



Hunting of flying foxes and perception of disease risk in Indonesian Borneo

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ABSTRACT

Widespread hunting of flying foxes has generated concern regarding population declines and the spread of emerging infectious diseases. To investigate the potential impacts of this trade, we conducted questionnaires in 45 settlements across 12 population centres within Central Kalimantan, Indonesia, a region previously identified as a hunting hotspot. By combining results from 63 hunter and 88 vendor interviews, we highlight two population centres (Palangka Raya and Buntok/Tamiang Layang) with higher hunting rates than other areas, which act as flying fox trading hubs. Flying fox populations were perceived to be declining province-wide: declines in captures and sales were reported by 81% of hunters and 60% of market vendors, who also reported availability as the key factor underlying temporal variations in trade. There was substantial risk of zoonotic disease transmission between bats, hunters and traders: the vast majority of respondents were unaware that flying foxes carry potentially fatal viruses, and so few people protected themselves from physical contact. Moreover, both hunters and vendors were frequently bitten and the majority of bites drew blood. Most hunters (58%) also reported unintentional by-catches that included keystone bird species and slow lorises. The scale of hunting over Central Kalimantan represents a serious threat to the long-term viability of flying fox populations (and potentially those of other species), and could have serious public health implications. Reducing or eliminating hunting and trade would mitigate the risk of disease transmission, while maintaining the economic and ecosystem benefits that flying foxes provide, in terms of pollination and seed dispersal.

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1. Introduction

Hunting of wild animals for bushmeat is widely recognised as one of the key causes of tropical biodiversity declines (Bradshaw et al., 2009; Corlett, 2007; Milner-Gulland et al., 2003). Although hunting has long been practiced in most tropical regions, rising human populations, technological developments, and improved access to forests and markets have all led to a dramatic increase in recent years (Milner-Gulland et al., 2003). As a result, tropical wildlife is typically being extracted at six times the sustainable rate (Bradshaw et al., 2009). This is particularly concerning in Southeast Asia, which is a global centre of wildlife trade (Nijman, 2010).

Unsustainable hunting of flying foxes has been reported throughout the palaeotropics, and is particularly common for large-bodied species of *Pteropus* across Indonesia, Malaysia, Philippines and several islands in the Pacific and Indian Oceans (Mickleburgh et al., 2009; Wiles and Brooke, 2009). Despite this, there is little information on bat hunting in the bushmeat literature relative to other animal groups, such as primates (Mickleburgh et al., 2009). The low reproductive and natural mortality rates of flying foxes make them particularly vulnerable to over-hunting (McIlwee and Martin, 2002), and as a result, population declines are being increasingly reported. On Niue Island, South Pacific, for example, 1555 *Pteropus tonganus* were shot during the 1998–1999 hunting seasons, removing 38–76% of the population (Brooke and Tschapa, 2002). Legal licence sales in peninsular Malaysia revealed a doubling of hunting effort for *Pteropus vampyrus* since 1996, which far exceeded sustainable levels derived from population models (Epstein et al., 2009). Major population declines have also been reported in protected

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areas of Sulawesi, a region where flying foxes represent a large proportion of wild animal trade (Lee et al., 2005).

Flying fox population declines may have considerable ecological and economic impacts because of the ecosystem services that these animals provide. These bats are important pollinators of forest trees, including species of commercial importance such as durian (*Durio zibethinus*) (Corlett, 1998; Kunz and Jones, 2000). Seed dispersal by flying foxes is also considered to be central to the maintenance of intact forest ecosystems but, on Pacific islands at least, this is highly dependent on the maintenance of high population densities (McConkey and Drake, 2006). Over hunting of flying foxes could therefore lead to reduced pollination and seed dispersal rates, resulting in potentially far-reaching environmental and economic implications for rural communities.

There is also increasing realisation that human contact with flying foxes through activities such as hunting could lead to adverse effects on public health via the transfer of emerging infectious diseases (EIDs). EIDs are defined by recent increases in incidence, impact or geographic range; causation by recently evolved pathogens; or recent movement into new populations – and can result in mass human fatalities (Daszak et al., 2004). Flying foxes are potentially effective transmitters of EIDs because they are capable of foraging over long distances (>80 km in a single night reported for *P. vampyrus* in Malaysia, Epstein et al., 2009), and may forage in farms and commercial orchards that are populated by domestic animals, which can serve as amplifier hosts to people (Breed et al., 2006). *Pteropus* spp. are a natural host of two EIDs from the genus *Henipavirus* (Nipah, Chua et al., 2002; and Hendra, Young et al., 1996), which have caused disease and death in both domestic animals and humans (reviewed by Breed et al., 2006). The most serious epidemic of Nipah virus to date arose from disease transmission from flying foxes to pigs and then humans, and resulted in 268 reported human cases, including over 100 deaths in Malaysia and Singapore (Breed et al., 2006). Subsequent regular outbreaks of Nipah virus in Bangladesh in the last decade show evidence of repeated contact between people and flying foxes with frequent human-to-human transmission of this virus (Breed et al., 2006). Increased contact between people and flying foxes, for example through hunting and consumption, may therefore be expected to increase the risk of zoonotic disease transmission. Hunters may be at particular risk of contracting diseases from animal bites and scratches. When animals are kept alive prior to sale, this risk is also shared by market vendors, who also have the added risk of infection from animal blood and body fluids entering open wounds while butchering (LeBreton et al., 2006). The acquisition of information on hunting and human contact with flying foxes is therefore critical for understanding the degree of risk faced, predicting future outbreaks of EIDs, and attempting to mitigate this risk as part of conservation efforts (Breed et al., 2006; Epstein et al., 2009).

Antibodies to Nipah virus have recently been detected in *P. vampyrus* populations in Kalimantan (Sendow et al., 2010), the Indonesian territory of Borneo, where hunting of this species has previously been reported (Struebig et al., 2007). Hunting is particularly intensive in the province of Central Kalimantan, which retains the largest proportion of Borneo's peat-swamp forest, a favoured habitat for *P. vampyrus*, and is hence a priority region for bat conservation research efforts (Struebig et al., 2006). In areas surrounding the provincial capital, Palangka Raya, flying foxes are hunted in nets strung up to the forest canopy in small clearings to intercept animals flying to/from fruiting or flowering trees. Counts of hunter numbers and captures indicate that, in 2003, up to 4500 individuals were extracted from the main hunting site in the Sabangau peat-swamp forest in a 30-day period (Struebig et al., 2007). Hunted bats, here and elsewhere in the province, are then sold alive or freshly killed by the vendor upon sale, due to buyers'

preference for fresh meat. Reports from the Malay peninsula (Mohd-Azlan et al., 2001), Sumatra (I. Singleton, pers. comm.) and other Bornean states (Struebig et al., 2007, 2010; S. Lhota, R. Puri and B. Yaap, pers. comm.) suggest that this level of hunting and trading greatly exceeds that witnessed in other areas. To date, however, it is unclear whether this level of bat-human contact is localised to the provincial capital or whether flying foxes are traded to other parts of Indonesia.

To identify flying fox conservation priorities and potential risk areas for future EID epidemics, we instigated interview surveys across the major population centres, and likely centres for flying fox hunting and trade in Central Kalimantan, where reports indicate hunting is most prevalent. Our aims were to document: (i) spatio-temporal variations in hunting and trade intensity; (ii) hunting and sale trends; (iii) the perceived economic value of the trade; (iv) reasons why people buy flying foxes; (v) potential levels of risk from zoonotic disease transmission associated with the trade; and (vi) whether flying fox hunting may also endanger other species through by-catches. Surveys of this nature are recognised as a priority for bat conservation in Southeast Asia (Kingston, 2010).

2. Methods

2.1. Survey locations

Central Kalimantan encompasses 153,800 km², representing 20% of Borneo's land area. Much of the province is forested, with predominantly peat swamp, freshwater swamp and mangroves in the southern flood plains. As such, access is difficult and human population size is relatively low. Sizeable human settlements are based alongside major rivers that are now linked to some extent by paved roads joining the major transport hubs of Palangka Raya and Banjarmasin (the latter of which is in South Kalimantan), and minor ports along the coast. We therefore targeted our surveys on 45 settlements in 15 key areas that included (i) all major human population centres; (ii) major road-river junctions and sea ports that could serve as potential centres of trade; and (iii) areas where previous information, obtained either by ourselves or colleagues elsewhere in Kalimantan, indicated that high levels of hunting occurred (Fig. 1). We are confident that our surveys encompassed all priority hunting areas in the province and that any hunting outside of these locations was minimal. Because the interior settlements of Muara Teweh and Puruk Cahu were found to support only low levels of trade (MJS, pers. obs.; G. Limberg and S.J. Husson, pers. comm.), we did not perform formal surveys in these areas. Questionnaire data referred to herein therefore refer to 42 settlements (24 hunting locations and 18 markets in towns/cities) in the remaining 12 key areas.

Between April 2007 and June 2010, we conducted 151 questionnaires with market vendors ($n = 63$) and hunters ($n = 88$) in around the 12 key areas (Table 1). While this effort was typically below the 3–5% of total population recommended for questionnaires (Oppenheim, 2001), it far exceeded 3–5% of flying fox market vendors (we likely surveyed all vendors in many locations) and hunters in each area. Surveys of hunters were conducted in 24 villages near forests or plantations that local people, including market vendors in each key area, identified as hunting sites. All hunting sites were typically easily accessible by either road or river from market locations.

2.2. Questionnaire design

We designed separate semi-structured questionnaires for hunters and market vendors that provided information on: (i) hunting

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