

# Characterizing and quantifying the wildlife trade network in Sulawesi, Indonesia

*by* Tiltje Ransalele 2

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From theory to practice, from molecules to ecosystems, from regional to global

## AUTHOR INFORMATION PACK

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Reference to a journal publication with an article number:

Van der Geer, J., Hanraads, J.A.J., Lupton, R.A., 2018. The art of writing a scientific article. *Heliyon*, 2(9), e00205. <https://doi.org/10.1016/j.heliyon.2018.e00205>.

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Reference to a website:

Cancer Research UK, 1975. Cancer statistics reports for the UK. <http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/> (accessed 13 March 2003).

Reference to a dataset:

[dataset] Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions. *Mendeley Data*, v1. <https://doi.org/10.17632/xwj98nb39r.1>.

Reference to software:

Coon, E., Berndt, M., Jan, A., Svyatsky, D., Atchley, A., Kikinzon, E., Harp, D., Manzini, G., Shelef, E., Lipnikov, K., Garimella, R., Xu, C., Moulton, D., Karra, S., Painter, S., Jafarov, E., & Molins, S., 2020. *Advanced Terrestrial Simulator (ATS) v0.88 (Version 0.88)*. Zenodo. <https://doi.org/10.5281/zenodo.3727209>.

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### Original Research Article

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## Characterizing and quantifying the wildlife trade network in Sulawesi, Indonesia



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### ABSTRACT

The island of Sulawesi in Indonesia is an important site for the wildlife trade that is currently undergoing rapid exploitation of its local fauna to supply wild meat markets of North Sulawesi. In this study, we used field surveys, ethnographic interviews, and daily counts in markets to document species of terrestrial wildlife on sale in North Sulawesi markets, and to identify the hunting sites, practices, and key actors within the wildlife trade. We quantify the volume of wild meat traded and their prices, with a particular focus on the flying fox trade.

Wildlife meat was routinely available for sale in 73% of the markets and supermarkets surveyed in North Sulawesi. The wildlife taxa most commonly found in these markets were flying foxes, wild pigs, rats and snakes. Wildlife hunting and trade networks extend to all provinces of the island through a well-organized, dynamic and easy to access network involving many actors. We identified 45 flying fox roosts in Sulawesi, 38 of which were under active hunting pressure. A third of the active hunting sites are located in Southeast Sulawesi, which acts as a hub for bat hunting and trade. We estimate that the number of flying foxes annually traded in Sulawesi ranges from 662,551 to more than one million individuals and conclude that current rates of flying fox harvest are unsustainable. Stricter law enforcement, implementation of hunting quotas, and further research efforts are therefore urgently needed to improve the sustainability of the wildlife trade in Sulawesi.

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## 1. Introduction

Southeast Asia, one of the most biodiverse regions in the world, is currently facing a biodiversity crisis threatening numerous species and ecosystems (Schipper et al., 2008; Wilcove et al., 2013). Overhunting and unsustainable harvesting constitutes one of the greatest threats to the biodiversity of the region (Di Minin et al., 2019; Gray et al., 2018; Harrison et al., 2016). Wild animals are traded live as pets or dead as wild meat, ornaments or medicines to supply local, regional and global markets (Gray et al., 2018; Nijman, 2010). Indonesia is an important wildlife trade hotspot in the region (Davies, 2009; Nijman, 2010). Widespread and poorly regulated trade in this country involves numerous species of wild birds (Bergin et al., 2018; Shepherd et al., 2016), marine invertebrates (Nijman et al., 2016), reptiles (Natusch and Lyons, 2012), primates (Nijman et al., 2017) and other mammals (Harrison et al., 2011; Lee et al., 2005; Luskin et al., 2014). Consequently, poaching and hunting have already devastated populations of several wildlife species in Indonesia (Harrison et al., 2016).

During the past few decades, the fourth largest island of Indonesia, Sulawesi, has undergone rapid exploitation of its fauna to supply wild meat markets in North Sulawesi province (Lee, 1997; Lee et al., 2005, 2009; Sheherazade and Tsang, 2015). Wildlife meat consumption in Sulawesi is closely associated with religious differences (Lee et al., 2005). The island is primarily inhabited by Muslims but a large Christian community, called Minahasan people, inhabits the province of North Sulawesi. Wild meat is not consumed by Muslim populations but is very popular among Minahasan people and has been part of their cultural habits for decades. Minahasan people consume wildlife as well as other meat such as cats and dogs on a daily basis but this consumption increases during the Christmas holidays and before *Pengucapan*, the "Minahasan Thanksgiving" (Lee, 2000; Sheherazade and Tsang, 2015). Wild meat has been sold in North Sulawesi markets since the 1970s and the wildlife trade business, benefiting from road improvement, underwent rapid expansion in the 1980s and 1990s (Clayton and Milner-Gulland, 2000). Studies in the 1990s and early 2000s showed that the wild animals for sale in North Sulawesi markets were mainly rats, fruit bats, and wild pigs (Clayton and Milner-Gulland, 2000; Lee et al., 2005; Milner-Gulland and Clayton, 2002). Legally protected species whose hunting and trade is prohibited such as macaques, babirusas, anoa, deers, cuscuses, and tarsiers were also sold in smaller numbers (Lee et al., 2005; Milner-Gulland and Clayton, 2002).

Over-hunting has already extirpated several wild mammal species in North Sulawesi, including *Pteropus* and *Acerodon* spp. fruit bats (flying foxes) and hunting activities have expanded to other provinces to supply the demand from the northern province (Clayton and Milner-Gulland, 2000; Lee et al., 2005; Milner-Gulland and Clayton, 2002). Flying foxes are highly vulnerable to over-hunting due to some of their ecological and life history traits (Epstein et al., 2009; Mickleburgh et al., 2009) and this group of bats is facing higher risk of extinction than other bats (Jones et al., 2003). Island flying fox species are suffering considerable and widespread decline worldwide (Vincenot et al., 2017) and their populations in Sulawesi might be severely impacted by the wildlife trade (Sheherazade and Tsang, 2015). However, the extent and structure of the wildlife trade network in Sulawesi remains unknown as previous studies focused on market vendors from North Sulawesi and not on other actors within the trade. In this study, for the first time, we conducted field surveys and ethnographic interviews in all provinces of Sulawesi and involving most wildlife trade actors to: (1) document the markets where wild meat is sold in North Sulawesi and identify the taxa on sale, (2) identify hunting sites and key actors within the wildlife trade from capture to consumption and (3) quantify the volume of wild meat trade and their prices. We focused particularly on the flying foxes, which is one of the main taxa traded. These data are urgently needed to assess the current level of sustainability of the trade and its impact on flying fox populations and to identify appropriate conservation measures to mitigate these impacts.

## 2. Material and methods

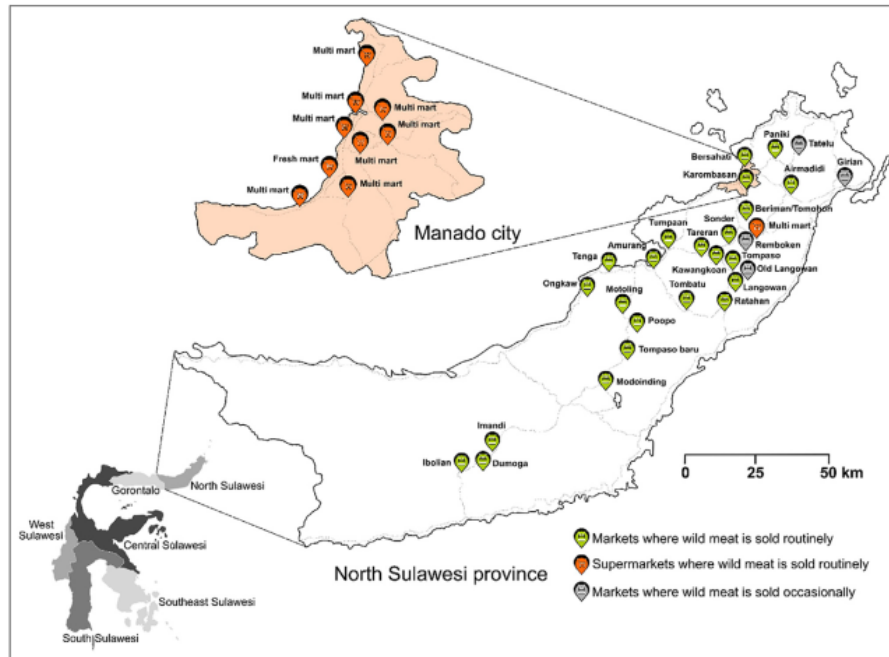
### 2.1. Market surveys

Local observers surveyed 31 markets and 14 supermarkets in nine districts of North Sulawesi province from November 2018 to February 2019 (Fig. 1 and Table A1). Surveys consisted of a single visit to each market or supermarket to assess the number of vendors selling wild meat and identify the wildlife taxa being sold. We also conducted in-depth surveys in five markets, including three of the largest wildlife markets in North Sulawesi, Langowan, Kawangkoan and Tomohon, in addition to Karombasan and Tareran markets (Fig. 1). For these in-depth surveys, observers monitored each market two to three times per week during 12 consecutive weeks from November 2018 to January 2019. During each visit to Langowan, Kawangkoan, Tomohon, and Karombasan markets, they recorded the daily quantity and prices of large fruit bats, wild pigs, rats, and snakes sold by each vendor. At Tareran market, only quantities of large fruit bats and rats were recorded. Prices were recorded in Indonesian rupiahs (IDR).

### 2.2. Mapping of bat roosts and hunting sites

As part of a multi-year wildlife viral surveillance project conducted in Sulawesi (USAID EPT-PREDICT project), we surveyed large areas of Sulawesi for flying fox roost sites and bat hunting areas in 2016 and 2017. From April 2018 to March 2019, we intensified this survey and systematically monitored suitable areas in five provinces of Sulawesi (Gorontalo, Southeast, South, West, and Central Sulawesi). These surveys were carried out in collaboration with our local network of collaborators including researchers and officials from provincial offices of the Directorate General of Livestock and Animal Health Services (DGLAHS) under the Indonesia Ministry of Agriculture. The GPS coordinates of each roost were recorded and hunting status assessed through direct observation and discussion with local community members. We also collected detailed demographic data





**Fig. 1.** Map of North Sulawesi province showing the 27 markets and 10 supermarkets where wild meat is sold routinely or occasionally (before Christmas, New year and Thanksgiving only) according to the results of our survey in 31 markets and 14 supermarkets in the province from November 2018 to February 2019. Dotted grey lines represent the provincial road network.

(species, sex, weight, age class, forearm measurement) on bats caught by hunters in three hunting sites located in Gorontalo, West Sulawesi, and Southeast Sulawesi provinces twice a year from 2016 to 2018.

### 2.3. Ethnographic interviews

We conducted 70 semi-structured interviews with market vendors ( $n = 38$ ), trade intermediaries ( $n = 9$ ) and wildlife hunters ( $n = 23$ ) from March to August 2016 and from July 2018 to January 2019 in North, Southeast, and West Sulawesi. Respondents were identified through discussions with local community members in markets and wildlife hunting areas of Sulawesi. We targeted knowledgeable informants actively involved in the wildlife trade, mostly focusing on bats, to understand the network configuration and identify key actors. Participation in interviews was anonymous and voluntary. Informed consent was obtained before each interview. No questions about respondents' personal information or identity were asked. Our research protocols were reviewed and approved by the Committee on Health Research Ethics of the National Institute of Health Research and Development, Indonesia Ministry of Health (protocols LB.02.01/5.2/KE.040/2016 and LB.02.01/2/KE.306/2018), by the Eijkman Institute Research Ethics Commission of the Eijkman Institute of Molecular Biology (protocol #117) and by the Institutional Review Board at the University of California, Davis (protocol #754490). We obtained local research permits from each province and district where the research was conducted.

Wildlife market vendors were asked which markets they sell their wildlife products in, the number of days they work per week, the wildlife taxa they sell routinely or occasionally and their geographic origins, the quantity of bats sold routinely every week and during the peak season and their corresponding prices. We asked trade intermediaries about the wildlife taxa they trade, the geographic origin of these animals, the quantity of wild animals traded monthly and annually, the price they pay to buy these animals and their selling price, the hunters and other intermediaries with whom they work, and information about the transportation and logistics to North Sulawesi and its associated cost. Wildlife hunters were asked about when they started their hunting activities, the hunting frequency, the quantity of animals they collect daily and weekly and its annual variation, the hunting seasons, their hunting methods, the price they were paid by trade intermediaries, the cost of their hunting activities, and the structure of the local group of hunters. All respondents were also asked about their perception of bat population trends in Sulawesi and, lastly, their awareness of the Indonesian law for wildlife protected species.

### 2.4. Wild meat quantities traded

The average quantities of bats, rats, wild pigs, and snakes sold every week in Langowan, Kawangkoan, Tomohon, Karombasan and Tareran markets were extrapolated from the daily counts collected in these markets, using the sum of the

average quantities sold every market day. Regular weekly average quantity ( $Q_{WR}$ ) was calculated from data collected between November 12 and December 21, 2018 and between January 2 and 31, 2019. The weekly average quantity during Christmas/New Year ( $Q_{WC}$ ) was estimated from the data collected between December 22 and 31, 2018. The annual quantity of wild animals sold ( $Q_A$ ) was estimated by using the sum of the product of  $Q_{WR}$  multiplied by 49 and  $Q_{WC}$  multiplied by three (corresponding to the two weeks before Christmas/New Year and one week before Thanksgiving). For the markets in which we did not collect daily count data, we used weekly averages provided by interview respondents, multiplied by the number of vendors in each market, to estimate  $Q_A$ . For the markets in which we did not collect interview data, we used estimates of weekly quantity of 50 kg for bats, 60 kg for wild pigs, and 15 kg of snakes per vendor. These quantities were the average minimal weekly quantities sold by a single wildlife vendor in the 10 markets where daily counts or interview data were available. We did not estimate the average weekly quantity of rats sold per vendor as it varied considerably among vendors.

We estimated the quantities of flying foxes caught and traded by hunters and intermediaries who responded to our interviews using the data they provided. The hunters we interviewed were able to give information on the total number of bats their hunting group took throughout the year. We used the product of the total daily or weekly quantities harvested and the length of the hunting season to estimate the annual quantity harvested from each colony. For trade intermediaries, we calculated the product of the number of trips to North Sulawesi per year, the average quantity of bats transported per trip during the low and high season, and the length of each season.

### 3. Results

#### 3.1. Wildlife diversity in markets of North Sulawesi

Wildlife meat was routinely available for sale in 23 of the 31 markets surveyed in North Sulawesi in 2018 and 2019 and was also occasionally traded in four additional markets, mostly before Christmas and New Year (Table A1 and Fig. 1). Most of these markets are located in Minahasa and South Minahasa districts (Table A1). Some markets were active every day while some were open only twice or three times per week. Many wildlife vendors shared their time among several markets from the same region (Dumoga/Ibolian/Imandi, Motoling/Tompaso Baru/Modoinding/Poopo, Kawangkoan/Sonder/Tareran markets). We also observed wildlife meat in 10 of the 14 supermarkets surveyed in Tomohon and Manado cities (Fig. 1). Many restaurants in North Sulawesi, called "Minahasan restaurants", also served wildlife meat but were not systematically surveyed and mapped for this study. Pictures are available in Appendix (Figs A1–A3).

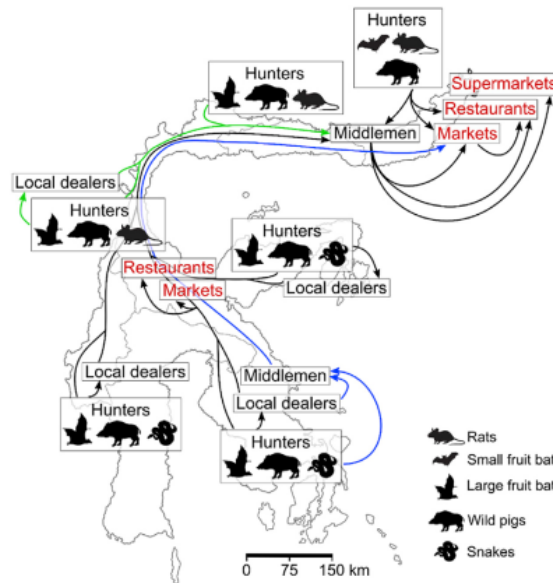
The wildlife taxa most commonly found in these markets were bats, wild pigs, rats, and snakes (Table A1). Large fruit bats (flying foxes), mostly *Acerodon celebensis* and *Pteropus alecto*, were commonly found in almost all wildlife markets (96%) we identified in North Sulawesi. They were sold roasted. All market vendors we interviewed confirmed that they had not received live bats for the past few years. Small fruit bats belonging to the genera *Cynopterus*, *Rousettus*, *Nyctimene*, *Thoopterus*, and *Styloctenium* were also observed in the markets of the western part of the province (Ibolian, Dumoga, Imandi and Modoinding markets). These small bats were sold freshly killed or roasted. Parts of wild pigs (*Sus celebensis*) and snakes (*Python* sp.) were also found in most markets we surveyed in the province (96% and 91%, respectively). Two wild pigs that were still alive and restrained were observed at the Tomohon market in January 2019. Roasted rats were also very common in wildlife markets (91%). These are called "white tailed rats" by local people but they belong to a large diversity of mostly endemic species including *Taeromys celebensis*, *Rattus xanthurus*, *Maxomys hellwaldii*, *M. musschenbroekii*, *Paruromys dominator*, *Echiothrix leucura*, and *Bunomys chrysocomus*. These forest species were considered healthier and tastier than black tailed rats hunted in paddy fields such as *Rattus hoffmani*, *R. argentiventer*, *R. rattus*, which are also available in some markets, but at a lower price. Protected species were available in some of these markets (Table A1) including: Celebes crested macaque (*Macaca nigra*) (39%), anoa (*Bubalus depressicornis*) (30%), cuscus (*Strigocuscus celebensis* and *Ailurops ursinus*) (17%), and babirusa (*Babyrousa celebensis*) (13%). Monitor lizards, squirrels, and frogs were also noticed occasionally (Table A1). The other taxa available in these markets were mostly domestic pig, dog, cat, and chicken as well as fish, all sold killed.

#### 3.2. Wildlife trade network in Sulawesi and its key actors

Wildlife hunting and trade extends to all provinces of Sulawesi as most of the animals sold in North Sulawesi markets were not locally sourced. Only rats, small fruit bats, and some wild pigs were provided to market vendors by a local network of hunters while large fruit bats, snakes, most wild pigs, and some rats were hunted in other provinces and transported to North Sulawesi (Fig. 2). Market vendors had poor knowledge of the origin of their wild meat and were only able to indicate the province of origin of some taxa. However, our interviews with trade intermediaries and hunters, and our bat hunting site survey allowed us to map the current wildlife trade network in further detail and identify its key actors (Fig. 2).

##### 3.2.1. Hunters, hunting sites and hunting practices

Out of the 19 hunters interviewed in North Sulawesi, most (89%) said they hunted rats, followed by wild pigs (42%), cuscuses (26%), small bats (16%), anoa (10%), snakes (5%), babirusas (5%) and monkeys (5%). Hunters interviewed in the other provinces were exclusively flying fox hunters. Hunting practices and sites varied according to the taxa hunted.

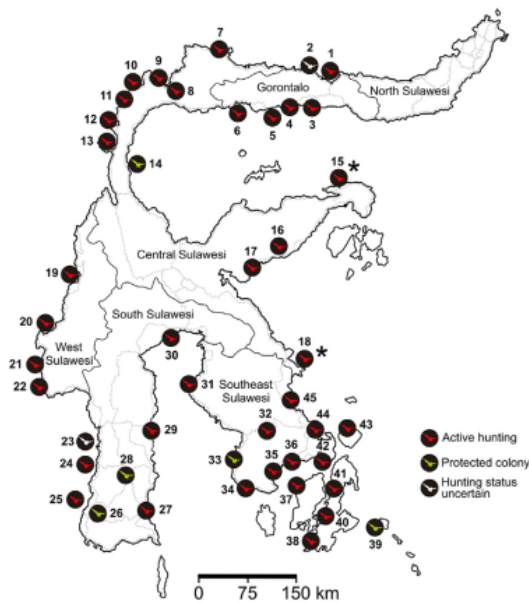


**Fig. 2.** Overview of the wildlife trade network in Sulawesi and its key actors for the four taxa most commonly traded (bats, wild pigs, snakes and rats). Wild meat selling places are highlighted in red. Sources of wildlife supply for middlemen based in North Sulawesi were located either in Gorontalo and Central Sulawesi (green net 54) or in West, South, and Southeast Sulawesi (black network). Two to three middlemen based in Southeast Sulawesi were also identified (blue network). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

**3.2.1.1. Bats.** Small fruits bats were hunted only in North Sulawesi, mostly in the western part of the province, by local villagers for their own consumption or sale in markets (Fig. 2). Flying foxes were hunted in all other provinces of Sulawesi (Fig. 2). Flying fox hunters were usually from Muslim communities living close to bat roosts and did not consume wild meat for religious reasons. Therefore, bat hunting in these regions was commercially motivated. Hunters usually started their activities after being encouraged and trained by trade intermediaries from North Sulawesi who pledged to buy the bats they would catch. Local conflicts among villagers to exploit a bat colony was reported several times during our study as these bats had an important economic value. Flying fox hunters interviewed in Gorontalo and West Sulawesi provinces were part of hunter groups with a leader coordinating bat hunting and selling to trade intermediaries. In one of these groups, benefits from bat sales were equally shared among all hunters while in the other group, each hunter was paid proportionally to the quantity of bats caught. In Southeast Sulawesi, the hunters interviewed were working and dealing with trade intermediaries independently. All hunters reported that bat hunting was the primary source of their annual income, although it was supplemented by fishing, farming (coconut, cashew nuts, corn), construction and other activities.

We identified 45 flying fox roosts in all provinces of Sulawesi except 100 North Sulawesi (Fig. 3 and Table A2). Most roosts were located in coastal mangrove swamps (*Rhizophora* sp., *Sonneratia* sp., *Bruguiera* sp., *Ceriops* sp., *Avicennia* sp., *Lumnitzera* sp., and *Nypa fruticans*) or coastal pine trees (*Pinus* sp.) (Table A2). A few roosts were located in swamps surrounding large lakes of Central and Southeast Sulawesi. We also identified a few colonies roosting in emergent trees of inland forests (Table A2). Of these 45 roosts, 38 (84%) were under active hunting pressure in 2018 and 2019, while the current hunting status of two of them remained uncertain. Southeast Sulawesi seems to be the current hub of the bat hunting and trade in Sulawesi, with at least 13 active hunting sites (34%) (Fig. 3). At least five hunting sites were located on the southernmost islands of the province (Wowoni, Muna and Buton islands). A bat roost in North Kolaka district, Southeast Sulawesi (#31 in Fig. 3), was reported as one of the most productive bat hunting sites in Sulawesi by four respondents. Central Sulawesi, harbored the second highest number (11, 29%) of active hunting sites. Only a few hunted roosts were identified in South Sulawesi (13%), Gorontalo (13%) and West Sulawesi (11%). These numbers contrast with the information given by market vendors regarding the origin of the flying foxes they sold: South Sulawesi was reported as the main source of flying foxes (95%), followed by Southeast Sulawesi (24%), Gorontalo (24%), Central Sulawesi (13%), and West Sulawesi (2%). Other islands (Kalimantan, West Nusa Tenggara, East Nusa Tenggara and North Maluku) were also reported as the source of flying foxes sold in North Sulawesi a few times during our interviews.

Several respondents in hunting areas reported the disappearance of bat roosts in the past few years due to overhunting, disturbance, or mangrove destruction for fisheries, and that local populations encouraged hunting because bats are considered pests that damage fruit crops and mangroves. We identified only five flying fox colonies (11%) protected by local villagers during our survey (Fig. 3), four of them protected for many years, and one colony in Toribulu, Central Sulawesi (#14 in Fig. 3) exploited by hunters before being protected by villagers in late 2016. Some of these roosts have become eco-tourism sites attracting local visitors, contributing to their protection.



**Fig. 3.** Map of Sulawesi showing the flying fox roosts identified in this study and their hunting status. The two *Pteropus griseus* roosts in Central Sulawesi are indicated by an asterisk. Other roosts are *Pteropus alecto* and/or *Acerodon celebensis*. Grey dotted lines correspond to the provincial road network in Sulawesi. Numbers refer to Table A2 where more information about each roost is provided.

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The black flying fox (*Pteropus alecto*) and the Sulawesi flying fox (*Acerodon celebensis*) were the most commonly harvested species in Sulawesi (Table A2). These often co-roost and were hunted without specific targeting of one or the other. According to the hunting data we collected from 2016 to 2018, the proportion of *Acerodon celebensis* bats harvested varied from 11 to 26% (Table A3). The sex ratio of hunted individuals is close to 1/1 and more than half of them were sexually mature adults (Table A3). The average weight of the collected bats was 486 g (regardless of the species) (Table A3). Two colonies of *Pteropus griseus*, called “white bats” by local hunters, were also harvested in Central Sulawesi (Fig. 3).

Most respondents reported that flying foxes in Sulawesi migrate seasonally, with a few colonies thought to never migrate. Bat hunting is therefore a seasonal activity in most areas. In most provinces (West Sulawesi, South Sulawesi, Southeast Sulawesi, and Gorontalo), flying fox colonies were reported to migrate during the rainy monsoon season, from January to April. These colonies were back to their roost at the beginning of the dry monsoon season, from May to December, with a peak of high population size from July to September. Several respondents in these provinces mentioned that hunting still happened during the flying fox birthing season in December. However, opposite migration pattern was reported for two roosts of Central Sulawesi (#12 and 16 in Fig. 3) with the period from November to June being reported as the high density season. In some mixed colonies, several respondents mentioned that *Pteropus* bats migrated while *Acerodon* bats did not and occupied the same roost throughout the year. However, many hunters paused their hunting activities during this low bat density season as the hunting effort required is too high compared to the number of bats that could be harvested. Recent changes in bat migration patterns, allegedly explained by a disrupted monsoon pattern due to climate change, were also reported by several hunters and trade intermediaries.

Hunting techniques used were hooked ropes (42%), nets (33%), air rifles (17%), and kites with hooks (8%). Hooked ropes suspended between bamboo poles or large trees around mangrove roost sites were used in Gorontalo, Central, and Southeast Sulawesi provinces (Fig A4 in Appendix). These permanent structures remain in place throughout the year, are checked each day during the high season or every two days during the low season. Up to 100 hooks may be placed on each 30 m rope. Bamboo poles were replaced at least annually. Nets deployed in the early morning before the bats fly back to their roost were also used in Gorontalo, Central, West, and South Sulawesi provinces (Fig A4 in Appendix). In some regions of Central Sulawesi and Gorontalo, hunters also used nets to target fruit trees where bats feed nocturnally. Air rifles were used in Central and West Sulawesi. The use of kites with hooks was only reported in Gorontalo province. Bats were usually killed directly after capture, often by drowning, and then stored in cooler boxes. Accidents due to crocodile attacks during hunting activities were reported several times in Central Sulawesi and several bat hunters were killed in this region.

**3.2.1.2. Rodents.** Eighty-nine percent of hunters interviewed in North Sulawesi said they hunted rats in the surroundings forests, both for their own consumption and for sale in markets or directly to consumers (Fig. 2). Central Sulawesi and

Gorontalo were also reported as the origin of many rodents sold in North Sulawesi markets, some of them coming from palm oil plantations (Fig. 2). Rat hunters used traditional bamboo traps (69%) and air rifles (31%). In paddy fields, hunters also caught rats overnight by digging holes and hitting them with a stick when they exited their burrows. A single hunter usually caught around 20 to 40 rats per day but it could be as many as 100 during the most productive nights.

**3.2.1.3. Wild pigs.** Wild pig hunting occurred in all provinces of Sulawesi (Fig. 2) but pigs were also imported from Kalimantan province (Borneo island) according to a trade intermediary. This respondent reported that wild pigs from Southeast Sulawesi were considered as the tastiest while those from Kalimantan (bearded pigs) were bigger but were not favored because of their poor taste. According to the same respondent, wild pigs from Gorontalo province were smaller than those from other provinces. Wild pigs were hunted using shotguns, wire traps, or mouth snares baited with a half coconut. Some pigs from North and Central Sulawesi were transported alive with tied feet and mouth to the markets.

**3.2.1.4. Snakes.** All snakes sold in North Sulawesi belonged to the genus *Python*. Pythons were mostly hunted in the swamps, forests, and paddy fields of Central, South, and Southeast Sulawesi (Fig. 2), where they were abundant and easily caught. Most were killed before being transported to North Sulawesi.

**3.2.1.5. Babirusas and anoas.** Hunting of large animals such as babirusa and anoas occurred in Sulawesi from 2016 to 2018 despite being illegal since 1999 (Government Regulation No. 7, 1999, Decree No. P.20/MENLHK/SETJEN/KUM.1/6/2018). Two of our respondents reported trapping these large animals in the protected mountainous areas of North Sulawesi province. Hunting these species required a significant effort because the deep forest sites required one day of walking to reach, and hunting trips lasted three to four days. These large animals were slaughtered directly in the forest and meat pieces were carried back to the village, often requiring several trips. Only a few of these animals were caught every month but their selling price was very high (>5,000,000 IDR).

**3.2.1.6. Monkeys.** Two respondents from North Sulawesi reported that macaque hunting was still active in the province. Both mentioned that a preferred hunting practice was to cut down the sleeping tree on which a group of macaques spent the night. This allowed them to capture 20 to 40 individuals in a single night.

### 3.2.2. Trade intermediaries

We identified trade intermediaries (which we call local dealers and middlemen) who played different roles in supplying wild meat to North Sulawesi vendors. Most belonged to the Minahasan, Balinese, or Torajan ethnic groups. Local dealers collected and stored bats and other wildlife (mostly wild pigs and snakes) directly from hunters. Many provided transportation, hunting equipment and food to hunters in advance to ensure that they would not sell their animals to another intermediary. When bat roosts are not exploited by local villagers, trade intermediaries sometimes sent their own hunters to harvest a bat colony for several weeks or months before leaving the area. Local dealers were located in all regions of Sulawesi where wildlife hunting occurred (Fig. 2). They did not organize the transportation of wild meat to North Sulawesi but sold it to other trade intermediaries that we called middlemen.

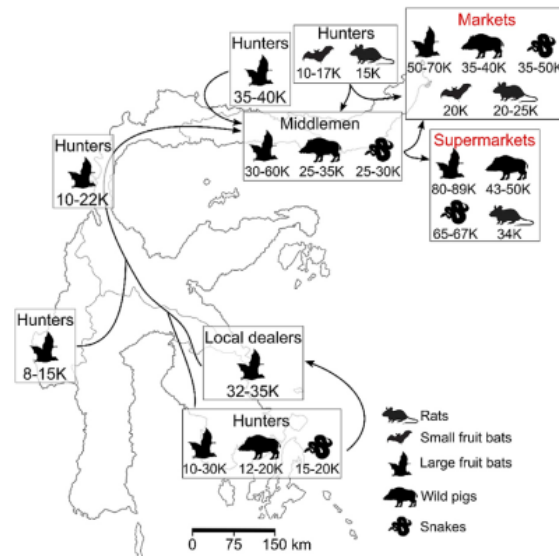
Middlemen typically bought wildlife from local dealers or directly from hunters and coordinated the transportation logistics to North Sulawesi from other provinces (Fig. 2). We estimate around 10 to 12 middlemen have established in North Sulawesi from our interviews. Their sources of wildlife were located either in Gorontalo and Central Sulawesi (green network in Fig. 2) or in West, South, and Southeast Sulawesi (black network in Fig. 2). We also identified two to three middlemen based in Southeast Sulawesi (blue network in Fig. 2). They all traded and transported bats, wild pigs, and snakes as well as dogs to North Sulawesi. Middlemen usually owned one or several pickups and trucks and worked with their own team of drivers. These drivers shuttled back and forth (two drivers per car) between North Sulawesi and other provinces to collect wild meat from local dealers or hunters, transported on ice. Several middlemen also transported vegetables from North Sulawesi to sell in South and Southeast Sulawesi to supplement income. A return trip from North Sulawesi took between 10 and 13 days. A single car and two drivers were therefore able to perform two to three trips per month. Several respondents also mentioned that bats were transported by plane from Southeast Sulawesi to Manado city in North Sulawesi but we were not able to confirm this.

### 3.2.3. Wild meat sellers

In North Sulawesi, wildlife is available for sale to consumers in markets, supermarkets, and Minahasan restaurants (Figs. 1 and 2, Table A1, Figs A1-A3). We also identified a few markets and restaurants selling wildlife in Central Sulawesi, around Poso and Parigi Moutong districts, where a large Christian community is established. These places were supplied by middlemen drivers on their way back to North Sulawesi from Southeast and Central Sulawesi (Fig. 2).

## 3.3. Wild meat quantities traded and prices

We estimate that 9400 to 13,800 kg of flying foxes were harvested annually in 2018 and 2019 from each of the three roosts we studied, representing around 20,680 to 26,634 individual bats removed from the colony each year (Table A3). Two



**Fig. 4.** Price ranges for wild meat paid to the main actors of the wildlife trade network in Sulawesi in 2018–2019. Prices are given in Indonesia Rupiahs (IDR) per kilogram of wild meat, 1 K IDR = 1000 IDR (1 USD = 14,000 IDR in July 2019).

respondents also reported that up to four tons of bats, around 8000 bat individuals, could be harvested monthly from the bat roost in North Kolaka, Southeast Sulawesi (#31 in Fig. 3). Four middlemen provided us with detailed numbers allowing us to estimate the annual quantities of bats they traded in 2018 and 2019. Bats were the priority taxa for three of them; they transported other taxa (wild pigs, snakes or dogs) only when there were not enough bats available to fill their vehicles completely (a single pickup can carry up to 1700–1900 kg of wildlife meat). Each middleman traded 18,800 to 122,400 kg of bats annually, all collected in West, South, and Southeast Sulawesi. The fourth middleman mostly focused on wild pigs and transported around 9600 kg of bats from Southeast Sulawesi annually. We estimate that these four middlemen together traded more than 176,500 kg of bats annually during the period 2018–2019. If we consider that their business represented a third of the total business activities of the 10 to 12 middlemen active in Sulawesi, the quantity of bats traded on the island annually could be as high as 529,500 kg, which would be more than one million bats hunted each year in Sulawesi when using an average weight of 486 g per bat (Table A3).

The quantities of wild meat sold daily varied in the five markets we studied (Fig A5 in Appendix), with Saturday usually the busiest. Wild pig was the largest taxon by quantity sold in Langowan and Kawangkoan markets and in the combined data from the five markets, followed by flying foxes (Fig A5 in Appendix). In the weeks before Christmas and New Year, wild meat sales increased in all five markets and were two to five times higher than the regular weekly average (Fig A5 in Appendix). Market vendors reported similar increases during the week before the “Minahasan Thanksgiving” celebrated in June–September. Other than the sale increases observed during these three weeks, vendors reported that sale volumes remained mostly similar to the regular weekly average throughout the year. We are therefore confident that our results are not significantly biased by the study period.

We estimate that the total annual quantities of wildlife sold in all Sulawesi markets were 319 tons of bats, 419 tons of wild pigs, and 72 tons of snakes (Table A4). According to the middlemen interviewed, the weight of wild pigs and snakes they traded was around 10–50 kg and 7–80 kg, respectively. Therefore, these quantities could correspond to 662,551 bats, 8380–41,900 wild pigs, and 900–10,285 snakes sold annually in North Sulawesi markets. These quantities are likely underestimates because wildlife meat sold in supermarkets and restaurants was not accounted for. Moreover, these numbers do not include the wildlife sold in markets and restaurants from Central Sulawesi where we did not collect data.

Prices paid to hunters in 2018 for their flying foxes varied across regions (Fig. 4). In 2018, the price for flying foxes in Southeast Sulawesi varied from 10 K to 30 K IDR/kg. Much lower prices, around 8–15 K IDR/kg, were paid in West Sulawesi. In Central Sulawesi, flying fox prices varied from 10 to 22 K IDR/kg. The highest prices, around 35–40 K IDR/kg, were paid to hunters in Gorontalo. Prices for wild pig and snake meat paid to hunters from Southeast Sulawesi were similar (Fig. 4). Several middlemen reported that they always kept at least 10 K IDR difference between their buying and selling prices.

Flying fox prices in markets were two to five times higher than the prices paid to hunters. In markets and supermarkets, bat meat was the most expensive wild meat (50–70 K/kg and 80–89 K/kg, respectively) and wild pigs the cheapest (35–40 K/kg and 43–50 K/kg, respectively) (Fig. 4). The cost of macaque meat was around 40 K/kg or 200 K/individual in 2018. In comparison, market prices for domestic meat were around 30–35 K/kg for chicken, 50–60 K/kg for domestic pigs, 100 K/animal for cats and 35 K/kg for dogs in 2018. The weeks before Christmas and Thanksgiving, prices increased of 20–40 K IDR per kg of wild meat (bats, wild pigs, and snakes).

### 3.4. Perception of bat population trends in Sulawesi

All wildlife hunters from North Sulawesi ( $n = 19$ ) reported that wildlife populations were seriously depleted and that only rats, small bats, and in some places wild pigs remained sufficiently abundant for hunting. Respondents from the two groups of flying fox hunters we interviewed in Gorontalo and West Sulawesi provinces did not notice a population size decrease in the bat colony they harvested. However, flying fox hunters from Southeast Sulawesi observed a strong population decrease in their colony over the past few years and reported that reduced harvests had forced some hunters in the village to stop hunting. All flying fox hunters we interviewed said that they released young juveniles and babies caught accidentally by placing them on tree branches in the mangrove close to the roost. In doing so, they believed that these babies would be taken care of by other females from the colony. Several hunters and trade intermediaries from different regions also reported that they never catch or trade bats from the genus *Dobsonia*. They believed these bats were legally protected and that catching or trading them would attract police attention to their business. These hunters said they always release the *Dobsonia* bats caught accidentally. However, no *Dobsonia* species is currently legally protected in Indonesia. Most trade intermediaries reported that bat populations in Central and South Sulawesi significantly decreased over the last 10 years attributed to the displacement of bats to other regions of Sulawesi.

Several market vendors commented on difficulties obtaining wildlife from trade intermediaries. Some attributed this to the road blockades organized by the Department of Forestry to monitor wildlife transportation into North Sulawesi. Others mentioned that it was a seasonal effect.

### 3.5. Awareness of protected species law in Sulawesi

Eighty-nine percent of the vendors and 84% of the hunters interviewed were aware of the Indonesian law prohibiting the hunting and trade of protected species including anoa, babirusas, and macaques. Most reported that these species were still available in markets because the law was not enforced and the risk of getting caught was very low.

## 90 4. Discussion

### 4.1. Diversity and sustainability of the wildlife trade in Sulawesi

Species diversity of wildlife currently traded in North Sulawesi markets is quite similar to the diversity observed in these markets in the early 2000s (Lee et al., 2005; Milner-Gulland and Clayton, 2002). Flying foxes, wild pigs, and rats are still among the most common and abundant taxa traded in the region. However, the large quantities of snakes (pythons) currently sold in North Sulawesi was not reported in previous work. It is possible that snakes are serving as a replacement for taxa that are becoming rare. Tarsiers, civets, and deers were regularly traded in the early 2000s (Lee et al., 2005) but they were not observed during our market surveys or reported in our hunter or vendor interviews. Protected species such as babirusa, anoa, Celebes crested macaque, and cuscus species are still hunted and traded in low numbers in several markets.

Among the four wildlife taxa most commonly traded in North Sulawesi, flying foxes were sold in the highest number of individuals and are the taxa most vulnerable to overhunting, due to their low reproductive rate and gregarious behavior which exposes large numbers of bats to a single hunter (Mickleburgh et al., 2009). Our data provide a critical update to previous studies (Lee et al., 2005; Sheherazade and Tsang, 2015). According to our estimates, the number of flying foxes annually traded in Sulawesi ranges from 662,551 to more than one million individuals with up to 20,000 to 26,000 bats harvested from a single roost annually. These quantities suggest that the Sulawesi trade in flying foxes is unsustainable. Previous work on *Pteropus* populations suggest that a take of 3–10% of the population is sustainable (Brooke and Tschapka, 2002; Epstein et al., 2009). A wild population of 6,620,000 to 22,066,000 flying fox individuals would therefore be needed in Sulawesi to sustain an annual harvest of 662,000 bats. However, there is a lack of data on baseline flying fox population size and demography in Sulawesi.

Our systematic mapping of flying fox roosts in Sulawesi provides preliminary data for long-term monitoring of bat populations on the island. We identified 45 flying fox roosts in Sulawesi, among which 38 were under active hunting pressure. It is likely that there are additional unidentified roost sites. While there are no published data on flying fox colony size in Sulawesi, colonies of *P. alecto* in Australia varied from 500 to 30,000 animals (Loughland, 1998; Vardon and Tidemann, 1999). Our own estimate based on departure counts in a colony of Gorontalo province is around 15,000 individuals. Thus, assuming a roost size of 15,000 and 30,000 individuals per site, the total flying fox population size in Sulawesi based on the 45 roosts we observed, would range from 675,000 to 1,350,000 individuals. This is well below the sustainable population size required for a 3–10% offtake, and suggests that the current rates of harvest are not sustainable in the long term. Similar conclusions were reached for other hunted Pteropodid species in Southeast Asia such as *Pteropus vampyrus* in Indonesia (Borneo) (Struebig et al., 2007; Harrison et al., 2011), Malaysia (Epstein et al., 2009), and the Philippines (Scheffers et al., 2012); *P. tonganus* on Niue Island (Brooke and Tschapka, 2002) and Solomon Islands (Lavery and Fasi, 2017) in the South Pacific Ocean; and in Africa such as *Eidolon helvum* in Ghana (Kamins et al., 2011). Intense hunting during birthing season, as reported in most provinces of Sulawesi during our study, may also increase the unsustainability of the trade. Moreover, unintended collateral mortality from bats may happen when using some hunting techniques such as air rifles which injure bats that escape and die later without being caught by hunters. The total bat mortality due to the trade may therefore be higher than our estimated

number of bats sold in markets. Further, the lack of information on migration between Sulawesi and other major islands suggests source-sink dynamics may artificially be inflating the sustainability of the bat harvest in Sulawesi (Breed et al., 2010). While this is a key conservation concern, it may also have a significant economic impact, through loss of pollination and seed dispersal ecosystem services (Aziz et al., 2017; Oleksy et al., 2015; Sheherazade et al., 2019).

The other taxa most commonly traded in North Sulawesi, wild pigs, snakes, and rats, present a lower risk of overhunting as they are traded in lower numbers and have higher reproduction rates than flying foxes (Macdonald, 1993; Shine et al., 1999). All are considered nuisance animals in most regions of Sulawesi. However, declines in their populations may have an impact on the ecosystems that have not yet been assessed. Wild pigs and pythons are also commercially hunted and traded in other regions of Southeast Asia where population declines were observed (Bennett et al., 2000; Kawanishi et al., 2013; Luskin et al., 2014; Nijman et al., 2012; Scheffers et al., 2012; Shine et al., 1999).

#### 4.2. Current extent of the wildlife trade network in Sulawesi

The trade network to supply wild meat to the markets of North Sulawesi is well organized and extends across the whole island. Hunters and trade intermediaries are established in all provinces of the island. The network is dynamic, open, and redundant, with numerous people playing similar roles (Phelps et al., 2016). There is no restriction on participation and any hunter can access the market easily. Local dealers and middlemen actively seek out hunters and new sources of wild meat. Hooked ropes, the most commonly used technique to hunt flying foxes, can be considered as passive hunting, easy to implement in addition to other daily activities. It requires little effort, skill, and time and low economic investment. It is therefore an opportunistic source of income for villagers living close to bat roosts. Similar hunting techniques using hooked roped and kites have been observed in other regions of Southeast Asia, including Malaysia and the Philippines (Mickleburgh et al., 2009; Mildenstein et al., 2016; Shively, 1997).

We clearly observed that middlemen reacted to wildlife population decline in North Sulawesi and Gorontalo provinces by displacing effort to other provinces or by targeting other taxa. The results of our flying fox roost survey show that a third of the flying fox hunting sites are now located in Southeast Sulawesi, mostly in the southern part of the province, while this province was the least import source of flying foxes a few years ago (Sheherazade and Tsang, 2015). This region is the furthest and most difficult to reach from North Sulawesi, which explains why it has been the last to be colonized by middlemen. Our study also shows that, despite the seasonality of bat hunting in most provinces, the supply in North Sulawesi markets remains mostly stable throughout the year as middlemen and trade intermediaries adapt to hunting seasonality and get bats from different regions at different periods of the year.

#### 4.3. Economics

Wildlife hunting in Sulawesi is mostly for commercial purposes and prices for flying foxes paid to hunters by middlemen varied widely across regions. The highest prices were paid to hunters in Gorontalo, where the supply is low and the demand from middlemen is high as this is the closest province from North Sulawesi and long trips are not required. Compared to the prices in West and Central Sulawesi, prices paid in Southeast Sulawesi are quite high, despite the remoteness of this province. This might be explained by strong competition between trade intermediaries in a region where a large number of local dealers and middlemen are active. Hunters in Southeast Sulawesi can choose to sell their bats to trade intermediaries offering the highest price after negotiations over the phone. This is likely not possible in West Sulawesi as only one middleman visited the region where we interviewed bat hunters. During the high season, a flying fox hunter in Southeast Sulawesi can earn around 20 million IDR per month, which is 10 times the minimum monthly wage in the province based on government standards.

Flying fox selling prices in markets also varied, Tomohon and Karombasan markets were the most expensive. Prices for other wild meat were more similar across markets. Prices for wild meat in 2018–2019 were three to four times higher than the prices in 1999 adjusted for inflation and bat meat was already more expensive than other meat at that time (Milner-Gulland and Clayton, 2002). This price increase after adjustment for inflation over the last 20 years may reflect wildlife population decrease in Sulawesi and the increased difficulty to supply markets of North Sulawesi. Future climate change may increase this difficulty as the future distribution of *Pteropus* species is predicted to change in some regions of their distribution range (Daszak et al., 2013).

#### 4.4. Potential strategies for wildlife trade management in Sulawesi

Indonesian law states that anyone who trades, keeps, or kills a protected species may be jailed for up to five years and/or fined up to 100 million Indonesia rupiahs (7000 USD) (Government Regulation No. 7, 1999). The trade of unprotected wildlife species also requires a legal permit and is allowed only if a quota is allocated for the species. These quotas are determined annually by the Natural Resources Conservation Agency (BKSDA) under the Directorate General of Forest Protection and Nature Conservation (PHKA) at the Ministry of Environment and Forestry. However, a high number of wildlife species, including flying foxes, do not have a hunting quota allocated so that their capture and trade is technically illegal (Bergin et al., 2018; Shepherd et al., 2016). Three flying fox species (*Acerodon humilis*, *Pteropus pumilus* and *Neopteryx frosti*) are currently legally protected (Environment and Forestry Ministry in 2018, Decree No. P.20/MENLHK/SETJEN/KUM.1/6/2018). However,



the flying fox species most commonly traded in Sulawesi (*Acerodon celebensis*, *Pteropus alecto* and *P. griseus*) are not legally protected and have no allocated hunting quotas. The inclusion of *Acerodon celebensis* and *Pteropus griseus* on the protected list would likely be a very significant and simple conservation policy, as their distribution ranges are mostly limited to Sulawesi where these species are massively hunted. Our study demonstrates that poaching and hunting of protected species occurs on the island. A high proportion of respondents were aware of the protected species laws but suggested that the risk of getting caught was low. This highlights a need for stricter law enforcement targeting market vendors and middlemen in coordination with the BKSDA and the Ministry of Transportation. Hunting quotas for species that are not protected and their strict implementation are also needed. Our study suggests that there would be high value in ecological research and field studies to monitor wildlife populations in Sulawesi including the quantification of the impact of the trade on their demography and on the ecosystem services they provide. This information would provide the basis for determining sustainable harvesting quotas for each species.

Educational outreach to communities in North Sulawesi around wildlife conservation would likely help highlight the importance of maintaining sustainable trading levels and it would be particularly useful targeted to those living close to hunting sites for bats, wild pigs, and snakes. In particular, the pest status of these species could be addressed by highlighting the ecosystem services they provide. This could include eco-tourism activities, which our study demonstrates has incite local communities to conserve bat roosts. Educational campaigns are already ongoing in North Sulawesi, with mixed results (Gursky and Fields, 2018). In particular, changing the wildlife consumption habits of Minahasan people is challenging as this behavior is considered to be a source of cultural pride.

Reducing consumer demand through the use of economic incentives would also likely be a valuable approach to conservation. Our survey showed that the price for domestic pig meat is higher than the price for snake or wild pig meat and similar to the price for flying fox meat. Strategies to provide a cheaper domestic alternative to wild meat in North Sulawesi would therefore potentially reduce demand for wild meat.

Finally, providing opportunities for alternative livelihoods to hunters may also be a solution to overhunting. Bat hunting is considered as "easy money" and is an important source of income for hunters, but most of them also have other activities such as farming and fishing that could be further developed. We observed that hunters in regions of Southeast Sulawesi where bat populations are declining and where hunting is less profitable than a few years ago were willing to find an alternative to hunting with the support of the local government. Middlemen could be a key target for intervention as a small number of them trade high volume of animals.

## 5. Conclusion

Our study showed that hundreds of thousands of bats, wild pigs, snakes, and rats are still hunted and traded annually in Sulawesi through a well-organized and dynamic network involving many actors. Flying fox hunting is an important source of income in Sulawesi, as it is easy to implement in conjunction with other daily activities, and hunters can readily access to the market. However, our analysis suggests current rates of flying fox harvests are significantly unsustainable, and that population declines have already affected the availability of wild meat. Trade intermediaries have reacted to the declines in North Sulawesi and Gorontalo provinces by displacing effort to the furthest provinces, where populations are now declining. We also demonstrate that trade of protected species is still ongoing too, but a lower scale, in North Sulawesi where there is an urgent need for stricter law enforcement. Implementation of hunting quotas as well as research and conservation efforts are also urgently needed to improve the sustainability of the wildlife trade in Sulawesi as the impact of this trade on Sulawesi local ecosystems remains mostly unknown.

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### Declaration of competing interest

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

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### Appendices



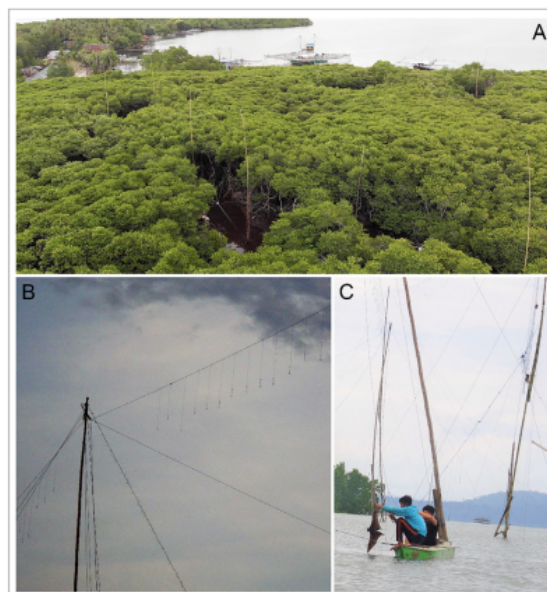
**Fig. A1.** (A) Wild meat for sale at Tareran market; (B) Wild meat (bats, wild pigs and birds) for sale at Dumoga market; (C) Wild meat (macaque, snakes and wild pigs) for sale at Dumoga market (pictures: Suryo Saputro/Alice Latinne).



**Fig. A2.** (A) Rat roasting in Kawangkoan market; (B) Roasted rats for sale at Tomohon market; (C) Roasted bats for sale at Tomohon market; (D) Wild meat (wild pigs, snakes, and bats) and dogs for sale at Tomohon market (pictures: Suryo Saputro/Alice Latinne).



**Fig. A3.** (A) Wild meat (wild pigs, rats, and bats) for sale in a supermarket in Manado; (B) Wild meat cooked in a Minahasan restaurant in North Sulawesi; (C) Pythons in a freezer in a middleman's house in Tomohon (pictures: Suryo Saputro/Alice Latinne).



**Fig. A4.** Flying fox hunting techniques in Sulawesi: (A) Drone photo showing poles holding nets around a roost of Sulawesi flying foxes in South Sulawesi; (B) Hooked ropes and bamboo poles in Southeast Sulawesi; (C) Hunter removing a black flying fox from hooked ropes in Southeast Sulawesi (pictures: Suryo Saputro/Alice Latinne).



**Fig. A5.** Quantities of large fruit bats, wild pigs, rats and snakes sold every day in Langowan (A), Kawangkoan (B), Tomohon (C), Karombasan (D) and Tareran (E) markets and total quantities sold in these five markets every week (F) from November 12, 2018 to January 31, 2019. Quantities are in kg, except for rats where quantities are given in numbers of individuals sold. The three days before Christmas (December 22–24, 2018) and New Year (December 29–31, 2018) are highlighted in grey.

**Table A1**  
Markets surveyed in North Sulawesi province in 2018–2019 and wildlife taxa sold in these markets

District	Subdistrict	City/Market	Wildlife for sale	Taxa	Market days	Number of wildlife vendors
Bolaang Mongondow	West Dumoga	Ibolian	Yes	Bats, Snakes, Wild pigs, Rats, Monkeys, Anoa, Squirrels, Monitor Lizards	Tue-Thu-Sun	7
Bolaang Mongondow	East Dumoga	Dumoga	Yes	Bats, Snakes, Wild pigs, Rats, Monkeys, Anoa, Squirrels, Monitor Lizards	Tue-Fri	7
Bolaang Mongondow	East Dumoga	Imandi	Yes	Bats, Snakes, Wild pigs, Rats, Monkeys, Anoa, Squirrels, Monitor Lizards	113 Mon-Wed-Sat	7
South Minahasa	Modoinding	Modoinding	Yes	Bats, Snakes, Wild pigs, Rats, Monkeys, Cuscus	Mon-Wed-Fri	10
South Minahasa	Tompaso Baru	Tompaso Baru	Yes	Bats, Rats, Wild pigs, Anoa, Snakes, Monkeys, Cuscus	Tue-Sat	10
South Minahasa	Ranoyapo	Poopo	Yes	Bats, Rats	114 Mon-Tue-Wed-Fri	5
South Minahasa	Motoling	Motoling	Yes	Bats, Snakes, Wild pigs, Rats, Monkeys, Anoa, Cuscus, Babirusa	Thu	11
South Minahasa	Sinon Sayang	Ongkaw	Yes	Bats, Snakes, Wild pigs, Rats	Mon-Sat	3
South Minahasa	Tenga	Tenga	Yes	Wild pigs, Rats, (Snakes)	11 -Wed-Fri	2
South Minahasa	Amurang	Amurang	Yes	Bats, Snakes, Wild pigs, Rats, (Monkeys)	Mon-Tue-Wed-Thu-Fri-Sat-Sun	6
South Minahasa	Tumpaan	Tumpaan	Yes	Bats, Snakes, Wild pigs	Mon-Tue-Wed-Thu-Fri-Sat-Sun	6
South Minahasa	Tareran	Tareran	Yes	Bats, Snakes, Wild pigs, Rats	Mon-Wed-Fri	2
Southeast Minahasa	Tombatu	Tombatu	Yes	Bats, Snakes, Wild pigs, Rats	11 -Wed-Sat	1–2
Southeast Minahasa	Ratahan	Ratahan	Yes	Bats, Snakes, Wild pigs, Rats	Mon-Tue-Wed-Thu-Fri-Sat-Sun	5
Minahasa	North Langowan	Langowan	Yes	Bats, Snakes, Wild pigs, Rats	Tue-Thu-Sat	7–11
Minahasa	North Kawangkoan	Kawangkoan	Yes	Bats, Snakes, Wild pigs, Rats, Anoa, Babirusa, Frogs, (Monkeys)	Mon-Thu-Sat	7–11
Minahasa	Sonder	Sonder	Yes	Bats, Snakes, Wild pigs, Rats	Mon-Wed-Fri	36
Minahasa	West Tompaso	Tompaso	Yes	Bats, Snakes, Wild pigs, Rats	Wed-Fri	2
Tomohon City	East Tomohon	Tomohon	Yes	Bats, Snakes, Wild pigs, Rats, Monitor Lizards, Frogs, Cuscus, Monkeys, Anoa, Babirusa	Mon-Tue-Wed-Thu-Fri-Sat-Sun	6–10
North Minahasa	Airmadidi	Airmadidi	Yes	Bats, Snakes, Wild pigs, Rats	11 Thu-Sat	2
Manado City	Wanea	Karombasan	Yes	Bats, Snakes, Wild pigs, Rats	Mon-Tue-Wed-Thu-Fri-Sat-Sun	2
Manado City	Wenang	Bersehati	Yes	Wild pigs, other taxa if ordered	Mon-Tue-Wed-Thu-Fri-Sat-Sun	1
Manado City	Mapanget	Paniki	Yes	Bats, Snakes, Wild pigs, Rats	Mon-Tue-Wed-Thu-Fri-Sat-Sun	1
Minahasa	East Langowan	Old Langowan	Occasion.	Bats	11 -Wed-Fri	Unknown
Bitung City	Girian	Girian	Occasion.	Wild pigs, other taxa if ordered	Mon-Tue-Wed-Thu-Fri-Sat-Sun	Unknown
Minahasa	Remboken	Remboken	Occasion.	Wild pigs, other taxa if ordered	Mon-Tue-Wed-Thu-Fri-Sat-Sun	Unknown
North Minahasa	Dimembe	Tatelu	Occasion.	Wild pigs, other taxa if ordered	11 -Tue-Wed-Thu-Fri-Sat-Sun	Unknown
Minahasa	West Tondano	Tondano	No	NA	Mon-Tue-Wed-Thu-Fri-Sat	NA
North Minahasa	Airmadidi	Sukur	No	NA	Tue-Thu-Sat	NA
North Minahasa	Kauditan	Kauditan	No	NA	Mon-Wed-Fri-Sun	NA
North Minahasa	Dimembe	Matungkas	No	NA	Mon-Wed-Fri-Sun	NA

**Table A2**

Flying fox roosts identified in Sulawesi and their hunting status in 2018–2019. Map numbers refer to Fig. 3. Pa, *Pteropus alecto*; Ac, *Acerodon celebensis*; Pg, *Pteropus griseus*.

Map #	Province	District	Subdistrict	Species	Habitat	Hunting
1	Gorontalo	North Gorontalo	Kwandang	Pa, Ac	Coastal mangrove swamp	Yes
2	Gorontalo	North Gorontalo	Sumalata		Coastal mangrove swamp	Unknown
3	Gorontalo	Boalemo	Paguyaman Pantai	52, Ac	Coastal mangrove swamp	Yes
4	Gorontalo	Boalemo	Tilamuta	Ac	Coastal mangrove swamp	Yes
5	Gorontalo	Boalemo	Tilamuta	Pa	Coastal mangrove swamp	Yes
65	Gorontalo	Pohuwato	Lemito	Pa	Coastal mangrove swamp	Yes
7	Central	Buol	Lakea		Coastal mangrove swamp	Yes
8	Central	Toli Toli	Basidondo	Pa	Mainland forest	Yes
9	Central	Toli Toli	Dondo		Coastal mangrove swamp (Nipa palm)	Yes
10	Central	Donggala	Sojol		Coastal mangrove swamp (Nipa palm)	Yes
11	Central	Donggala	Sojol	Pa, Ac	Coastal mangrove swamp (Nipa palm)	Yes
12	Central	Donggala	Damsol		Lake mangrove swamp (Nipa palm)	Yes
13	Central	Donggala	Balaesang		Coastal mangrove swamp (Nipa palm)	Yes
14	Central	Parigi Moutong	Toribulu	Pa	Coastal mangrove swamp	No
15	Central	Banggai	Bualemo	Pg	Coastal mangrove swamp	Yes
16	Central	Banggai	West Toili	Pa, Ac	Lake mangrove swamp	Yes
17	Central	Morowali	North Bungku	Pa, Ac	Coastal mangrove swamp	Yes
45	Central	Morowali	Bungku	Pg	Coastal mangrove swamp	Yes
19	West	Mamuju	Karossa		Coastal mangrove swamp	Yes
20	West	Mamuju	Mamuju	Pa, Ac	Island forest	Yes
21	West	Majene	Tabu	Pa, Ac	Coastal mangrove swamp	Yes
22	West	Majene	Sendana	Pa, Ac	Coastal mangrove swamp	Yes
23	South	Pinrang	Suppa		Coastal mangrove swamp	Unknown
24	South	Baru	Balusu	Pa, Ac	Coastal mangrove swamp	Yes
25	South	Pangkajene Kepulauan	Liukang Tupabbiring		Coastal mangrove swamp	Yes
26	South	Maros	Simbang	Pa, Ac	Residential area	No
27	South	East Sinjai	Tongke Tongke		Coastal mangrove swamp	Yes
28	South	Soppeng	Lalabata	Pa	Residential area	No
29	South	Wajo	Sajoanging		Coastal mangrove swamp	Yes
30	South	North Luwu	Bonebone	52	Coastal mangrove swamp	Yes
31	Southeast	North Kolaka	Ngapa	Pa	Coastal mangrove swamp	Yes
32	Southeast	Konawe	Puriala	Pa	Lake mangrove swamp	Yes
33	Southeast	Kolaka	Watubangga	Pa, Ac	Coastal pine trees	No
34	Southeast	Bombana	Poleang		Coastal mangrove swamp	Yes
35	Southeast	Konawe Selatan	Tinanggea	Pa, Ac	Coastal mangrove swamp	Yes
36	Southeast	Konawe Selatan	Laya	Pa	Coastal mangrove swamp	Yes
37	Southeast	Muna	North Tiworo		Coastal mangrove swamp	Yes
38	Southeast	Bau Bau			Coastal mangrove swamp	Yes
39	Southeast	Wakatobi	South Wangi-Wangi	Ac	Coastal pine trees	No
40	Southeast	Buton	Kapuntori		Coastal mangrove swamp	Yes
41	Southeast	Muna	South Wakonumba	Pa	Coastal mangrove swamp	Yes
42	Southeast	Konawe Selatan	Kolono	Pa, Ac	Coastal mangrove swamp	Yes
43	Southeast	Konawe Kepulauan	Wowoni		Coastal mangrove swamp	Yes
44	Southeast	Konawe Selatan	Moramo		Coastal mangrove swamp	Yes
45	Southeast	Konawe	Bondoala	Pa	Coastal mangrove swamp	Yes

**Table A3**

Demographic data from bats hunted in three flying fox roosts in Gorontalo, West Sulawesi and Southeast Sulawesi and estimates of the quantity of bats harvested annually in each roost. Pa, *Pteropus alecto*; Ac, *Acerodon celebensis*. A, Adults; SA, Subadults; J, Juveniles; B, babies.

Province	n	Numbers of Ac/Pa hunted (proportion in %)	Numbers of males/females hunted (proportion in %)	Average weight (g)	Numbers of A/SA/J/B hunted (proportion in %)	Estimates of annual quantity harvested (in kg/in individuals)
Gorontalo	479	116/363 (24.2/75.8)	225/254 (47/53)	493.62	298/176/2/0 (62.2/36.7/1.1/0)	11,200kg/22,736 bats
West Sulawesi	382	41/341 (10.7/89.3)	173/209 (45.3/54.7)	454.34	140/186/54/3 (36.6/48.7/14.1/0.6)	9400 kg/20,680 bats
Southeast Sulawesi	363	96/267 (26.4/73.6)	208/155 (57.3/42.7)	517.68	252/78/28/4 (69.4/21.5/7.7/1.4)	13,800 kg/26,634 bats
Global	1224	253/971 (20.7/79.3)	636/618 (52/48)	486.54	690/440/84/7 (56.4/35.9/6.9/0.8)	

**Table A4**  
Quantities (in kg or individuals) of large fruit bats, wild pigs, rats and snakes sold annually in North Sulawesi markets and estimated from daily observations (bold), vendor interviews or general estimates (italics).

Markets	Large fruit bats (kg)	Wild pigs (kg)	Rats (individuals)	Snakes (kg)	Source
Tomohon	<b>46,692</b>	<b>26,710</b>	<b>5594</b>	<b>6199</b>	Daily obs.
Karombasan	<b>16,743</b>	<b>16,413</b>	<b>149</b>	<b>8935</b>	Daily obs.
Kawangkoan	<b>25,410</b>	<b>41,956</b>	<b>2675</b>	<b>3636</b>	Daily obs.
Langowan	<b>30,505</b>	<b>134,312</b>	<b>3373</b>	<b>6080</b>	Daily obs.
Tareran	<b>3671</b>	6240	<b>1413</b>	1890	Daily obs.
Ibolian/Dumogo/Imandi	8372	21,840	7800	5460	Interviews
Modoinding	48,360	31,200	NA	7800	Interviews
Motoling/Poopo/Tompaso Baru	57,200	34,320	NA	8580	Interviews
Sonder	24,960	15,600	NA	3120	Interviews
Amurang	31,200	18,720	NA	4680	Interviews
Ongkaw	2600	9360	NA	2340	Estimate
Tumpaan	5200	18,720	NA	4680	Estimate
Tombatu	5200	3120	NA	780	Estimate
Ratahan	2600	15,600	NA	3900	Estimate
Tompaso	2600	6240	NA	1560	Estimate
Aimadidi	5200	6240	NA	1560	Estimate
Bersehati	Not sold	3120	NA	Not sold	Estimate
Paniki	2600	3120	NA	780	Estimate
Tenga	Not sold	6240	NA	Not sold	Estimate
<b>Total</b>	<b>319,113</b>	<b>419,071</b>	<b>21,004</b>	<b>71,980</b>	

**References**

17 Aziz, S.A., Clements, G.R., McConkey, K.R., Sritongchuy, T., Pathil, S., Abu Yazid, M.N.H., Campos-Arceiz, A., Forget, P.-M., Bumrungsri, S., 2017. Pollination by the locally endangered island flying fox (*Pteropus hypomelanus*) enhances fruit production of the economically important durian (*Durio zibethinus*). *Ecol. Evol.* 7, 8670–8684.

27 Bennett, E.L., Nyaoi, A.J., Sompud, J., 2000. Saving Borneo's bacon: the sustainability of hunting in Sarawak and Sabah. In: Robinson, J.G., Bennett, E.L. (Eds.), *Hunting for Sustainability in Tropical Forests*. Columbia University Press, New York, pp. 305–324.

7 Bergin, D., Chng, S.C.L., Eaton, J.A., Shepherd, C.R., 2018. The final straw? An overview of Straw-headed Bulbul *Pycnonotus zeylanicus* trade in Indonesia. *Bird Conserv. Int.* 28, 126–132.

50 Breed, A., Field, H., Smith, C., Edmonston, J., Meers, J., 2010. Bats without borders: long-distance movements and implications for disease risk management. *EcoHealth* 7, 204–212.

20 Brooke, A.P., Tschapka, M., 2002. Threats from overhunting to the flying fox, *Pteropus tonganus*, (Chiroptera: Pteropodidae) on Niue island, South Pacific Ocean. *Biol. Conserv.* 103, 343–348.

43 Clayton, L., Milner-Gulland, E., 2000. The trade in wildlife in North Sulawesi, Indonesia. In: Robinson, J.G., Bennett, E.L. (Eds.), *Hunting for Sustainability in Tropical Forests*. Columbia University Press, New York, pp. 473–496.

35 Des, B., 2005. *Black Market: inside the Endangered Species Trade in Asia*. Earth Aware Editions.

Daszak, P., Zambrana-Torrel, C., Bogich, T.L., Fernandez, M., Epstein, J.H., Murray, K.A., Hamilton, H., 2013. Interdisciplinary approaches to understanding disease emergence: the past, present, and future drivers of Nipah virus emergence. *Proc. Natl. Acad. Sci.* 110, 3681–3688.

7 Minin, E., Brooks, T.M., Toivonen, T., Butchart, S.H.M., Heikinheimo, V., Watson, J.E.M., Burgess, N.D., Challender, D.W.S., Goettsch, B., Jenkins, R., Moilanen, A., 2019. Identifying global centers of unsustainable commercial harvesting of species. *Sci. Adv.* 5, eaau2879.

15 Feinstein, J.H., Olival, K.J., Pulliam, J.R.C., Smith, C., Westrum, J., Hughes, T., Dobson, A.P., Zubaïd, A., Rahman, S.A., Basir, M.M., Field, H.E., Daszak, P., 2009. *Pteropus vampyrus*, a hunted migratory species with a multinational home-range and a need for regional management. *J. Appl. Ecol.* 46, 991–1002.

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

38 Ky, S., Fields, L., 2018. The link between conservation and education. *Primate Conserv.* 32, 153–157.

Harrison, M.E., Cheyne, S.M., Darma, F., Ribowo, D.A., Limin, S.H., Struebig, M.J., 2011. Hunting of flying foxes and perception of disease risk in Indonesian Borneo. *Biol. Conserv.* 144, 2441–2449.

37 Harrison, R.D., Sreekar, R., Brodie, J.F., Brook, S., Luskin, M., O'Kelly, H., Rao, M., Scheffers, B., Velho, N., 2016. Impacts of Hunting on Tropical Forests in Southeast Asia. *Conserv. Biol.* 30, 972–981.

19 S., K.E., Purvis, A., Gittleman, J.L., 2003. Biological correlates of extinction risk in bats. *Am. Nat.* 161, 601–614.

Kamins, A.O., Restif, O., Ntiamao-Baidu, Y., Suu-Ire, R., Hayman, D.T.S., Cunningham, A.A., Wood, J.L.N., Rowcliffe, J.M., 2011. Uncovering the fruit bat bushmeat commodity chain and the true extent of fruit bat hunting in Ghana, West Africa. *Biol. Conserv.* 144, 3000–3008.

25 Kawanishi, K., Clements, G.R., Gumal, M., Goldthorpe, G., Yasak, M.N., Sharma, D.S.R., 2013. Using BAD for good: how best available data facilitated a precautionary policy change to improve protection of the prey of the tiger *Panthera tigris* in Malaysia. *Oryx* 47, 420–426.

20 Fry, J.H., Fasi, J., 2017. Buying through your teeth: traditional currency and conservation of flying foxes *Pteropus* spp. in Solomon Islands. *Oryx* 53, 505–512.

Lee, R., 2000. Impact of subsistence hunting in North Sulawesi, Indonesia, and conservation options. In: *Hunting for Sustainability in Tropical Forests*. Columbia University Press, New York, pp. 455–472.

48 Lee, R.J., 1997. The Impact of Hunting and Habitat Disturbance on the Population Dynamics and Behavioral Ecology of the Crested Black Macaque (*Macaca nigra*). University of Oregon, Eugene, OR.

24 Lee, R.J., Gorog, A.J., Dwyahreni, A., Siwu, S., Riley, J., Alexander, H., Paoli, G.D., Ramono, W., 2005. Wildlife trade and implications for law enforcement in Indonesia: a case study from North Sulawesi. *Biol. Conserv.* 123, 477–488.

Lee, T.M., Sodhi, N.S., Prawiradilaga, D.M., 2009. Determinants of local people's attitude toward conservation and the consequential effects on illegal resource harvesting in the protected areas of Sulawesi (Indonesia). *Environ. Conserv.* 36, 157–170.

44 Highland, R.A., 1998. Mangal root selection by the flying-fox *Pteropus alecto* (Megachiroptera : Pteropodidae). *Mar. Freshw. Res.* 49, 351–352.

40 Luskin, M.S., Christina, E.D., Kelley, L.C., Potts, M.D., 2014. Modern hunting practices and wild meat trade in the oil palm plantation-dominated landscapes of Sumatra, Indonesia. *Hum. Ecol.* 42, 35–45.

- Donald, A.A., 1993. The Sulawesi Warty Pig (*Sus Celebensis*). In: *Pigs, Peccaries and Hippos Status Survey and Action Plan*. IUCN.
- Mickleburgh, S., Waylen, K., Racey, P., 2009. Bats as bushmeat: a global review. *Oryx* 43, 217–234.
- Mildenstein, T., Tanshi, L., Racey, P.A., 2016. Exploitation of bats for bushmeat and medicine. In: Voigt, C.C., Kingston, T. (Eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*. Springer.
- Per-Gulland, E.J., Clayton, L., 2002. The trade in babirusas and wild pigs in North Sulawesi, Indonesia. *Ecol. Econ.* 42, 165–183.
- Natusch, D.J.D., Lyons, J.A., 2012. Exploited for pets: the harvest and trade of amphibians and reptiles from Indonesian New Guinea. *Biodivers. Conserv.* 21, 2899–2911.
- Niiman, V., 2010. An overview of international wildlife trade from Southeast Asia. *Biodivers. Conserv.* 19, 1101–1114.
- Niiman, V., Shepherd, C.R., Mumpuni, Sanders, K.L., 2012. Over-exploitation and illegal trade of reptiles in Indonesia. *Herpetol. J.* 22, 83–89.
- Niiman, V., Spaan, D., Nekaris, K.A.-I., 2016. Large-scale trade in legally protected marine mollusc shells from Java and Bali, Indonesia. *PLoS One* 10, e0140593.
- Niiman, V., Spaan, D., Rode-Margono, E.J., Wirdateti, Nekaris, K.A.I., 2017. Changes in the primate trade in Indonesian wildlife markets over a 25-year period: fewer apes and langurs, more macaques, and slow lorises. *Am. J. Primatol.* 79, e22517.
- Orlowsky, R., Racey, P.A., Jones, G., 2015. High-resolution GPS tracking reveals habitat selection and the potential for long-distance seed dispersal by Madagascar flying foxes *Pteropus rufus*. *Glob. Ecol. Conserv.* 3, 678–692.
- Ops, J., Biggs, D., Webb, E.L., 2016. Tools and Terms for Understanding Illegal Wildlife Trade. *Frontiers in Ecology* 14, 479–489.
- Scheffers, B.R., Corlett, R.T., Diesmos, A., Laurance, W.F., 2012. Local demand drives a bushmeat industry in a Philippine forest preserve. *Trop. Conserv. Sci.* 5, 133–141.
- Schipper, J., Chanson, J.S., Chiozza, F., Cox, N.A., Hoffmann, M., Katariya, V., Lamoreux, J., Rodrigues, A.S.L., Stuart, S.N., Temple, H.J., Baillie, J., Boitani, L., Lacher, T.E., Mittermeier, R.A., Smith, A.T., Absolon, D., Aguiar, J.M., Amori, G., Bakkour, N., Baldi, R., Berridge, R.J., Bielby, J., Black, P.A., Blanc, J.J., Brooks, T. M., Burton, J.A., Butynski, T.M., Catullo, G., Chapman, R., Cokeliss, Z., Collen, B., Conroy, J., Cooke, J.G., da Fonseca, G.A.B., Derocher, A.E., Dublin, H.T., Duckworth, J.W., Emmons, L., Emslie, R.H., Festa-Bianchet, M., Foster, M., Foster, S., Garshelis, D.L., Gates, C., Gimenez-Dixon, M., Gonzalez, S., Gonzalez-Maya, J.F., Good, T.C., Hammerson, G., Hammond, P.S., Happold, D., Happold, M., Hare, J., Harris, R.B., Hawkins, C.E., Haywood, M., Heaney, L.R., Hedges, S., Helgen, K.M., Hilton-Taylor, C., Hussain, S.A., Ishii, N., Jefferson, T.A., Jenkins, R.K.B., Johnston, C.H., Keith, M., Kingdon, J., Knox, D.H., Kovacs, K.M., Langhammer, P., Leus, K., Lewison, R., Lichtenstein, G., Lowry, L.F., Macavoy, Z., Mace, G.M., Mallon, D.P., Masi, M., McKnight, M.W., Medellin, R.A., Medici, P., Mills, G., Moehlman, P.D., Molur, S., Mora, A., Nowell, K., Oates, J.F., Olech, W., Oliver, W.R.L., Oprea, M., Patterson, B.D., Perrin, W.F., Polidoro, B. A., Pollock, C., Powell, A., Protas, Y., Racey, P., Ragle, J., Ramani, P., Rathbun, G., Reeves, R.R., Reilly, S.B., Reynolds, J.E., Rondinini, C., Rosell-Ambal, R.G., Rulli, M., Rylands, A.B., Savini, S., Schank, C.J., Sechrest, W., Self-Sullivan, C., Shoemaker, A., Sillero-Zubiri, C., De Silva, N., Smith, D.E., Srinivasulu, C., Stephenson, P.J., van Strien, N., Talukder, S., Taylor, B.L., Timmins, R., Tiñira, D.G., Tognelli, M.F., Tsytsulina, K., Veiga, L.M., Vie, J.C., Williamson, E.A., Wyatt, S.A., Zhai, Y., Young, B.E., 2008. The status of the world's land and marine mammals: diversity, threat, and knowledge. *Science* 322, 225–230.
- Sheherazade, Tsang, S.M., 2015. Quantifying the bat bushmeat trade in North Sulawesi, Indonesia, with suggestions for conservation action. *Glob. Ecol. Conserv.* 3, 324–330.
- Sheherazade, Ober, H.K., Tsang, S.M., 2019. Contributions of bats to the local economy through durian pollination in Sulawesi, Indonesia. *Biotropica* 51, 913–922.
- Shepherd, C.R., Eaton, J.A., Chng, S.C.L., 2016. Nothing to laugh about – the ongoing illegal trade in laughingthrushes (*Garrulax* species) in the bird markets of Java, Indonesia. *Bird. Conserv. Int.* 26, 524–530.
- Shepherd, C.R., Ambariyanto, Harlow, P.S., Mumpuni, 1999. Reticulated pythons in Sumatra: biology, harvesting and sustainability. *Biol. Conserv.* 87, 349–357.
- Stuart, G.E., 1997. Poverty, technology, and wildlife hunting in Palawan. *Environ. Conserv.* 24, 57–63.
- Stuebig, M.J., Harrison, M.E., Cheyne, S.M., Limin, S.H., 2007. Intensive hunting of large flying foxes *Pteropus vampyrus natunae* in Central Kalimantan, Indonesian Borneo. *Oryx* 41, 390–393.
- Vardon, M.J., Tidemann, C.R., 1999. Flying-foxes (*Pteropus alecto* and *P. scapulatus*) in the Darwin region, north Australia: patterns in camp size and structure. *Aust. J. Zool.* 47, 411–423.
- Vincenot, C.E., Florens, F.B.V., Kingston, T., 2017. Can we protect island flying foxes? *Science* 355, 1368–1370.
- Wilcove, D.S., Giam, X., Edwards, D.P., Fisher, B., Koh, L.P., 2013. Navjot's nightmare revisited: logging, agriculture, and biodiversity in Southeast Asia. *Trends Ecol. Evol.* 28, 531–540.



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---

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---

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Publication

---

36

Roberto Carlucci, Giulia Cipriano, Francesca Cornelia Santacesaria, Pasquale Ricci et al. "Exploring data from an individual stranding of a Cuvier's beaked whale in the Gulf of Taranto (Northern Ionian Sea, Central-eastern Mediterranean Sea)", *Journal of Experimental Marine Biology and Ecology*, 2020

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---

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---

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40

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48

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---

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---

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72

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73

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---

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---

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---

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---

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---

91

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---

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---

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---

95

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---

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---

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---

105 Malik Oedin, Fabrice Brescia, Mélanie Boissenin, Eric Vidal, Jean-Jérôme Cassan, Jean-Claude Hurlin, Alexandre Millon. "Monitoring hunted species of cultural significance: Estimates of trends, population sizes and harvesting rates of flying-fox (Pteropus sp.) in New Caledonia", PLOS ONE, 2019

Publication

---

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---

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---

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