

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 has amongst the highest primate species richness, and many species are included on the country's protected species list, partially to prevent over-exploitation. Nevertheless traders continue to sell primates in open wildlife markets especially on the islands of Java and Bali. We surveyed 13 wildlife markets in 2012–2014 and combined our results with previous surveys from 1990–2009 into a 122-survey dataset with 2,424 records of 17 species. These data showed that the diversity of species in trade decreased over time, shifting from rare rainforest-dwelling primates traded alongside more widespread species that are not confined to forest to the latter type only. In the 1990s and early 2000s orangutans, gibbons and langurs were commonly traded alongside macaques and slow lorises but in the last decade macaques and slow lorises comprised 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 we recorded 1,272 primates of eight species. Traders offered long-tailed macaque (total 1,007 individuals) and three species of slow loris (228 individuals) in five of the six markets, whereas they traded ebony langurs (18 individuals), and pig-tailed macaques (14 individuals) mostly in Jakarta. Pramuka and Jatinegara markets, both in Jakarta, stood out as important hubs for the primate trade, with a clear shift in importance over time from the former to the latter. Slow lorises, orangutans, gibbons and some langurs are protected under Indonesian law, which prohibits all trade in them; of these protected species, only the slow lorises remained common in trade throughout the 25-year period. Trade in non-protected macaques and langurs is subject to strict regulations—which market traders did not follow—making all the market trade in primates that we observed illegal. Trade poses a substantial threat to Indonesian primates, and without enforcement, the sheer volume of trade may mean that species of Least Concern or Near Threatened may rapidly decline. *Am. J. Primatol.* 79:e22517, 2017.

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INTRODUCTION

Numerous authors have highlighted wildlife trade as a major cause of species declines and extinction risk [Li et al. 2000; McNeely et al., 2009; Smith et al., 2009], highlighting South-east Asia as a trade hotspot [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; Shepherd et al. 2005; 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; Smith, 1978; Southwick & Siddiqi, 1994; Wolfheim, 1983]. While numbers exported in recent decades are considerably lower

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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 in respect to primates [Groves, 2001]. Depending on the taxonomy used the country is home to ca. 46 species, including orangutans (*Pongo* spp.), siamangs (*Symphalangus syndactylus*), gibbons (*Hylobates* spp.), langurs (*Trachypithecus* and *Presbytis* spp.), proboscis monkeys (*Nasalis larvatus*), simakobus (*Simias concolor*), macaques (*Macaca* spp), tarsiers (*Tarsius* spp), and slow lorises (*Nycticebus* spp). Indonesia's primates include many endemic species including single island endemics, especially on 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; Kelle et al., 2014; Koh & Ghazoul, 2010; Langner & Siegert, 2009; Miettinen et al., 2011], but increasingly researchers recognize the effects of killing [Corlett, 2007; Meijaard et al., 2011; Nijman 2005a] and live trade [Nijman, 2005b; Nijman & Nekaris, 2014; Shepherd, 2010] as clear impediments to primate conservation. The live primate trade in Indonesia comprises the large-scale legal export of ranched or captive-born macaques [Soehartono & Mardiatuti, 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 (82nd position) but below Malaysia (22nd position) and Brunei Darussalam (tied 1st position). The relatively high rank may suggest protection of Indonesia's primates and their habitats. Indeed on paper, the country has 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, a comprehensive system is in place to regulate trade [Soehartono & Mardiatuti, 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. 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, researchers have conducted relatively few large-scale or long-term studies, and fewer still have published on primate trade 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 [2005b] 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. 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.); in recent years about 20 traders sell primates and other—non-domesticated—mammals. Barito comprises a row of some 25 specialized bird and pet shops situated on one side of Jalan (Jl, meaning Road) Barito, in south Jakarta. Ten to twenty mobile sellers bring their cages daily to Barito. Primates are mostly sold in the permanent shops. Jatinegara comprises a series of more than 100 permanent bird shops along both sides of Jl Kemuning, a side street of Jl Matraman Jaya; in addition a minimum of 30 vendors display mobile bird shops adjacent and in front of the permanent shops as well as on the curb of Jl Matraman Jaya. Primarily owners of permanent shops sell macaques, whereas the mobile shop owners sell macaques and additional primate species. Sukahaji is comparable to Pramuka but is of much smaller scale, and with permanent shop owners selling live primates, and temporary shop owners selling their parts. 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 I). 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). We requested prices in Indonesian rupiah and converted them to US dollars using the exchange rate of June 2014 (1 USD = 11,900 IDR).

Traders openly sell primates in the wildlife markets. 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 the data in a notebook directly after having left the market. We did not survey back alleys. We noted species and age class (infant, juvenile, adult) when possible, and took photographs 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 traders kept cages 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 impossible for many of the surveyors to identify them all to species level. In Jatinegara in Jakarta, because of 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 making an estimate. Masked monkeys

(locally known as “*topeng monyet*”), that is, 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 were not for sale, we did not include them in our survey. We did not purchase any animals during this study.

We do not believe that the ethnicity of the surveyor influenced the outcome of our surveys, as we focused on the readily observable trade. While conducting surveys, often in mixed Indonesian—other Asian, Indonesian—non-Asian or non-Asian—other Asian teams, there was no indication that one type of surveyor was able to see more than another and species identification skills did not appear to differ between these ethnic groups. We were not able to test the effect of ethnicity, however, as agreements on numbers and species composition was reached on the spot while conducting the survey as a team.

Analysis

We obtained data from previous studies conducted on Java and Bali from 1990 [Walker, 1991], 1997 [Nijman, 2005b, 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, not only protected species. None of these surveys covered more than one calendar year and all surveyors conducted them in different years. Combined with our data from 2012, 2013, and 2014, these surveyors identified primates for sale at 36 wildlife markets (Appendix I). Survey efforts differed between markets and surveyors visited 23 of them in only 1 or 2 years (although during these years they could have been surveyed multiple times). Surveyors visited eleven wildlife markets (three in Jakarta, three in Surabaya, two in Bandung, and one in Bogor, Malang, and Denpasar each) in at least 4 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 that included five or more of the frequently surveyed markets (thus excluding Walker [1991] which included only 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 vendors offered the species for sale. We calculated the 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. When 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 flux and taxonomists now recognize more species 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, especially when young individuals are involved). We therefore 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. We used two-tailed tests, with $P < 0.05$ as a criterion for significance.

Ethical Statement

The Indonesian Institute of Sciences (1997) and Ministry of Research and Technology (2012–2014) granted permission to conduct our research, and the work adhered to the legal requirements of Indonesia. In both our United Kingdom and Indonesian Institutes, we did not require institutional permission for this observational research on animal markets. Our research adhered to the American Society of Primatologists Principles for the Ethical Treatment of Non-human Primates; we did not handle primates, and we avoided causing distress to the primates at all times (though the traders in the markets did not follow these guidelines and the primates suffered a great deal of distress, discomfort, 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 1,272 primates of eight species during 51 surveys in five of the six 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, that is, *N. coucang* (76% of the identified individuals), *N. javanicus* (17%), or *N. menagensis* (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 I). We encountered ebony langurs (18 individuals). Sumatran langurs (1 individual) and silvered langurs (1 individual) only at Jatinegara, and pig-tailed macaques (14 individuals) were present in Jatinegara and Satria.

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 we excluded Mawar, where we recorded no macaques during 11 surveys ($H = 27.31$, $df = 4$, $P < 0.0001$). When we restricted the analysis to the three Jakarta markets only, the numbers recorded differ significantly between markets ($H = 18.69$, $df = 2$, $P < 0.0001$). With pairwise comparisons we show that Jatinegara differed 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 twice what we recorded in other markets. The other markets did not differ significantly from one another. Although we recorded more slow lorises in Jatinegara than in the other two Jakarta markets, the number of slow

TABLE I. Number of Animals Detected in Surveys of Long-Tailed Macaques *Macaca fascicularis* and Slow Lorises *Nycticebus* spp. in Wildlife Markets in Java and Bali, Indonesia, February 2012–July 2014

Market	Species	2012	2013	2014	Range
Jakarta, Jatinegara	<i>M. fascicularis</i>	50.0 ± 35.7 (5)	23.6 ± 18.6 (3)	62.4 ± 52.4 (7)	11–175
	<i>Nycticebus</i> spp.	23.0 ± 12.8 (7)	2.3 ± 4.0 (3)	3.1 ± 3.8 (7)	0–41
Jakarta, Pramuka	<i>M. fascicularis</i>	34.5 ± 23.3 (2)	9.0 ± 1.4 (2)	1 (1)	1–51
	<i>Nycticebus</i> spp.	2.0 ± 1.0 (3)	0 (3)	1 (1)	0–3
Jakarta, Barito	<i>M. fascicularis</i>	1.5 ± 0.7 (2)	1.0 ± 1.4 (2)	4.2 ± 3.5 (5)	0–10
	<i>Nycticebus</i> spp.	4.3 ± 4.0 (3)	0 (2)	2.8 ± 2.3 (6)	0–9
Bandung, Sukahaji	<i>M. fascicularis</i>	4.5 ± 4.9 (2)	7.0 ± 7.1 (2)	1.8 ± 1.0 (5)	1–12
	<i>Nycticebus</i> spp.	0 (2)	0.5 ± 0.7 (2)	0 (5)	0–1
Garut, Mawar	<i>M. fascicularis</i>	0 (2)	0 (3)	0 (6)	—
	<i>Nycticebus</i> spp.	0 (2)	0 (3)	0 (6)	—
Denpasar, Satria	<i>M. fascicularis</i>	—	47 (1)	29.0 ± 8.5 (2)	23–47
	<i>Nycticebus</i> spp.	—	0 (1)	0 (2)	—

Note: Presented are mean ± standard deviation of animals detected with the sample size (number of surveys) between brackets.

lorises openly for sale did not differ between these three markets ($H=5.80$, $df=2$, $P=0.055$).

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 suggest that in 2012 we observed more slow lorises 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 for a young slow loris at Jatinegara was slightly higher than that of an adult (USD 75 vs. USD 58); for all age classes combined the mean asking price was USD 63 ± 52 ($N=10$). If these prices are representative for the other markets surveyed in 2012–2014, then the combined monetary value of the primates observed over the 3-year period was on the order of USD 47,000. The monetary value of the protected slow lorises constituted 14% of this total.

Changes Over the Last 25 Years

The dataset from 111 surveys of eleven wildlife markets in Java and Bali contained 2,062 records of at least 17 species (Table II). 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 availability 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 suggested that apes were particularly abundant in trade in 1997–2000 ($\chi^2=30.2$, $df=1$, $P<0.001$) and langurs were particularly abundant in the period 2002–2009 ($\chi^2=27.9$, $df=1$, $P<0.001$). Macaques were less abundant in 1997–2000 than in the 2002–2009 or 2012–2014. Slow lorises did not show any peak or dip in numbers over these three periods.

Clear changes have occurred over the 25-year period. Up to 2003, surveyors recorded orangutans, siamangs and gibbons 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; from 2009 on, surveyors predominantly found the native ebony langur but not any tarsiers. Conversely, long-tailed macaques increased in number whereas the availability of slow lorises remained relatively constant. Overall the Diversity index decreased

significantly over time (Spearman's rank Correlation Coefficient $\rho=-0.952$, $P=0.0003$, $N=8$) whereas Evenness did not change ($\rho=-0.095$, $P=0.822$, $N=8$; Fig. 1).

In 7 of the 8 years that researchers conducted surveys, 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 increased to 15–30 individuals/survey (Fig. 1); however, there was no statistically significant change in the proportion of protected species encountered in markets over time ($\rho=0.262$, $P=0.531$, $N=8$).

While it is difficult to assess to what extent the trade has shifted from one market to the next, we found some marked changes by comparing individual markets between years. 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 loris [Anonymous, 1998; Harris, 2003; Malone et al., 2002; Nijman 2005a; Walker 1991; Webber 2002]. In our more recent surveys, mostly long-tailed macaques were traded but in smaller numbers (Fig. 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. This market was on the radar of those that monitored the bird trade, however, 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 in our recent surveys it stood out as the most significant market in Indonesia where primates were traded (both in volume and species on offer). We found that the number of individuals of certain species 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, if we focused on just long-tailed macaques and compared data from 2013 with those of 2000 and 2009 we found as many markets had fewer individuals openly for sale as those that had more (Fig. 2).

Age and Physical Condition of Primates in Trade

Vendors of orangutans exclusively trade infants that they always kept singly. Likewise, traders offered gibbons and siamangs almost exclusively traded as infants, occasionally as juveniles; they 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.

TABLE II. Primates Traded in Eleven Wildlife Markets in Five Towns on Java and One Town in Bali as Observed in Surveys Between 1990 and 2014

Species ^a	<i>Pongo pygmaeus</i>	<i>Symphalangus syndactylus</i>	<i>Hylobates</i> spp.	<i>Macaca fascicularis</i>	<i>Macaca nemestrina</i>	<i>Trachypithecus auratus</i>	<i>Trachypithecus cristatus</i>	<i>Presbytis</i> spp.	<i>Tarsius</i> spp.	<i>Nycticebus</i> spp.
Range	B	S	B, S, J	B, S, J, Ba	B, S	J, B, Ba	B, S	B, S, J	B, S, Sul	B, S, J
IUCN	EN	EN	EN	LC	VU	VU	NT	NT - EN	DD - EN	VU - CR
Status	1925	1931	1925	—	—	1999	—	1931	1931	1973
Protected since										
Year	Markets ^b	Source ^c								
Aug-Dec 1990	1 (11)	2.09 [100] 23	1.09 [100] 12	3.91 [100] 43	12.36 [100] 136	3.64 [100] 40	0.18 [100] 2	7.64 [100] 84	0.55 [100] 6	1.18 [100] 13
Aug-Sep 1997	7 (12)	0.17 [14] 2	0.25 [29] 3	5.83 [100] 70	1.17 [43] 14	0.92 [57] 11	0.67 [28] 8	0.42 [43] 5	0	1.75 [86] 21
Jun-Jul 2000	10 (17)	0.18 [10] 2	0.18 [20] 3	4.41 [100] 75	1.53 [40] 26	0.71 [60] 12	0	0	0	2.24 [60] 38
Jul-Aug 2002	8 (16)	0.13 [25] 2	0.25 [38] 4	10.56 [100] 169	1.19 [38] 19	2.56 [60] 41	0.19 [13] 1	0.06 [13] 1	0.19 [25] 3	1.81 [75] 29
Jul-Aug 2003	8 (16)	0.06 [13] 1	0.06 [13] 1	8.00 [100] 128	0.69 [38] 11	0.06 [13] 1	0	0.06 [13] 1	0.06 [13] 1	2.00 [60] 32
May-Jul 2009	10 (10)	0	0	3.50 [60] 35	0	0	0	0	0	1.50 [20] 15
Feb-Oct 2012	5 (11)	0	0	30.09 [100] 331	0	1.18 [40] 13	0	0	0	16.45 [100] 181
Jan-Dec 2013	5 (10)	0	0	15.20 [100] 152	0.20 [20] 2	0	0	0	0	0.70 [60] 7
Jan-Jun 2014	5 (19)	0	0	27.63 [100] 525	0.74 [40] 14	0.26 [20] 5	0.05 [20] 1	0.05 [20] 1	0	2.16 [100] 41

Note: Presented are the mean number of individuals observed, the percentage of markets where the species was traded in square brackets, and 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).

B, Borneo; S, Sumatra; J, Java; Ba, Bali; Su, Sulawesi; CR, critically endangered; EN, endangered; VU, vulnerable; NT, near-threatened; LC, least concern.

^a*Hylobates* includes *moloch*, *agilis*, and *muelleri*; *Presbytis* includes *melalophos*, *femoratis*, and possibly *comata*; *Nycticebus* includes *javanicus*, *coucang*, and *menagensis*; *Tarsius* include *bancanus* and *dianae*. Other primates recorded was 1 moor macaque *Macaca maura* in 1997.

^bPresented are firstly the number of markets included in the survey and secondly, between brackets, the number of surveys that were conducted.

^cI: Walker [1991], II: Nijman [2005 and unpubl. data], III: Malone et al. [2002, 2004], IV: Webber [2002], V: Harris [2003], VI: Profana [2009], VII: this study.

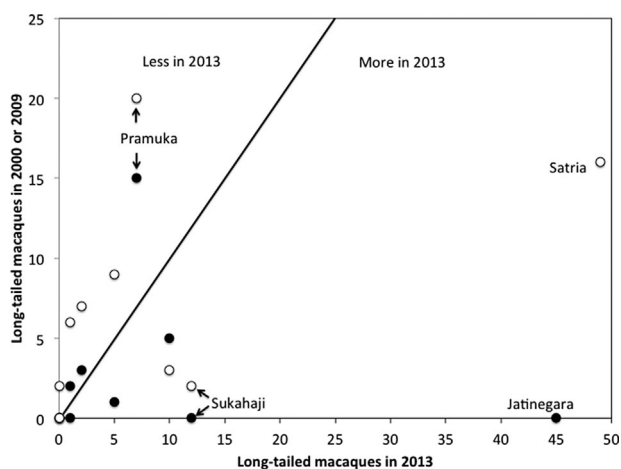


Fig. 1. Relationship between the number of long-tailed macaques observed during wildlife market surveys in 2013 (this study, x-axis) and those in 2000 (Malone et al. 2002, white circles, y-axis) and 2009 (Nursaid et al. 2009, black circles, y-axis); samples are matched for months of survey. The line represents equal numbers in both periods. 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.

Traders mostly kept them singly, sometimes tethered them but mostly caged them.

Traders mainly sold infant or juvenile long-tailed macaques. In some markets traders presented them largely singly but in other markets traders sold them in larger volumes and kept them in groups, caged together. Traders offered pig-tailed macaques mostly as single individuals, rarely several, and while many traders sold infants or juveniles, we observed some adults in trade as well. Traders offered slow lorises in an equal proportion of adults and non-adults. Slow lorises were most often displayed on their own or in pairs but could occur in groups of 5–6; occasionally traders kept slow lorises in plastic crates with up to ten individuals together.

Almost without exception, markets were invariably hot, poorly ventilated, 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 (for example whole bananas for exudativorous slow lorises or boiled rice for frugivorous macaques). Markets were often open for longer than 12 hr, typically starting at 04.00 hr before sunrise and closing at 22.00 hr, well after sunset.

Siamangs, gibbons and especially slow lorises in the markets regularly had their teeth removed (canines in siamangs and gibbons; the toothcomb and premolars in slow lorises). Traders either brought the animals to the market after clipping their teeth on route, or clipped them in the market in full view of the public. We had vendors offer to remove the teeth on the spot if we were to purchase the primates “as to make them more safe.”

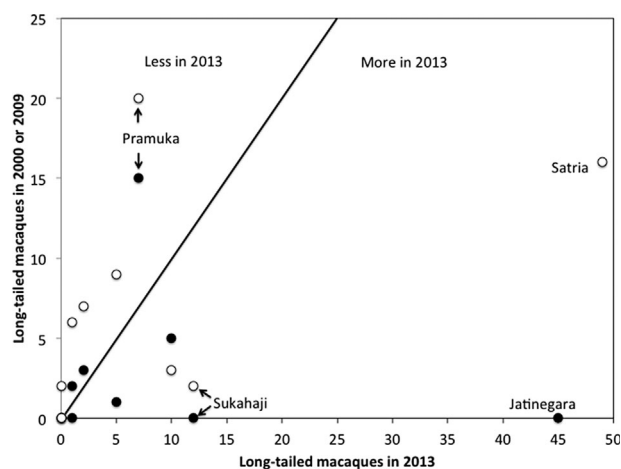


Fig. 2. Diversity (solid line) and Evenness (broken line) and encounter rates with primates (black bars: protected species, gray bars: non-protected species) in eleven wildlife markets in Java and Bali.

Primates were displayed in close proximity to other animals in the market, with primates being tethered on top of cages with other animals, or with the primates cages stacked amidst other cages. These included 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 (including songbirds, waterbirds, owls, eagles) and domesticated birds (chickens, turkeys, ducks, and pigeons). Smaller primates were occasionally caged with other animals (e.g., slow lorises with civets or infant macaques with domesticated dogs). Plenty of opportunity was available 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 cages until at least the end of the working day.

Trade Networks

The most parsimonious hypothesis about origin of the primates observed in trade is that they all originated in Indonesia. We did not observe species that do not occur in Indonesia. Individuals of species with a range that includes Indonesia as well as one or more neighboring countries (e.g., Malaysia or Brunei Darussalam) were 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, that is, the islands of Java, Sumatra and Borneo (Table I). 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 silvery gibbon *H. moloch* to Java), allowing us to make inferences on the origin of the primates observed in the trade in Java and Bali (Table II).

For 650 individuals, we could make a firm statement whether they originated from Java or from other islands, and using these data we found 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, that is, including those that occur throughout western Indonesia, then 69% of all primates traded in Java originated from Sumatra, 7% from Borneo, 1% from Sulawesi and just 23% from Java itself.

The wildlife markets on Java and Bali are part of a loose network, with traders in one market 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, 2005b; 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. Primates, however, have been and still are commonly traded in the open wildlife markets throughout the country. Combining our own survey data with those 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 the pet trade as often as young individuals do. For the smaller species, including slow lorises, both sellers and purchasers perceive adults and non-adults as suitable pets.

It is a common view amongst conservationists that mothers must be killed to obtain infants and that this practice could explain the high prevalence of young animals in our surveys. We had no direct evidence pertaining to this possibility and may be relevant only for arboreal species such as orangutans

and gibbons in which the young cling to the mother for extended periods [Nijman 2005a]. Slow lorises adults and young are captured in a similar manner, and infants are left for parts of the night parked in trees or bamboo by their mothers and can be collected by hunters from these spots. Macaques and langurs are often caught with nets or with the aid of dogs and all age-classes enter the trade, although not necessarily the pet trade [Anonymous, 1998; Lee 2013].

The conditions under which vendors kept the primates in the markets were dismal; they had no access to appropriate food, water or shelter leading not only to suffering but also to ill-health and undoubtedly premature death. Given that many 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) they must have been transported over thousands of kilometers. While in recent years the different islands in western Indonesia have been well-connected by an air traffic network, 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 [2005b], considering 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 were packed, it is inevitable that these transports lead to high levels of mortality. The treatment 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 tooth-comb in slow lorises) either pulled out or cut off [Gray et al., 2015]. Apart from the immediate physical pain this procedure causes the animals, it 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 saw in the markets in Java and Bali will be released in the wild, 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 range of taxa that 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. Because of poor care the animals are also likely to be immunologically compromised, exacerbating the risk of disease transmission.

Proximate Reasons for Temporal Changes

It is possible that over the 25 years covered by our study nothing has changed in terms of species composition and numbers of primates in trade, and that the changes we recorded are artifacts of what is and what is not openly offered for sale. Thus, it is possible that all that has changed is that species that are more common now were previously kept hidden from view while species that we now no longer see in the markets are still there but they are all kept hidden from view. While we do not have data on such hidden trade to test this possibility we consider it unlikely given the open nature of the trade in both protected and unprotected species and the almost total lack of enforcement in the markets over the last 25 years. During each survey protected species were openly offered for sale and the proportion of legally protected primates on offer did not increase or decrease over time. Traders want to sell the primates they have on offer and it would not make sense for them to hide their wares if there is no reason to do so. Furthermore, both high profile species such as orangutans and less popular and less well-known species such as various langurs have declined in number, whereas other well-known species such as slow lorises and long-tailed macaques were equally or more abundant in our recent surveys than they used to be.

While it is difficult to identify the proximate reasons for the temporal changes in the numbers of primates traded, it is worth asking why some species have become 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 which intercepts trade chains and thus curbs the supply, and changes in availability of primates because of a wild population decline.

There is little evidence that societal changes in demand have had an impact on the primate pet trade in Java and Bali. There is no evidence that the number of bird markets on Java, or the number of birds they trade has diminished over the last decades. Indeed the demand for songbirds remains high [Chng et al., 2015; 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 because all are derived from the wild.

Other wild-caught species, such as civets, which are traded alongside primates in the Javan and Balinese markets have clearly increased in popularity in recent years [Nijman et al., 2014]. It is possible that the continued attention that orangutans have received over the last 25 years has led to a decline in their attractiveness as a pet, but at the same time, we suspect that slow lorises have become more attractive as pets because of the attention that slow lorises have received, especially on social media [Nekaris et al., 2013]. No evidence suggests law enforcement has increased with respect to the primate trade either in the markets or at different points along the supply chain. In fact, many have noted that there is a clear lack of law enforcement in this respect, both in the past and at present [Basuni & Setiyani 1989; Felbab-Brown 2013; Lee et al., 2005; Malone et al., 2002, 2004; Nijman, 2005a, 2015; Nijman et al., 2014; Shepherd, 2010]. Overall then, there is no evidence that an increase in 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 or are offered in similar numbers as they were in the past. 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 destruction of forest, especially lowland forest, and the large-scale conversion of forest to make room for industrial scale cash-crop plantations over this period, may have led to a temporary increase in the number of forest-dwelling primates in trade, but in the long term these changes inevitably must have led to a diminished number of wild primates. This long-term change is what we see reflected in the markets in Java.

Legality of the Trade in Primates in Indonesia

Of the primates that we encountered in the markets in Java and Bali, various laws and regulations protect many of 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. Protected species laws are, however, 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, 2005b; 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]. In recent years, the only approved exports of live specimens involved macaques, which were bred in captivity, 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) received permission to captive-breed 80 spectral tarsiers (*Tarsius spectrum*) to be sold as pets [Partono, 2014], but to date these animals 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 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. All commercial trade in the markets, both in protected and non-protected species, is illicit to a lesser or greater degree. The constant demand set by societal trends with different taxa becoming fashionable as pets, 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. These large numbers, and the openness of the trade, also suggest clear deficiencies in the effectiveness of the law enforcement efforts of the relevant agencies.

Tackling the illegal trade in animals is challenging. With great monetary gains to be made from the illegal wildlife trade (and generally low risks of detection and prosecution) the limited resources for controlling such trade are spread thin over vast

geographic areas. 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, 2005b; Phelps et al., 2010]. 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 reduce substantially 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 bans 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 orangutans 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.

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APPENDIX I

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

Market	Type	1997	2000	2002	2003	2009	2012	2013	2014
Serang	Small	X				X			
Jakarta, Pramuka	Large	X	X	X	X	X	X	X	X
Jakarta, Jatinegara	Large			X	X	X	X	X	X
Jakarta, Barito	Medium	X	X	X	X	X	X	X	X
Jakarta, Sangaji	Small			X	X				
Bogor, Taman Topi	Small	X	X						
Bogor	Medium	X	X			X	X		
Sukabumi	Small	X				X		X	
Bandung, Sukahaji	Large		X			X	X	X	X
Bandung, Indah Plaza	Small		X				X	X	X
Bandung, Jl Rajiman	Small		X						
Bandung Kebun Kelapa	Small		X						
Garut, Mawar	Small	X				X	X	X	X
Cirebon, Plered	Medium					X			
Sragen	Medium					X			
Purwokerto, Wage	Medium		X			X			
Semarang, Karimata	Medium		X						
Muntilan, Mekar	Medium					X			
Surakarta, Depok	Large					X			
Ambarawa	Medium					X			
Wonosobo	Medium	X							
Yogyakarta, Ngasem	Large		X			X			
Surabaya, Bratang	Large	X	X	X	X	X		X	X
Surabaya, Turi	Medium	X	X	X	X	X		X	X
Surabaya, Kupang	Large	X	X	X	X	X		X	X
Probolinggo, Randu PAGER	Small					X			
Malang, Senggol	Large	X	X	X	X	X			
Sitobondo	Medium					X			
Lumajang	Medium					X			
Madiun, Joyo	Medium		X			X			
Ngawi, Mantingan	Medium					X			
Jombang, Tunggorono	Small					X			
Jember, Gebang	Small		X			X			
Pasuruan, Kebun Agung	Small					X			
Pasir Putih	Medium	X						X	
Denpasar, Satria	Medium	X	X					X	X

Uncited references

Corlett [2007], Li et al. [2000], Phelps et al. [2010], Shepherd et al. [2005]