts on the online marketplace on Facebook. Owls are offered for sale during all months of each year surveyed but more so from February to April; availability did influence price. We found that price was significantly explained by body mass, but not by association with the Harry Potter franchise or by tameness. We found that owls have become more popular as pets, and as they are potentially sourced from the wild, this inevitably causes conservation concerns. Owls are just one of many taxa suffering from the unregulated and accessible marketplace that social media sites offer to vendors.

KEY WORDS: Owls · Strigiformes · Harry Potter · Wildlife trade · Facebook

1. INTRODUCTION

The influence of digital media, particularly films, on the wildlife trade is of increasing research interest (Yong et al. 2011, Militz & Foale 2017, Nijman & Nekaris 2017, Silk et al. 2018). Past studies have shown evidence that films featuring animals have influenced the popularity of such animals to be traded as pets. The effects observed are often complex and are not always direct. For example, certified registrations for Dalmatian breeds were found to increase by 6.2-fold 7 yr following the release of the film '101 Dalmatians' (Herzog et al. 2004), whereas after the release of the first 'Jurassic Park' film and the 'Teenage Mutant Ninja Turtle' television series, there was a delayed spike in the global trade of reptiles from 1 to 3 yr later (Ramsay et al. 2007, Nijman & Shepherd 2011). In the case of 'Finding Nemo', a film whose main character, Nemo, is a clownfish, it was initially reported that import volumes of clownfish species increased after the film's release in 2003 (Prosek 2010, Rhyne et al. 2012). Further studies, however, have suggested that the 'Nemo effect' was not significant after considering the overall increase in import and trade of marine aquarium fish (Militz & Foale 2017). The 'Harry Potter' series by J. K. Rowling is another film franchise with a massive global audience. Owls, which feature prominently in these films, are considered messengers between the human and magical world and are pet companions to the

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main characters (Nijman & Nekaris 2017). For instance, Harry Potter has a snowy owl *Bubo scandiacus* named Hedwig, while his best friend, Ron Weasley, owns a common scops owl *Otus scops*.

This film franchise led to testing the 'Harry Potter effect', a phenomenon whereby the presence of owls in the films normalises the keeping of owls as pets, with a resulting increase in the trading of, and in the keeping of, owls as pets (Nijman & Nekaris 2017). The Harry Potter effect is supported by anecdotal observations of increases in owl trading in India (Ahmed 2010), Indonesia (Shepherd 2012), Thailand (Chng & Eaton 2015) and Japan (Vall-Llosera & Su 2019). Panter et al. (2019) recently reported an increase in global international trade in owls towards the end of the 1990s and early 2000s, coinciding with the release of the first Harry Potter books and film, but noted that this occurred coincidentally with a general increase in the international raptor trade and the global expansion of the Internet and social media.

Two research groups have studied the Harry Potter effect quantitatively, one in a country where trade in owls is either prohibited or strictly regulated (Indonesia) and one where owls can be traded legally (UK). Nijman & Nekaris (2017) compared the bird trade in open markets in Indonesia before (1979–2010) and after (2012–2016) the release of the Harry Potter books and films, and found an increase in the number of species of owls offered, an increase in the absolute number of owls for sale and an increase in owls as a proportion of the total number of birds in the markets (Nijman & Nekaris 2017). There was a clear time-lag between the release of the films and books and the increase in the owl trade, suggesting a delayed Harry Potter effect. Finally, Nijman & Nekaris (2017) found that common species (i.e. the ones offered in greater numbers in the markets) were cheaper than the rarer ones, irrespective of size, suggesting a possible anthropogenic Allee effect, whereby a premium is placed on rarer species (Courchamp et al. 2006, Holden & McDonald-Madden 2017).

Megias et al. (2017) did not find a Harry Potter effect based on official owl ownership statistics and potential independent variables for drivers of demand such as UK box-office and book sales. Likewise, they did not find strong support to suggest that the end of the Harry Potter series had a noticeable impact on the number of pet owls handed over to UK wildlife sanctuaries. Despite the differences in finding support for a Harry Potter effect on owl keeping, both Nijman & Nekaris (2017) and Megias et al. (2017) voiced concerns over the realised and perceived impacts that the films may have on trade and species conservation, and the need for further research to understand films as drivers of the wildlife trade (Militz & Foale 2017, Vesper 2017).

Quantifying the relationship between digital media (i.e. films) and demand for certain species as a wildlife trade driver is challenging, and requires long-term data for in-depth understanding. Market surveys have traditionally been one of the main methods to gather data on the trade of a species (Cheung & Dudgeon 2006, Regueira & Bernard 2012, Nijman & Shepherd 2015). More recently, the Internet and social media platforms have shifted the way wildlife is traded legally and illegally (Lavorgna 2014). As a result, research is being increasingly focussed on online trade, including markets for orchids (Hinsley et al. 2016), reptiles (Sung & Fong 2018), mammals (Siriwat & Nijman 2018) and birds (Alves et al. 2013). Beyond identifying the scope and scale of the trade, studies on the Internet provide insight into understanding consumer preferences and demand (Sung & Fong 2018).

Thailand has been one of the countries known as a hub for both legal and illegal wildlife trade, with a well-documented long-term history of market surveys recording the bird trade since the 1960s (McClure & Chaiyaphun 1971, Round 1990, Chng & Eaton 2015). The combination of loosely monitored online trade and the 46 million Facebook users in the country has also made Thailand a key study area (Phassaraudomsak & Krishnasamy 2018, Siriwat & Nijman 2018). Here, we report on the trade of owls in Thailand in 2 different market places: the traditional physical brick-and-mortar markets and online markets. We predicted that availability, links to the Harry Potter books and films, body size, and tameness are factors that affect price. Although we did not find a direct Harry Potter effect on the trade of owls in Thailand, we demonstrate that owls are becoming increasingly available, and the unregulated nature of the trade is a serious conservation concern.

2. MATERIALS AND METHODS

2.1. Data acquisition

We surveyed Bangkok's main bird market, the Chatuchak weekend market (also known as JJ market), for the presence of owls in June 2011 (2 visits) and December 2018 and February 2019 (3 visits). In Thailand, previous bird market surveys have mainly been conducted in this market. We compiled data

from McClure & Chaiyaphun (1971), Round (1990), Nash (1993), Round & Jukmongkkol (2003) and Chng & Eaton (2015). We recorded survey dates, number of visits, total birds observed, and species and number of owls observed and then calculated the number of owls as a proportion of all birds traded in this market.

We searched online for exotic pet groups in Thai and English and located 9 Facebook groups. We monitored the online trade of owls on Facebook over a 24 mo period from April 2017 to March 2019. Each group could be searched by anyone with a Facebook account. In cases where groups required approval from administrators to join, the interaction was limited to simply requesting approval. Since each group acted as a 'market platform' for buying and selling wildlife, we used a typical economic market approach and implemented market survey protocols in each monitoring session (see Barber-Meyer 2010, Nekaris et al. 2010). Due to the potentially sensitive content, we followed the guidelines of Roulet et al. (2017) to conduct covert observations. We did not interact with any participants and only collected openly available information. We abided by the website's terms and conditions and followed ethical guidelines and anonymised data after cross-checking the data for duplicates, so as not to publish any information that could be attributed to an individual (cf. Kosinski et al. 2015, Martin et al. 2018). Only 1 group focussed primarily on birds, and the remaining 8 groups focused on a variety of taxa of exotic pets. The number of members in each group ranged from 4080 to 26 851, with an average of 17 200 members.

From April 2017 to March 2019, we collected data on the owls for sale, which included details on species, number of individuals, price, date and any information that informed on trade methods (cf. Siriwat & Nijman 2018). We carried out monitoring on a monthly basis. To determine our monitoring sessions, we used the Facebook group photo limit approach, whereby Facebook limits group pages to 5000 pictures at any given time (cf. Iqbal 2016). We anonymised data and saved pictures of owls in order to cross-reference duplicate posts to minimise double-counting. We removed birds that were unidentifiable (i.e. very young chicks) from further analyses.

We followed the taxonomy of Eaton et al. (2016) and König & Weick (2008), with the exception of the Australasian barn owl *Tyto javanica*, which we recognise as a species (Aliabadian et al. 2016). We collected price data in Thai Baht (THB), presented here in US$ based on a mean conversion rate of THB 32.8 = US$ 1 (exchange rate ranged from 31.1 to 34.5 THB within the monitoring period).

2.2. Analysis

We conducted analyses on the number of sales posts and number of individuals traded. In the analyses, we highlighted the composition of species being traded and developed hypotheses to explore the price dynamics (Table 1). We used a generalised linear model (GLM) in R Version 3.2.1 (R Core Team 2018). For analysis, we classified owls as 'featured in the Harry Potter films or species similar to those featured in Harry Potter films' (based on colour and size) and 'not featured in Harry Potter films'. Additionally, we also incorporated other variables into the model in an attempt to explain the price. These variables included the availability (number of individuals posted for sale), body size (mass), temporal factor (month) and a tameness variable (advertisements using terms related to 'tame', 'egg-reared', or 'friendly' to describe owls offered for sale). We also tested for an anthropogenic Allee effect (Courchamp et al. 2006, Holden & McDonald-Madden 2017), where we examined the

Table 1. Factors included in the generalised linear model to explain prices for owls traded on Facebook in Thailand

Factor	Hypothesis
'Harry Potter effect'	Owls with links to species featured in the Harry Potter film franchise will be acknowledged as such in the advertisements, and these popular featured owls will be more expensive.
Number of owls	When more owls are available, the prices of individual owls will decrease.
Seasonality	The number of owls traded is linked to natural availability or breeding cycles of owls, which will be reflected in seasonality. During seasons with fewer owls available, owls will be more expensive.
Size	Larger owls will be sold for higher prices.
Tameness	Owls advertised as 'egg-raised' or 'tame' will be sold at a higher price.
Anthropogenic Allee effect	Species that are rare (and thus less available on the market) will be more expensive. The same pattern will occur within species, whereby prices will be higher in months with fewer posts.

relationship between price and availability (number of posts and number of individuals posted for sale), both between species and within the same species (comparing monthly price data). We assumed a normal distribution for the response variable (price) and log-transformed continuous variables. We report *t*-values from the GLMs and associated p-values. To explore the effect of time of year on the owl trade, we tested if the number of posts and number of owls were equally distributed over the 12 months of the year. We also explored whether asking prices during months with significantly more owls for sale dropped and, conversely, if asking prices during months with significantly fewer owls for sale increased.

The first Thai book translation of Harry Potter came out in the same year as the English version in 1997, followed by the first film in 2001. The final instalment of the film came out in 2011. We use this period (1997–2011) as the transition period.

3. RESULTS

3.1. Owl presence in the brick-and-mortar bird market

We did not observe any owls in Chatuchak during our visits in 2011, 2018 or 2019. Nash (1993) likewise did not record any owls during any of his visits to this market. In contrast, McClure & Chaiyaphun (1971), Round (1990), Round & Jukmongkkol (2003) and Chng & Eaton (2015) recorded a total of 402 owls. With close to 750 000 wild-caught birds recorded in Chatuchak, overall, owls rarely made up more than 0.5% of the total number of birds for sale; an exception was a 1 d visit by Chng & Eaton (2015), who recorded 17 owls of 3 species, making up 1.3% of the total that day (1271 birds). Based on previous market surveys, owls represent a small fraction of the total birds traded in Thai markets (Fig. 1a). We found no

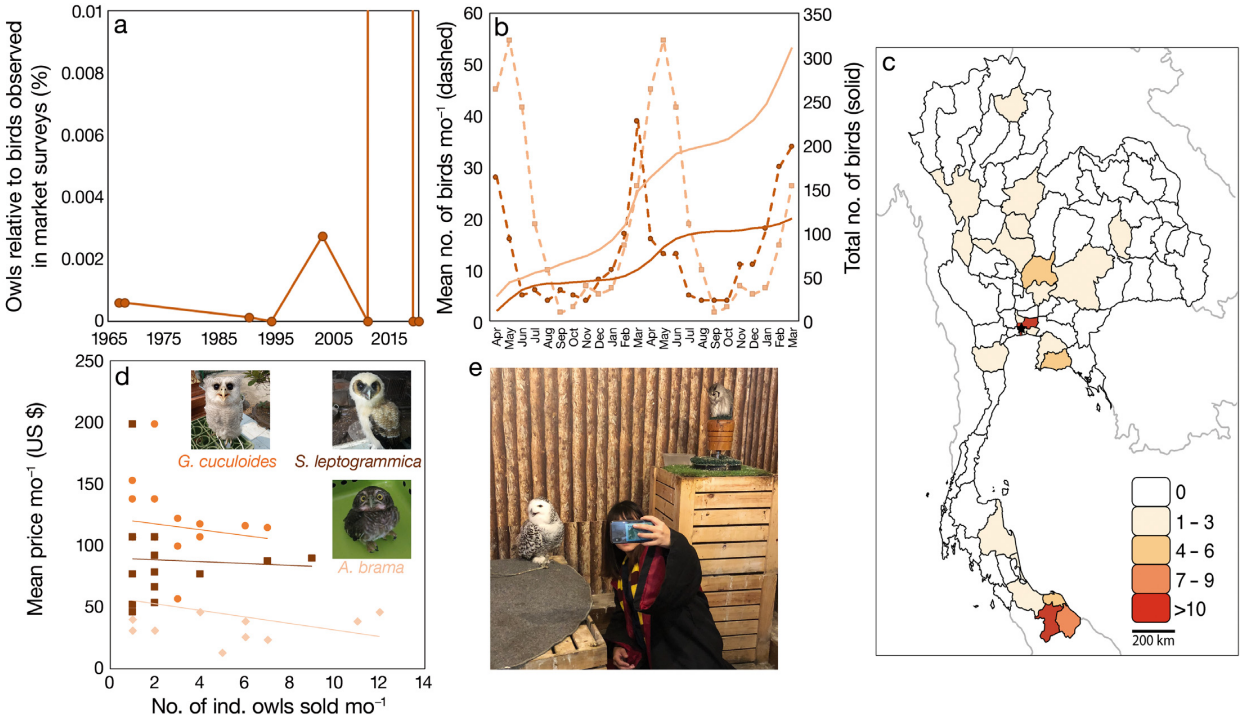

Fig. 1. (a) Percentage of owls relative to all birds observed as reported from 6 market surveys between 1966 and 2019. In their market survey, Chng & Eaton (2015) reported that owls contributed to 1.3% of all birds for sale (off the scale in this figure). (b) Observed seasonality recorded in this study (April 2017 to March 2019; orange) compared to McClure & Chaiyaphun (1971) (November 1966 to January 1969; brown), represented in the number of owls traded per month (dashed) and total number of owls sold (solid line). (c) Distribution of posts throughout Thailand where province data were available. (d) Availability and price of the 3 most commonly traded species, spotted owlet *Athene brama*, barred eagle-owl *Glaucidium cuculoides* and brown wood owl *Strix leptogrammica*. (e) Guests dressed up in Harry Potter-themed props pose for a selfie with a snowy owl *Bubo scandiacus* (left) named 'Hedwig' and a northern white-faced owl *Ptilopsis leucotis* (right) on display in a themed café in Bangkok

significant overlap in the percentage of owls or the absolute number of owls observed with the period during which Harry Potter films or books were first released (2001–2011). Thus, we found little evidence of a 'Harry Potter effect' on the owl trade within Chatuchak Market.

3.2. Online market survey

During the Facebook surveys from April 2017 to March 2019, we recorded 311 individual owls of 17 species from 206 posts during 39 monitoring sessions (Table 2, Fig. 1b). Of the 17 species, 14 are native to Thailand and are listed as protected species in Thailand. Two posts (4 individuals) were unidentifiable, as the pictured owls were too young and there was insufficient description to aid in species identification. Prices for individual owls ranged from US$ 12 to US$ 1676. The barred eagle-owl *Bubo sumatranus* accounted for most of the trade by posts (n = 36), while the spotted owlet *Athene brama* was the most popular by individual count (n = 60). For about half of the posts (n = 104), geographic origin of the seller was provided; these posts originated from 20 provinces around the country (Fig. 1c). Most posts originated from Bangkok, the capital city (n = 32) and Yala, the southern-most province of Thailand (n = 31). Five international sellers advertised on Thai Facebook pages, with 3 posts from Indonesia, and 2 posts from Malaysia.

We qualitatively observed that owls were not traded in equal numbers throughout the year, as was also the case in the market surveys of McClure & Chaiyaphun (1971) that were conducted over 82 weekends from November 1966 to January 1969 (Fig. 1b). The number of posts and number of individual owls that were recorded for sale were not equally distributed over the 12 months (posts: $\chi^2 = 68.37.49$, df = 11, $p < 0.001$; individuals: $\chi^2 = 166.49$, df = 11, $p < 0.001$; Table 3). In the months of February to April,

Table 2. Summary of owl species traded on Facebook in Thailand as monitored over the 24 mo study period. Mean mass obtained from König & Weick (2008). All identified owl species are classified as 'Least Concern' on the IUCN Red List, with the exception of the snowy owl *Bubo scandiacus*, which is listed as 'Vulnerable'

Species	Mean mass (g)	Harry Potter species	No. of posts	No. of individuals	Price in US$ (mean ± SD)
Spotted owlet *Athene brama*	113	No	27	60	45 ± 20
Snowy owl *Bubo scandiacus*	1925	Yes	2	2	884
Barred eagle-owl *B. sumatranus*	1257	Yes	45	45	116 ± 40
Northern great horned owl *B. virginianus*	58	Yes	1	1	1677 ± 4
Buffy fish owl *B. ketupu*	1564	No	27	31	83 ± 29
Brown hawk-owl *B. zeylonensis*	200	No	5	7	36 ± 18
Collared owlet *Glaucidium brodiei*	163	No	2	4	37
Asian barred owlet *G. cuculoides*	282	No	11	29	21 ± 23
Collared scops owl *Otus lettia*	139	Yes	1	7	Not available
Mountain scops owl *O. spilocephalus*	69	Yes	1	1	24
Oriental scops owl *O. sunia*	85	Yes	15	29	31 ± 21
Northern white faced owl *Ptilopsis leucotis*	204	No	5	7	899
Brown wood owl *Strix leptogrammica*	950	No	33	38	88 ± 33
Spotted wood-owl *S. seloputo*	1011	No	15	25	86 ± 13
Oriental bay owl *Phodilus badius*	365	No	5	7	27
Australasian barn owl *Tyto javanica*	41	Yes	7	13	41
Eastern grass owl *T. longimembris*	130	No	1	1	28 ± 4
Unidentifiable			2	4	

Table 3. Seasonality in trade and asking prices of owls in Thailand (mean ± SD), showing that in the peak season from February to April, when more owls are offered for sale, prices are lower for 2 of the 3 most commonly traded species, and the opposite is observed during the low season from August to October

Trade	Sample size (N)	24 mo period	February–April	August–October
All owls (ind. mo^{-1})	311	13.0 ± 10.3	27.3 ± 9.2	4.5 ± 0.8
All owls (no. posts mo^{-1})	206	8.6 ± 5.8	16.0 ± 5.9	4.0 ± 1.1
Spotted owlet (monthly asking price, US$)	60	45.1 ± 30.3	41.7 ± 33.9	58.9 ± 41.6
Barred eagle-owl (monthly asking price, US$)	44	116.4 ± 31.5	106.6 ± 5.3	116.9 ± 35.2
Brown wood owl (monthly asking price, US$)	38	88.1 ± 37.6	67.9 ± 19.9	106.7

significantly more owls were offered for sale than in the other months combined (χ^2 = 127.57, df = 1, p < 0.0001), whereas in August to October, significantly fewer owls were for sale than in the other months combined (χ^2 = 44.16, df = 1, p < 0.001).

For the 3 commonly traded species for which we had sufficient price data, we tested whether asking prices were influenced by availability (Table 3). All 6 outcomes were in the predicted direction (lower prices during high availability, higher prices during low availability); (binomial test, p = 0.04). Spotted owlets were not cheaper during the 3 mo period when significantly more spotted owls were offered for sale compared to the other months combined (χ^2 = 0.25, df = 1, p = 0.617), but they were more expensive when fewer owls were advertised (χ^2 = 4.22, df = 1, p = 0.040). Brown wood owls *Strix leptogrammica* were significantly cheaper during periods of high owl availability (χ^2 = 4.60, df = 1, p = 0.032) and significantly more expensive when few owls were offered for sale (χ^2 = 3.95, df = 1, p = 0.047), again when compared against the other 9 months of the year. Barred eagle-owl prices were less influenced by availability (χ^2 = 0.83, df = 1, p = 0.362 and χ^2 = 0.01, df = 1, p = 0.975 for periods of high and low owl availability, respectively).

We did not observe a shift in species composition between the physical bird markets and the online bird market (Table 4). Comparison with surveys conducted by Round (1990), Nash (1993) and Chng & Eaton (2015) were less meaningful, as they recorded far fewer species and individuals than we did; however, data from McClure & Chaiyaphun (1971) allowed for comparison between studies. We did not find statistically significant variation in genera surveyed for sale in the study by McClure & Chaiyaphun (1971) and in our study (*t*-test, t_8 = 1.12, p = 0.29). Overall, the composition and distribution of species listed for sale were similar. However, more owlets (*Glaucadium* spp.) were recorded in our online study compared to the surveys in Chatuchak, whereas conversely, McClure & Chaiyaphun (1971) recorded more barn owls (*Tyto* spp.) for sale.

Table 4. Comparison of species composition as observed from physical markets recorded in the late 1960s (McClure & Chaiyaphun 1971) and on online platforms recorded in the present study (2017–2019)

Genus (no. of species recorded)	1966–1969 (no. of ind.)	2017–2019 (no. of ind.)
Otus (4)	30	37
Ptilopsis (1)	0	7
Bubo (8)	116	86
Strix (2)	56	63
Glaucadium (2)	8	31
Athene (1)	89	60
Ninox (1)	26	0
Phodilus (1)	6	7
Tyto (3)	44	14

3.3. Harry Potter effect and price variation

Based on the species' GLMs, we found that price significantly explained the number of individuals available (t_{11} = −2.36, p = 0.038), whereby more common owls were less expensive. We did not find a statistically significant relationship with body mass (t_{11} = 1.79, p = 0.10) or with a Harry Potter association (t_{11} = −0.84, p = 0.43) at the species level. In 8 posts (5%), descriptive terms related to Harry Potter were mentioned either in the sale advertisement or in the comments, such as 'Hedwig' or 'Harry's owl'. This type of description was seen for 2 species of imported owls (snowy owl *Bubo scandiacus* and northern white-faced owl *Ptilopsis leucotis*), and 1 post for the Asian barred owlet *G. cuculoides*.

In an attempt to explain price further, we also conducted the GLM analyses at the individual level. We modelled price with owl body mass, count or availability, Harry Potter association and domestication or tameness. We found that the only factor that significantly explained price was body mass (t_{135} = 7.04, p < 0.01). A high number of posts (n = 80) included statements linked to domestication or tameness, such as 'friendly' or 'egg-reared', but we did not find these terms to be a statistically significant explanatory factor of price (t_{135} = −0.61, p = 0.54). Likewise, we found no effect on asking prices of whether the species for sale was featured in the Harry Potter films or was a species similar to one that was in the films (t_{135} = −0.39, p = 0.70). In testing for an anthropogenic Allee effect, we assessed price relationships with availability (number of posts and number of individuals posted for sale) between species and within 3 of the most commonly traded species. Including all species, we did not find a significant relation between price and number of posts (linear regression, $F_{1,22}$ = 0.0017, p = 0.97) and number of owls for sale ($F_{1,22}$ = 0.06, p = 0.81). For the 3 species where >12 mo of data were available, we did not find a statistical relationship between price and availability either for the number of posts or for the number of owls for sale (spotted owlet [$F_{1,10}$ = 1.38, p = 0.27; $F_{1,10}$ = 1.20, p = 0.29]; barred eagle-owl [$F_{1,15}$ = 0.27, p = 0.61; $F_{1,15}$ = 0.85, p = 0.38]; brown wood owl [$F_{1,12}$ = 0.03, p = 0.86; $F_{1,12}$ = 0.03, p = 0.86]; Fig. 1d).

The trade in imported or non-native species contributed to less than 5% (7/151) of posts and only 4% by individuals traded. The average price for the 2 CITES-listed species, i.e. the northern white-faced owl and the snowy owl, was at US$ 891 compared to the average price of domestic owls at US$ 65. Of the 7 posts offering these CITES-listed species for sale, only 3 offered specific importation documentation.

4. DISCUSSION

We found that owls are traded on Facebook in Thailand, but we did not find unequivocal evidence for the 'Harry Potter effect' within the owl trade. Compared to the only other study that examined a general online trade (Phassaraudomsak & Krishnasamy 2018), we found 5 additional species of owls traded, making a total of 15 species. Although there are limitations such as methodological differences or gaps in time, in making comparisons between market and online surveys, and even between online surveys, the overlap of 10 species from the 2 online surveys may reflect commonly sold species. The data shown here in the 2 yr data set are more than what has been observed in physical market surveys in the past few decades, suggesting an increase in, or at least an expansion of, the owl trade with subsequent conservation implications.

A few studies have directly compared the trade of wildlife between traditional and online market surveys. For Thailand, we only have online prices and traditional market prices for 1 species of owl, the spotted owlet, as Chng & Eaton (2016) recorded a price of US$ 15 in Chatuchak market. In contrast, we recorded prices between US$ 12 and US$ 106, averaging US$ 45. Nijman & Nekaris (2017) compared asking prices of owls offered for sale in Indonesian physical bird markets with those online. They found that for 1 species (spotted wood owl *Strix seloputo*) prices were higher online, for 2 species (buffy fish owl *Bubo ketupu* and Javan owlet *Glaucidium castanopterus*) prices were lower, and for 4 other species, there was no price difference. Nijman et al. (2019) analysed market and online surveys of the wild cat trade in 8 countries on 3 continents and revealed that in some countries, wildlife trade is indeed shifting to online platforms. However, the rate of this shift to online platforms depends on external factors such as a country's Internet penetration rate, or enforcement of protected species legislation inside physical markets (Nijman et al. 2019). For diurnal raptors, a clear shift of trade in physical bird markets to online platforms was reported in Indonesia. Birds of prey, including globally threatened species, were commonly traded in the bird markets Java and Sumatra in the 1990s to 2000s (Shepherd 2006, Nijman et al. 2009), but at present very few are recorded (Chng et al. 2015, Harris et al. 2015, Chng & Eaton 2016, V. Nijman unpubl. data). In contrast, Iqbal (2016) and Gunawan et al. (2017) reported that in recent years, a large number of individuals of over 2 dozen species of raptor were now frequently offered for sale on online platforms.

Owl parts (talons, skulls, feathers, bones and meat) have historically been harvested for use in traditional medicine, for superstitious beliefs and the wild meat trade (Shepherd & Shepherd 2009, Williams et al. 2014, Padhy 2016). Televised news media have popularised the religious activity of sacrificing of owls in India during the Diwali light festival, and this has led to an increase of owls in markets in the lead-up to the festival; in some cases, vendors even offer home-delivery services of owls (Padhy 2016). Furthermore, anecdotal reports suggest an increase in trade of live owls in markets in Indonesia (Nijman & Nekaris 2017), and dead owls in Malaysia (Shepherd & Shepherd 2009) and in India for medicinal use (Ahmed 2010).

The perception of owls has changed following their association with Harry Potter. Although without direct statistical correlation, we found explicit references to 'Harry Potter' or 'Hedwig owl', when referring to the exotic species of owls. Differences in culture must also be considered to gain a better understanding of the role or impact of the Harry Potter books and films, or indeed any other film franchise. Even though Megias et al. (2017) found no Harry Potter effect on owl keeping in the UK, it is crucial to closely monitor trade trends in countries which have both growing affluence and accessibility for exotic or otherwise unusual pets as well as weaker law enforcement and fewer social stigmas on keeping legally protected and globally threatened species (Nijman & Nekaris 2017).

The 'Harry Potter effect' has visibly created a phenomenon in 'themed' cafés, many of which feature owls on display with Harry Potter props that have emerged in cities throughout Japan, Malaysia and Bangkok (Fig. 1e). For example, in Japan, these dedicated bird cafés have resulted in increased imports of captive-bred owls, despite strict legal constraints (Vall-Llosera & Su 2019). The display of owls and use of Harry Potter props reflect that the association of owls and the film franchise has become normalised, and perhaps even symbolic in many communities. Even decades after their release, the impacts of globally influential films such as the Harry Potter franchise, with their associated wildlife, both in reality

and perceived, are still worthy of exploration (Militz & Foale 2017, Nijman & Nekaris 2017).

It is also critical to remark in the impact of unregulated online trade in owl species in general. The observed seasonality is an indicator that owls may be sourced from the wild, either taken as eggs or through wild-trapping. These collection methods are a conservation concern, as unregulated harvesting may have potential implications on the viability of the wild population (Daut et al. 2015). Seasonality in the trade appeared to be associated with availability in the wild, following the natural breeding cycles of owls (Lenton 1984, König & Weick 2008, Robson 2008). Seasonality in the trade of bird species was also observed in physical markets, which showed an extended breeding period in Thailand from March to August in which more nestlings and fledglings were offered for sale (McClure & Chaiyaphun 1971). These previous results are consistent with our findings. Owl species are top predators that play a key role in the ecosystems where they are found (Comay & Dayan 2018). Owl species with ranges in Thailand are also protected from trade under Thai wildlife laws; the continuing online trade, however reflects a lack of law enforcement or monitoring within the easily accessible virtual markets (Siriwat & Nijman 2018). In the USA, owls were recognised as the most popular taxon of birds from an assessment of public interest within cultural niches (Schuetz & Johnston 2019). Therefore, until more research is conducted on the impact of hunting on the ecosystem, the harvesting of owls for the pet trade must be monitored. Considering the fast-moving nature of these online platforms, the Thai state should cooperate directly with operators and consumers to raise awareness on the legality of the trade.

The trade in native vs. non-native species in the physical markets and the online platforms in Thailand appears to differ markedly between taxa. We only noted 5 posts of owl species that were non-native to Thailand and that were either imported into the country or that were the offspring of owls imported previously. We have no evidence to suggest that any of the species native to Thailand were sourced from anywhere else than Thailand, and as such less than 5% of the total number of owls in the online trade were sourced abroad. These values are somewhat comparable to those found in another online study (Phassaraudomsak & Krishnasamy 2018) but differ considerably from studies conducted in the Chatuchak animal market. Siriwat et al. (2019) reported that 80% of primates and carnivores traded for sale online in Thailand were species that were found in Thailand. In Chatuchak, Chng & Eaton (2016) found that 44% of bird species and 45% of the individual birds offered for sale were not native to Thailand, and Nijman & Shepherd (2015) found that 97% of the turtles and tortoises on sale belonged to non-native species. Todd (2011) found 32 Malagasy species (reptiles, amphibians, mammals) offered for sale during a 1 mo survey in 2010 in Chatuchak market.

A few comprehensive studies have taken an alternative approach that focussed on the role of social media platforms on wildlife demand or perceptions towards keeping wild animals as pets, where response to wildlife content was strategically analysed on platforms such as YouTube and Twitter (Nekaris et al. 2013, Radford et al. 2018, Clarke et al. 2019). These studies showed that a species' exoticness has a strong influence on creating 'viral' content. An example of this trend is the uncritical sharing of exotic pet or wildlife content on the Internet that may lead to misperceptions about wild animals. In 2009, comments on a YouTube video that showed a pet pygmy slow loris *Nycticebus pygmaeus* being tickled were analysed, and the authors found that the video content incentivised people to want slow lorises as pets, despite slow lorises being an Appendix I-listed species and classified as Vulnerable on the IUCN Red List (Nekaris et al. 2013). Furthermore, in 2016, a short clip of a habituated ring-tailed lemur *Lemur catta* was circulated, reaching over 20 million viewers within a few weeks. This post similarly led to a marked increase in search trends for 'lemurs' but also to an increase in direct references to 'wanting a lemur' pet (Clarke et al. 2019; see also Reuter et al. 2018).

Although we have primarily highlighted how digital media potentially contribute to the demand for wildlife as pets, it is essential to emphasise the potential benefits of digital media. Digital media can be used positively for conservation when shared strategically between the conservation community and the movie industry. For example, films can offer a vital opportunity to address the perception of wildlife species and can encourage audience engagement for conservation issues (Silk et al. 2018). Furthermore, equipped with education materials, films can also produce positive outcomes (Yong et al. 2011). There is a growing body of literature that links digital media and sentiments related to conservation, and this may even extend beyond the wildlife trade to address other global environmental issues, such as climate change (Lowe et al. 2006, Sakellari 2015). Whether in the form of film or on social media platforms, it is our responsibility to consume content conscientiously and at the very least, to be aware of conservation issues associated with wild animal content (Nekaris & Campbell 2012).

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