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DOI: 10.1002/ajp.22517

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RESEARCH ARTICLE

Changes in the Primate Trade in Indonesian Wildlife Markets over a 25-Year Period: Fewer Apes and Langurs, More Macaques and Slow Lorises

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Indonesia is one of the richest countries in terms of the number of primate species present, and many species have been included on the country's protected species list, partially to prevent them from over-exploitation. Despite this, primates have been, and still are, commonly traded in the open wildlife markets throughout the country, and nowhere more so than on the islands of Java and Bali. We surveyed 13 wildlife markets in 2012-2014 and combined this with previous surveys conducted over the period 1990-2009 into a 122-survey dataset with 2,424 records of 17 species. These data reveal that over time the diversity of species in trade has decreased. It shifted from rare rainforest-dwelling primates traded alongside more widespread species that are not confined to forest to the latter only. In the 1990s and early 2000s orang-utans (*Pongo* spp.), siamangs (*Symphalangus syndactylus*), gibbons (*Hylobates* spp) and various langur (*Presbytis* spp and *Trachypithecus* spp) were commonly traded alongside macaques (*Macaca* spp), and slow lorises (*Nycticebus* spp) but in the last decade macaques and slow lorises comprise the bulk of the trade. In 2012-2014 we monitored six wildlife markets in Jakarta, Bandung and Garut (all on Java) and Denpasar (Bali). During 51 surveys were recorded 1,272 primates of 8 species. Long-tailed macaque (*M. fascicularis*) (total 1,007 individuals) and three species of slow loris (228 individuals) were traded in five of the six markets, whereas ebony langurs (*T. auratus*) (18 individuals) and pig-tailed macaques (*M. nemestrina*) (14 individuals) were mostly traded in Jakarta. Jatinegara and Pramuka market, both in Jakarta, stand out as important hubs for the primate trade, but with a clear shift in importance over time from the latter to the former. Slow lorises, orangutans, gibbons and some langurs are protected under Indonesian law, prohibiting all trade in them; of these protected species only the slow lorises remain common in trade throughout the 25-year period. Trade in non-protected macaques and langurs is subject to strict regulations –none of which were abided by the traders in the markets we monitored- making the trade in all primates as observed in the markets of Java and Bali illegal. Trade poses a real threat to primates in

Indonesia, and without enforcement, the sheer volume of trade may mean that species now considered Least Concern or Near Threatened may rapidly decline.

Key words: wildlife trade; CITES; Indonesia; *Nycticebus*; *Pongo*; *Macaca*; *Hylobates*; *Presbytis*

INTRODUCTION

Wildlife trade has been highlighted as a major cause of species declines and extinction risk [McNeely et al., 2009; Smith, 2009]. Internationally, South-east Asia has been identified as a hotspot for the illegal trade in wildlife [Nijman, 2010; Rosen & Smith, 2010]. The trade in primates, be it as live individuals, as body parts or as meat, is often invoked as a significant threat to their conservation [Cowlshaw & Dunbar, 2000; Eudey, 2008; Maldonado & Peck 2013; Mittermeier et al., 2009; Nijman et al., 2011; Nijman & Nekaris, 2014]. In the 1950s to early 1970s the international primate trade peaked to supply the demand for the biomedical industry and pharmaceutical markets. During this period, tens of thousands of wild-caught primates were exported from range countries each year [Mack & Mittermeier, 1984; Southwick & Siddiqi, 2001; Smith, 1978; Wolfheim, 1983]. While numbers exported in recent decades are considerably lower than before, and a significant shift has occurred towards captive-born and captive-bred primates [Nijman et al., 2011], the domestic trade in live primates within range countries remains largely undocumented [but see Ceballos-Mago & Chivers, 2010; Duarte-Quiroga & Estrada, 2003; Healy & Nijman, 2014; Jones-Engel et al., 2005; Shepherd 2010].

Indonesia is a hyper-rich country with respect to primates [Groves, 2001]. Depending on the taxonomy used the country is home to around 46 species of primates, including orangutans (*Pongo* spp), siamangs (*Symphalangus syndactylus*), gibbons (*Hylobates* spp), langurs (*Trachypithecus* spp), including proboscis monkeys (*Nasalis larvatus*) and simakobus (*Simias concolor*), macaques (*Macaca* spp), tarsiers (*Tarsius* spp) and slow lorises (*Nycticebus* spp). The country is home to many endemic species including single island endemics, especially on the islands of Sumatra, Borneo (shared politically with Malaysia and Brunei Darussalam), Java, Sulawesi and the Mentawais.

The main threat to primates in Indonesia comes from deforestation, large-scale habitat conversion and fire [Carlson et al., 2012; Koh & Ghazoul 2010; Kelle et al. 2014; Langner & Siegert 2009; Miettinen et al. 2011], but increasingly the effects of killing [Meijaard et al. 2011; Nijman 2005] and live trade [Nijman 2005; Nijman & Nekaris 2014; Shepherd, 2010] are recognized as clear impediments to their conservation. The live primate trade in Indonesia comprises the large-scale legal export of ranched or captive-born macaques [Soehartono & Mardiasuti 2001], illegal international trade [Nekaris et al., 2010] and illegal domestic trade [Shepherd, 2010]. Within Indonesia, and especially on the islands of Sumatra, Java and Bali, primates are openly traded in wildlife markets that are present in most large cities.

Listed as 55th out of 177 countries assessed in 2014, Indonesia ranks relatively high on the 'Biodiversity and Habitat' protection component of the global Environmental Performance Ranking [Hsu et al., 2014]. Compared to its neighbors, Indonesia is ranked above the Philippines (82st position) but below Malaysia (22st position) and Brunei Darussalam (tied 1st position). The relatively high rank may suggest proper protection of Indonesia's primates and their habitats. Indeed on paper, the country has more than adequate legislation in place to protect vulnerable species [Noerjito & Maryanto, 2001]. In addition, most legally and non-legally protected species of primates occur within a number of protected areas such as national parks and nature reserves where they should be safe from exploitation. Even for populations of non-protected species that are not situated within the country's protected area network, there is a comprehensive system in place to regulate all trade [Soehartono & Mardiasuti, 2001]. These laws and regulations should mean that primates cannot be openly traded within Indonesia, yet primates have been and still are commonly traded in the open wildlife markets throughout the country. These traded species include conservation icons such as Bornean orang-utans (*Pongo pygmaeus*) [Morrogh-Bernard et al. 2014], small-ranged endemics such as ebony langurs (*Trachypithecus auratus*), and Critically Endangered species such as the Javan slow loris (*Nycticebus javanicus*). Unfortunately, relatively few large-scale or long-term studies have been conducted, and fewer still published on the trade in primates in Indonesia's wildlife markets. Shepherd [2010] reported on 66 surveys in Sumatra over a 10-year period during which he recorded 1953 individuals of 10 species. Nijman [2005] reported on 335 surveys in Java and Bali over a 10-year period. Shepherd's [2010] study was restricted to three markets in one city (Medan), and Nijman's [2005] was restricted to gibbons and orangutans only, making them less than ideal for comparative purposes.

Here we try to fill this gap by focusing on the trade in primates in the open wildlife markets of the Indonesian islands of Java and Bali as observed in the period 2012-2014, and compare our results to surveys conducted in the 1990s and 2000s. A significant number of the species encountered in these markets are considered globally threatened and many are protected by Indonesian law. All international trade in them is regulated through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to which Indonesia acceded in 1978 (Table 2). The aims of our research and monitoring program are to increase the knowledge and awareness of the trade in these species, to put current practices in a historic context and to provide quantitative data that can be used for better regulation and enforcement of existing legislation.

METHODS

Data Acquisition

We conducted regular market surveys in five markets on Java between February 2012 and July 2014 and one market on Bali between July 2013 and July 2014. Three of the markets were in the country's capital Jakarta (Pramuka, Barito, Jatinegara), one in the provincial capital of West Java, Bandung (Sukahaji), one in the regency

capital of Garut (Mawar), and one in the provincial capital of Bali, Denpasar (Satria). All are known in Indonesia as '*pasar burung*' (bird market) or '*pasar satwa*' (animal market), but a range of wildlife (animals and in some markets plants) are for sale. Pramuka is one of the largest open wildlife markets in Southeast Asia. It comprises a permanent four-story building with over 200 shops occupied almost exclusively by bird traders and traders in avicultural supplies (food, cages, etc.), but a small number of traders sell primates and other mammals. Barito comprises a row of some 25 specialized bird and pet shops situated on one side of Jalan (JI, meaning Road) Barito, in south Jakarta. A small number of mobile sellers bring their cages daily to Barito. Primates are mostly sold in the permanent shops. Jatinegara comprises a series of permanent bird shops along both sides of Jl Kemuning, a side street of Jl Matraman Jaya; in addition vendors display mobile bird shops adjacent and in front of the permanent shops as well as on the curb of Jl Matraman Jaya. The macaques are sold primarily in the permanent shops, whereas the mobile shops sell macaques and additional primate species. Sukahaji is comparable to Pramuka but is of much smaller scale, and primates are sold in various permanent shops. Mawar is a small wildlife market selling a combination of birds and domesticated pets, with typically less than 25 shops in operation. Satria is a medium-sized wildlife market in the center of Denpasar where several traders offer long-tailed macaques and other mammals for sale.

In addition to monitoring the above-mentioned wildlife markets, in 2013 and 2014 we surveyed the wildlife markets in Bogor, an additional one in Bandung, three in Surabaya and one in Pasir Putih (Appendix 1). Also in 2013-2014, we obtained prices of primates at Jatinegara market; prices are first quotes and these would have gone down after bartering or when more than one primate was purchased at a time (none were). Prices were requested in Indonesian rupiah and are converted to US dollars using the exchange rate of June 2014 (1 USD = 11,900 IDR).

Primates are traded openly in the wildlife markets and there was no need to resort to undercover techniques. Typically one or two, occasionally three, surveyors often of mixed ethnicity (including in >80% of the surveys one or more of the authors of this paper) walked through markets slowly, recording numbers and species in mobile phones or by memorizing numbers and recording it in a notebook directly after having left the market. Back alleys were not surveyed. We noted species and age class (infant, juvenile, adult) when possible, and photographs were taken opportunistically. Adult slow lorises are easily identifiable when properly seen, and young ones can be distinguished when properly inspected; in the wildlife markets many slow lorises were rolled up in a ball and cages were often tucked away in dark corners, making it difficult to see the distinguishing markings. This, and the fact that many slow lorises were still very young, made it not possible for many of the surveyors to identify them all to species level. In Jatinegara in Jakarta, due to the sheer number of animals for sale and the large number of individual macaques often inhabiting the same cage, we were not always able to count the exact number of primates and resorted to giving an estimate. Masked monkeys (locally known as '*topeng monyet*'), i.e. long-tailed

macaques that perform tricks and often wear the fronts of plastic doll heads as masks, were occasionally present in some markets (e.g. Jatinegara, Pasir Putih) but given that these are not for sale, these were not included in our survey. No animals were purchased during this study.

Analysis

We obtained data from previous studies conducted on Java and Bali from 1990 [Walker, 1991], 1997 [Nijman, 2005, and unpubl. data], 2000 [Malone et al., 2002, 2004], 2002 [Webber, 2002], 2003 [Harris, 2003], and 2009 [Nursaid et al., 2009]. We included only studies that made it explicit that they recorded and counted all species, and not for instance, only protected species. Note that none of these surveys cover more than one calendar year and all were conducted in different years. Combined with our data from 2012, 2013 and 2014 these surveyors recorded primates for sale at 36 wildlife markets (Appendix 1). Survey efforts differed between markets and 23 were visited only in one or two years (although during these years they could have been surveyed multiple times). Eleven wildlife markets (three in Jakarta, three in Surabaya, two in Bandung, and one in Bogor, Malang and Denpasar each) were surveyed in at least four years, often with multiple visits within years. For an analysis of temporal changes in primate trade over time, we focus on these markets and those studies surveyed that included five or more of the frequently surveyed markets (thus excluding Walker 1991 who only included Pramuka in her survey). For these wildlife markets we calculated the mean number of individuals recorded per survey as well as the proportion of markets in which the species was offered for sale. We calculated Shannon-Wiener Diversity Index ($H = - \sum_{i=1}^S p_i \ln p_i$) and Evenness ($E = H / \ln S$), where S = total number of species recorded during a survey in a given year, p_i = the proportion of S comprising the i th species, based on what species and the total numbers of each species recorded in any given year. Combined the total number of individuals and the diversity indices provide an overview of the nature of the trade in any given year, allowing us to compare changes over time.

The taxonomy of Indonesian primates has been in a state of flux and more species are now recognized than when surveys were conducted in the 1990s [Groves, 2001; Masters et al. 2013]. Identification of certain taxa (e.g. slow lorises, gibbons, langurs) by non-experts can pose problems. To counter this for analysis we pooled numbers for the *Hylobates* gibbons, for *Presybytis* langurs, for tarsiers and for slow lorises. We used non-parametric statistics, analyzing differences within wildlife markets between years, between markets and between species. All tests were two-tailed and significance is accepted when $P < 0.05$.

Ethical Statement

Permission to conduct our research was granted by the Indonesian Institute of Sciences (1997) and Ministry of Research and Technology (2012-2014), and the work adhered to the legal requirements of Indonesia. The study

of primates in the wildlife markets was observational in nature and no institutional permission for research on animals was needed. Our research adhered to the American Society of Primatologists Principles for the Ethical Treatment of Non-human Primates; primates were not handled, and causing distress to the primates was avoided at all times (note that the traders in the markets do not follow these guidelines and the primates suffer a great deal of distress, uncomfot, pain and suffering, both in the markets and during capture and transport to and between markets). Discussions with traders followed the ethical guidelines proposed by the Association of Social Anthropologists of the UK and Commonwealth.

RESULTS

Numbers and Species Composition in 2012-2014

We observed 1272 primates of 8 species during 51 surveys in 5 of the 6 wildlife markets we monitored. The most abundant was the long-tailed macaque, with 1007 individuals, followed by the three species of slow loris, with 228 individuals. Of the slow lorises, we could identify 58% to the species level. All belonged to one of three Indonesian slow loris species, i.e. *N. coucang* (76% of the identified individuals), *N. javanicus* (17%) or *N. menegensis* (7%). Apart from the slow lorises and Javan langurs, we saw no other protected primate species, such as orangutans, gibbons, or tarsiers.

We observed long-tailed macaques in each of the five wildlife markets where we observed primates, and slow lorises were present in four (not in Satria, Bali, although we did observe Javan slow loris skins and bones: [Nijman & Nekaris, 2013]) (Table 1). We encountered ebony langur (18 individuals). Sumatran langur (1 individual) and silvered langur (1 individual) only at Jatinegara, and pig-tailed macaques (14 individuals) were present in Jatinegara and Satria.

Insert Table 1 here

The wildlife markets differed in the numbers of long-tailed macaques openly for sale (Kruskal Wallis One-way Analysis of Variance, $H = 42.13$, $df=5$, $P < 0.0001$), even when Mawar, where we recorded no macaques during 11 surveys, is excluded ($H = 27.31$, $df=4$, $P < 0.0001$). Restricting the analysis to the three Jakarta markets only, the numbers recorded differ significantly between markets ($H = 18.69$, $df=2$, $P < 0.0001$). Pairwise comparisons show that Jatinegara differs from all the other markets (Mann Whitney $U > 5.17$, $df=1$, $P < 0.05$ for all comparisons), apart from Satria market ($U = 0.23$, $df=1$, $P = 0.64$). Both Jatinegara and Satria offered large numbers of long-tailed macaques for sale, typically between 20 and 50 per survey, which is at least double that of what we recorded in the other markets. The other markets did not differ significantly from one another. Despite having recorded more slow lorises in Jatinegara than in the other two Jakarta markets, the number of slow lorises openly for sale did not differ between the three markets in Jakarta ($H = 5.80$, $df=2$, $P = 0.055$).

The number of surveys we conducted in Jatinegara was sufficient to explore differences between years. For long-tailed macaques we did not find a significant difference between years ($H = 3.298$, $df=2$, $P = 0.192$) but for the slow lorises we did ($H = 10.695$, $df=2$, $P < 0.01$). Pairwise comparisons revealed that in 2012 more slow lorises were observed than in 2013 ($U = 5.76$, $df=1$, $P < 0.02$) and in 2014 ($U = 8.30$, $df=1$, $P < 0.01$), but the difference between 2013 and 2014 was not significant ($U = 0.348$, $df=1$, $P = 0.56$).

The asking price for a non-adult long-tailed macaque at Jatinegara was USD 40 ± 13 ($N=7$) and for a pig-tailed macaque USD 70 ± 10 ($N=3$). The asking price of a young slow loris at Jatinegara was slightly higher than that of an adult (USD 75 vs USD 58); combining all age classes the mean asking price was USD 63 ± 52 ($N=10$). If these prices are representative for the other markets surveyed in 2012-2014 as well, then the combined monetary value of the primates observed over the three-year period was in the order of USD 47,000. The monetary value of the protected slow lorises comprises 14% of this total.

Changes Over Time

The dataset from 111 surveys of eleven wildlife markets in Java and Bali contained 2,062 records of at least 17 species (Table 2). We recorded long-tailed macaques as present in most of the markets most of the time, slow lorises between 60-100% of the time, pig-tailed macaques 0-40% and ebony langurs between 0-60%. The distribution of the main taxa (apes, macaques, langurs, slow lorises) over three time periods (1997-2000; 2002-2009; 2012-2014) was not homogeneously distributed ($\chi^2 = 133.9$, $df=6$, $P < 0.001$). Pairwise comparisons reveal that compared to all the other primates combined apes were particularly abundant in trade in 1997-2000 ($\chi^2 = 30.2$, $df=1$, $P < 0.001$) and again compared to all the other primates combined langurs were particularly abundant in the period 2002-2009 ($\chi^2 = 27.9$, $df=1$, $P < 0.001$). Compared to all the other species in trade, macaques were less abundant in 1997-2000 than in the 2002-2009 or 2012-2014. Compared to all the other primates combined slow lorises did not show any peak or lull in numbers observed over these three time periods.

Insert Table 2 here

Clear changes have occurred over the 25-year period. In the earlier surveys, up to 2003, orangutans, siamangs and gibbons were present during most of the surveys, with on average 0.1-0.5 apes / survey. From 2009 onwards, apes were no longer present in the markets. Likewise, langur species (*Presbytis* and *Trachypithecus*) and tarsiers not native to Java or Bali were not commonly present during surveys before 2003 and from 2009 onwards predominantly the native ebony langur was found to be present and no tarsiers were present. Conversely, long-tailed macaques increased in number whereas the availability of slow lorises remained relatively constant. Overall the Diversity decreased significantly (Spearman's rank Correlation Coefficient $\rho = -0.952$, $P = 0.0003$, $N = 8$) whereas the Evenness did not change ($\rho = -0.095$, $P = 0.822$, $N = 8$) (Figure 1).

In 7 of the 8 years that surveys were conducted, encounter rates (number of primates recorded per survey) with legally protected species were lower than that of non-protected species. The encounter rate with legally protected species varied between 1 and 18 individuals / survey, but was mostly ~5 individuals / survey. The encounter rate with non-protected species was mostly between 5-10 individuals / survey in the period up to 2009 but in recent years it has increased to 15-30 individuals / survey (Figure 1).

Insert Figure 1 here

While it is difficult to assess to what extent the trade has shifted from one market to the next, comparing individual markets between years does show some marked changes. Pramuka in Jakarta for instance, had a wide range of primate species on offer in the 1990s and early 2000s, including orangutans, different species of gibbons, and various species of langur, macaque and slow lorises [Walker 1991; Anonymous 1998; Malone et al. 2002; Webber 2002; Harris 2003; Nijman 2005]. At present mostly long-tailed macaques are traded but in smaller numbers (Figure 2). Conversely, Jatinegara, also in Jakarta, was an insignificant market for the primate trade in the 1990s, to such an extent that most primate survey teams did not visit the market (the market was on the radar of those that monitored the bird trade and we therefore can be confident that primates were not traded in noticeable numbers in Jatinegara during this period). In 2003 it emerged as an intermediate sized market [Harris 2003] and at present it stands out as the most significant market in Indonesia where primates are traded (both in volume and species on offer). The number of individuals of certain species has changed between markets over time, but not in a uniform manner (e.g. all markets having less or all markets having more individuals on offer). For example, focusing on just long-tailed macaques and comparing data from 2013 with those of 2000 and 2009 as many markets have fewer individuals openly for sale than those that have more (Fig. 2).

Insert Figure 2 here

Age and Physical Condition of Primates in Trade

Trade in orangutans in the markets exclusively comprises infants, and these were always kept singly. Likewise, gibbons and siamangs were almost exclusively traded as infants, occasionally as juveniles, and were mostly kept singly, either in a cage but often also tethered. Langurs comprised a mix of all ages, but a large proportion of them were infants and juveniles. They were mostly kept singly, sometimes were tethered but mostly caged.

The trade in long-tailed macaques was almost exclusively in infants or juveniles. In some markets they were traded largely singly but in other markets they were traded in larger volumes and were kept in groups, caged together. Pig-tailed macaques were traded mostly as single individuals, rarely several, and while as seen in long-tailed macaques many were infants or juveniles, some adults were observed in trade as well. Slow lorises were traded in an equal proportion of adults and non-adults. Slow lorises were most often displayed on their own or in

pairs but could be up to 5 or 6; occasionally slow lorises were kept in plastic crates with up to ten individuals together.

Almost without exception, markets were hot, with a closed incessant heat with the sun beating down, loud, often adjacent to main roads (pollution), and were crowded with people. The primates habitually did not have access to water, shade, shelter or appropriate food (the ones that did frequently left it untouched as it was inappropriate: whole bananas for exudativorous slow lorises or boiled rice for frugivorous macaques); markets were often open for longer than 12 hours, typically starting at 04.00 hrs before sunrise and closing at 22.00 hrs, well after sunset.

Siamangs, gibbons and especially slow lorises in the markets regularly have their teeth removed (canines in siamangs and gibbons; the toothcomb and premolars in slow lorises). This was either done in the market prior to them being offered for sale, in the markets themselves in full view of the public, and we have also had vendors offering to remove the teeth on the spot if we were to purchase them “as to make them more safe”.

Primates were displayed amongst and wedged in between other wild-caught mammals, including fruit bats (mostly *Pteropus vampyrus*), civets (mainly *Paradoxurus hermaphroditus*), leopard cats (*Prionailurus bengalensis*), domesticated mammals (rabbits, hedgehogs, guinea pigs, dogs and cats), wild-caught birds (songbirds, waterbirds, owls, eagles, etc.) and domesticated birds (chickens, turkeys, ducks and pigeons). There was plenty of opportunity for physical contact between these groups and for feces and excretions from one species to get into direct contact with other species. Mortality in certain groups, especially songbirds, was high and deceased animals often remained in their respective cages until at least the end of the working day.

Trade Networks

The most parsimonious origin of the primates observed in trade is that they all originated from Indonesia. Species that do not occur in Indonesia were not observed. Individuals of species with a range that includes Indonesia as well as one or more neighboring countries (e.g. Malaysia or Brunei Darussalam) are most likely caught in Indonesia as opposed to elsewhere. While two individuals, one tarsier and one macaque, originated from Sulawesi, the remainder comprised species from western Indonesia, i.e. the islands of Java, Sumatra and Borneo (Table 1). Some of these species occur on all three islands (e.g. long-tailed macaques), others on Borneo and Sumatra but not on Java (e.g. pig-tailed macaques) and yet others are endemic to just one island (e.g. the Bornean agile gibbon *H. albibarbis* to Borneo), allowing us to make inferences on the origin of the primates observed in the trade in Java and Bali (Table 2).

For 650 individuals we could make a firm statement whether they originated from Java or from other islands, and using these data we show that 23% of the trade comprised primates from Java. For 256 individuals we could furthermore establish whether they originated from Sumatra or Borneo, and of these, 91% were Sumatran and

9% Bornean primates. Assuming that these percentages are representative of the trade in all species, i.e. including those ones that occur throughout western Indonesia, then 69% of all primates traded in Java originate from Sumatra, 7% from Borneo, 1% from Sulawesi and just 23% from Java itself.

The wildlife markets on Java and Bali are comprised of a loose network, with traders in one market being linked to other traders in markets in the same city (e.g. in Jakarta or Surabaya) or indeed markets in other cities [cf. Malone et al., 2004; Nekaris & Jaffe, 2007; Nijman, 2005; Shepherd, 2010]. Thus traders in Medan (North Sumatra) supply traders in Jakarta, as do traders in southern Sumatra. Traders in Jakarta are linked to those in Bandung and Surabaya, amongst others, and the traders in Denpasar have close links to those in Surabaya. Smaller markets often have close links to the nearest larger ones in nearby cities.

DISCUSSION

Characteristics of the Primate Trade

Indonesia stands out as one of the countries with the highest number of primate species, and the majority are adequately protected, at least on paper. Despite this, primates have been and still are commonly traded in the open wildlife markets throughout the country. Combining our own survey data with that of others, we found that during 122 surveys of 13 wildlife markets over a 24-year period close to 2,500 primates of 17 species were recorded. A large number of the primates encountered in trade were young, with many of them still physically and mentally dependent on their (absent) mother. Especially for the larger species, young individuals, but not adults, are perceived to make suitable pets, and thus adults do not end up in trade the same way as young individuals do. For the smaller species, including slow lorises, both adults and non-adults are perceived as suitable pets.

The conditions under which the primates are kept in the markets are totally inadequate –no access to appropriate food, water or shelter, for instance– leading not only to suffering but also to ill-health and undoubtedly premature death. Given that a significant number of the primates observed in the markets were from islands other than Java or Bali where the markets were situated (i.e. 69% from Sumatra, 7% from Borneo, 1% from Sulawesi) means that in order to arrive at the markets they must have been transported over thousands of kilometers. While in recent years the different islands in western Indonesia are well-connected by a network of airline companies, the vast majority of primates we observed in the markets must have been transported overland, cramped in cages or bags in cars, busses or trucks, and making sea-crossings by ferry, thus taking several days to complete. Nijman [2005], for gibbons, calculated that the majority of individuals observed in the wildlife markets of Java and Bali had to have been transported over at least 600 km in a straight-line distance, with some having traversed over 2000 km in a straight-line distance. While data are lacking, given the age of the primates involved, their physical condition as observed in the markets, and the conditions in which they are

packed, it is inevitable that these transports lead to high levels of mortality. The treatments of slow lorises, and to a lesser extent, gibbons and siamangs are particularly cruel, given that they routinely have their canines (gibbons) or their canine-shaped first premolars, canines and incisors (the latter forming the toothcomb in slow lorises) either pulled out or cut off [Gray, et al., 2015]. Apart from the immediate physical pain this causes the animals, this often leads to infections, secondary abscesses and, for slow lorises, is a major cause of death [Madani & Nekaris, 2014; Moore et al., 2015]. We do not expect that any of the primates we have seen in the markets in Java and Bali will be released in the wild (all good intentions aside, there is a whole range of good reasons why not to do this), but individuals without proper dentition are condemned to a life of special care and are not suitable for release.

As indicated in the Introduction, the wildlife markets in Java and Bali are widely known as bird markets but many have a wide range of species on offer. From a disease transmission perspective these markets, with close human-animal proximity, with animals having high viral burden or strains of higher transmission efficiency, thus facilitating transmission of viruses to humans, represent the perfect storm (SARS: Webster [2004]; H5N1: Woo et al. [2006]; simian foamy viruses: Jones-Engel et al. [2008]; henipaviruses: Field [2009]; human influenza: Karlsson et al. [2012]; malaria: Huffman et al. [2013]). Wild-caught birds and mammals, including a whole range of taxa that are known to spread human and other primate diseases (waterfowl, eagles, fruit bats, civets, and of course primates), are cramped in small cages, adjacent and on top of each other, in unhygienic conditions, with the animals themselves, because of poor care, being immunologically compromised.

Proximate Reasons for Temporal Changes

While it is difficult to find the proximate reasons for the changes in the numbers of primates traded over time, it is worth asking the question why some species are now less prevalent in trade than they were in the past. We consider three main potential drivers: changes in demand within Javan and Balinese society, law enforcement in the markets or intercepting trade chains and thereby curbing the supply, and changes in availability of primates because of decline in numbers in the wild.

Little evidence either way suggests that societal changes in the demand have had an impact on the primate pet trade in Java and Bali. There is no evidence to suggest that the number of bird markets on Java, or the number of birds they trade has diminished over the last decades – the demand for songbirds remains high [Owen, et al., 2014] and the shift towards captive-bred individuals for some bird species [Jepson & Ladle, 2009] is irrelevant for the primate pet trade since all are derived from the wild.

While other wild-caught species that are traded alongside primates in the Javan and Balinese markets, such as civets, have clearly increased in popularity in recent years [Nijman et al., 2014] the data do not suggest that this

has been the case for primates. We cannot rule out that the continued attention that orangutans have received over the last 25 years has resulted in a decline in the number of people that want to keep one as a pet, whereas we find it likely that the increased attention that slow lorises have received, especially on social media, may explain part of the increase in numbers observed in the markets [Nekaris, et al., 2013].

There is no evidence to suggest that there has been an increase in law enforcement with respect to the primate trade either in the markets or at different points along the supply chain. In fact, it has been frequently noted that there is a clear lack of law enforcement in this respect, both in the past and at present [Basuni & Setiyani 1989; Lee et al. 2005; Malone et al. 2002, 2004; Nijman, 2005; Shepherd, 2010]. Overall then, there is no evidence that law enforcement, and little evidence that a change in consumer preference, is behind the observed changes. Instead we find it most plausible that what has happened at the source can best explain why species such as orangutans, gibbons and langurs have become less common in the markets in Java and species such as long-tailed macaques and slow lorises have become more numerous. Given that two-thirds of the primate trade in Java originates from Sumatra it is relevant to reflect on what has changed on that island over the last 25 years. The wholesale destruction of especially lowland forest, be it by fire or otherwise, and the large-scale conversion of forest to make room for industrial scale cash-crop plantations over this period, while perhaps temporarily leads to an increase in the number of forest-dwelling primates in trade, inevitably leads to a diminished number of wild primates.

Legality of the Trade in Primates in Indonesia

Of the primates that we encountered in the markets in Java and Bali, a large number were included in various laws and regulations to protect them from exploitation, with the majority included on these lists by the mid-1970s [Noerjito & Maryanto, 2001]. In 1999, these various laws were consolidated into Law Number 7 regarding the preservation of flora and fauna (Peraturan Pemerintah No 7, 1999), and ebony langurs were added to the list of protected species by ministerial instruction in 1999 (SK Menhutbun No 733/Kpts-II/1999). The killing, possession and trade in these species is not permitted and fines of up to USD 8,500 and prison sentences of up to 5 years can be imposed on lawbreakers. Unfortunately, it has been well-documented that protected species laws are inadequately enforced in Indonesia [Lee et al., 2005; Lyons & Natusch, 2011; Nijman & Shepherd, 2009; Shepherd, 2010].

Orangutans, gibbons and slow lorises are all included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), effectively banning all international commercial trade [Nekaris & Nijman, 2007; Nijman, 2005; Soehartono & Mardiasuti, 2001]. All other primates are included on Appendix II of CITES, meaning that any export has to be approved by the Indonesian CITES authorities [Soehartono & Mardiasuti, 2001]. Data from the last seven years show that the only exports of live specimens

that has been approved are for macaques, all the result of captive breeding, apart from 100 pig-tailed macaques and 20 long-tailed macaques that were derived from the wild (V. Nijman, unpublished data based on CITES trade data available in December 2014). In addition, in 2014 one company based in Jakarta (PT Alam Nusantara Jayatama) was given permission to captive-breed 80 spectral tarsiers (*Tarsius spectrum*) to be sold as pets [Partono, 2014], but to date these have not been exported.

Long-tailed macaques, pig-tailed macaques, Sumatran langurs and silvery langurs, all encountered in the wildlife markets, are not included on Indonesia's protected species list [Noerjito & Maryanto, 2001]. Therefore the killing of these primates when they raid for instance a farmer's crop is not illegal, and keeping these species as a pet is not liable to fines. Commercial harvest and trade in these non-protected primates, however, is subject to strict regulations as is their transportation across provincial boundaries, and indeed their export. As argued by Shepherd [2010] none of these regulations are met, or indeed can be met, by traders in the open wildlife markets of western Indonesia. Subsequently all commercial trade, both in protected and non-protected species, as monitored in the present study is illicit to a lesser or greater degree. The constant demand set by trends and lack of law enforcement, indicates that without intervention the illegal trade in primates will continue and markets such as Jatinegara are expected to become an even larger hub for trade. With limited efforts going into wildlife trade enforcement in Indonesia, and indeed large parts of Southeast Asia, the total number of primates we observed in trade can be seen as the proverbial 'tip of the iceberg'. While this leaves unknown how much remains undetected, it indicates that there is a substantial illegal trade in primates. To have large numbers of a CITES I and II-listed protected animals being captured, transported and openly traded is hard to view as anything other than an indictment against the law enforcement efforts of the relevant agencies.

Tackling the illegal trade in animals is never going to be easy. With great monetary gains to be made from the illegal wildlife trade (and generally low risks of detection and prosecution) but with limited resources being spread out over vast geographic areas, this is a daunting task. The weight of legal instruments to control the trade is undermined when local harvesters realize that little action is being taken against known traders [Nijman et al., 2012], and low rates of prosecution, low penalties and imposition of below-maximum fines all act as a limiting factor to enforcement success [Nijman, 2005]. However, most enforcement agencies realize that wildlife trade streams pass through a limited number of trade hubs, and these streams and hubs provide ample opportunities to maximize the effects of regulatory efforts. The markets we and others have monitored are prime examples of these trade hubs, and only through targeted and well-informed actions will authorities be able to substantially reduce the illegal primate trade in Indonesia.

CONCLUSION

Our own results from extensive surveys in the bird markets of Java and Bali, combined with data collected by others, corroborate the view that the demand for primates as pets in this part of Indonesia is large, to such an extent that it impedes the conservation of selected primate species. Protective legislation and regulation preclude any of the primates to be traded in the wildlife markets, making all the trade we observed illegal. While numbers of primates openly offered for sale at the markets have remained high, significant changes have occurred over the last quarter of a century. Forest-dwelling species such as orang-utans and gibbons are observed in lower numbers, whereas species that are not just forest-dependent such as long-tailed macaques and slow lorises, are observed in equal or higher numbers. While the causes of the observed patterns remain unclear it seems unlikely that law enforcement in the markets or changes in consumer preference can offer a good explanation, making it likely that changes in the availability of wild primates are at least partially responsible. The continued open availability of primates in the open markets in Java and Bali can only be seen as an indictment against the law enforcement efforts of the relevant agencies.

ACKNOWLEDGEMENTS

Over the years we received support from Indonesian Institute for Sciences (LIPI), the Directorate General for Nature Conservation and Forest Protection (PHKA) and Ministry of Research and Technology (RISTEK) for our research and surveys. We thank International Primate Protection League, Leverhulme Trust (RPG-084), Cleveland Zoo and Zoo Society, Amersfoort Zoo, ZGAP, Columbus Zoo, People's Trust for Endangered Species, Brevard Zoo, Henry Doorly Zoo and Little Fireface Project for providing funding. F. Cabana, P. Dana, T. Blanthorn, P.Q. Lee, J. Lehtinen, J. Margono, A. Nunur, J. Phillips, S. Poindexter, D. Rustandi, C.R. Shepherd, C. Young, S. Williams, M. Williams, A. Zalaeny joined us on our surveys. Three reviewers gave constructive comments and made helpful suggestions for improvement.

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Figure and Table legends

Figure 1. Diversity (solid line) and Evenness (broken line) and encounter rates with primates (solid bars: protected species, open bars: non-protected species) in eleven wildlife markets in Java and Bali.

Figure 2. Relationship between the number of long-tailed macaques *Macaca fascicularis* observed during wildlife market surveys in 2013 (this study, x-axis) and those in 2000 (Malone et al. 2002, white circles, y-axis) and 2009 (Nursaid et al. 2009, black circles, y-axis); samples are matched for months of survey. The line is that of unity. Four markets are indicated by name, showing that for in Sukahaji market in Bandung, Jatinegara market in Jakarta and Satria market in Denpasar more long-tailed macaques were on offer in 2013 than in previous years, but that numbers were lower in Pramuka market in Jakarta.

Table 1. Surveys of long-tailed macaques *Macaca fascicularis* and slow lorises *Nycticebus* spp in wildlife markets in Java and Bali, Indonesia, February 2012 to July 2014. Presented are mean \pm standard deviation with the sample size (number of surveys) between brackets.

Table 2. Primates traded in eleven wildlife markets in five towns on Java and one town in Bali as observed in surveys between 1990 and 2014. Presented are the mean number of individuals observed [percentage of markets where the species was traded; not included for 1990 because only one market was surveyed] total number of individuals observed. Towns (markets) are Jakarta (Pramuka, Barito, Jatinegara), Surabaya (Bratang, Turi, Kupang), Bandung (Sukahaji, Bandung Indah Plaza), Bogor (Pasar Bogor), Malang (Senggol) and Denpasar (Satria); sources: 1: Walker (1991), 2: Nijman (2005 and unpubl. data), 3: Malone et al. (2002, 2004), 4: Webber (2002), 5: Harris (2003), 6: Profauna (2009), 7: this study. Key: B = Borneo, S = Sumatra, J = Java, Ba = Bali, Su = Sulawesi. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near-threatened, LC = Least Concern.

Appendix. Wildlife markets visited by different surveys teams where at least one primate has been recorded. Small markets have typically less than 20 shops, medium markets comprise between 20 and 49 shops and large markets comprise 50 to >200 shops (markets do vary in size, with often more shops open on weekends, and fluctuate somewhat in size over the years, but generally will remain within their respective size classes). Data from 1997 are from Nijman [2005 and unpubl. data]; from 2000 are from Malone et al. [2002], data from 2002 are from Webber [2002], data from 2003 are from Harris [2003], data from 2009 are from Profauna [2009] data from 2012-2014 are from this study.