

Chapter 12

Exploitation of Bats for Bushmeat and Medicine

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Abstract Bat hunting for consumption as bushmeat and medicine is widespread and affects at least 167 species of bats (or c. 13 % of the world's bat species), in Africa, Asia, across the islands of Oceania, and to a lesser extent in Central and South America. Hunting is particularly prevalent among the large-bodied fruit bats of the Old World tropics, where half (50 %, 92/183) the extant species in the family Pteropodidae are hunted. Pteropodids that are hunted are six times more likely to be Red Listed as threatened: 66 % of species in IUCN threatened categories (CR, EN, VU, NT), compared to 11 % of species in the 'Least Concern' (LC) category. However, there still appears to be an information gap at the international level. One third of the hunted species on the Red List are not considered threatened by that hunting, and nearly a quarter of the bat species included in this review are not listed as hunted in IUCN Red List species accounts. This review has resulted in a comprehensive list of hunted bats that doubles the number of species known from either the IUCN Red List species accounts or a questionnaire circulated in 2004. More research is needed on the impacts of unregulated hunting, as well as on the sustainability of regulated hunting programs. In the absence of population size and growth data, legislators and managers should be precautionary in their attitude towards

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hunting. Roost site protection should be a priority as it is both logistically simpler than patrolling bat foraging grounds and reduces the comparatively larger scale mortality and stress that hunting at the roost can cause. Education and awareness campaigns within local communities should demonstrate how bats are a limited resource and emphasize characteristics (nocturnal, slow reproducing and colonial) that make them particularly vulnerable to hunting pressure.

12.1 Introduction

Most of the chapters in this book (Voigt and Kingston 2016) consider negative consequences for bats from indirect effects of anthropogenic perturbations. In contrast, this chapter explores the direct exploitation of bats by humans for bushmeat and medicine.

A global review of bats as bushmeat was published in 2009 providing an overview of bat hunting based on published literature and a questionnaire widely distributed among bat biologists in 2004 (Mickleburgh et al. 2009). Here, we summarize what is currently known about the exploitation of bats for consumption and medicinal use, synthesizing the 2009 review with what has been published since and unpublished information the authors have gathered from colleagues. The result is a comprehensive list of hunted bats species that contains nearly twice as many species as known from either the IUCN Red List species accounts or the 2009 review. It is unclear whether the increased concern about hunting is the result of greater actual hunting pressure, or just represents our increased understanding of hunting impacts. What is clear is that reviews now explicitly attribute species declines and extinction risk to hunting pressure.

Most of the chapter discusses conservation needs in light of what is known about bat hunting. We summarize regional patterns in bat hunting and protection efforts and highlight areas of conservation concern. We provide details of current research aimed at learning more about hunting impacts, and we give examples of management activities to strengthen protection efforts against population-level effects of hunting. We end with recommendations for research to better understand the effects of hunting on bat populations as well as strategies for effectively managing hunting to support bat conservation. All common and scientific species names follow Simmons (2005).

12.2 Background

12.2.1 Overview of Bat Hunting

Bat hunting is widespread and affects at least 167 species of bats (or c. 13 % of the world's 1331+ bat species, Bat Conservation International 2015), occurring in Africa, Asia, across the islands of Oceania, and in some parts of Central and

South America (compiled from IUCN 2014; Mickleburgh et al. 2009, and personal communications by the authors; Appendix). Hunting is particularly prevalent on the large-bodied fruit bats (family Pteropodidae) in the Old World tropics, where half (50 %, 92/183) of all extant species experience hunting pressure (Mickleburgh et al. 2009; IUCN 2014). A much smaller proportion of insectivorous (<8 %, 75/962 species) are hunted, particularly members of the Emballonuridae, Hipposideridae and Molossidae in Asia and Southeast Asia, Vespertilionidae in North Africa and West and Central Asia, and Phyllostomidae in Brazil, Peru, and Bolivia as well as Rhinolophidae in sub-Saharan Africa, (Mickleburgh et al. 2009; Lizarro et al. 2010; IUCN 2014) (Appendix).

Bats are hunted for a variety of reasons, from their perceived medicinal properties e.g. Nicobar flying fox, *Pteropus faunulus*, Kingston et al. (2008); ‘small bats’ in Nepal (Tuladhar-Douglas 2008); fat from pteropodid species in Pakistan (Roberts 1997) to their use in ornate decoration such as the teeth of the Makira flying fox (*Pteropus cognatus*) used for necklaces (James et al. 2008). Bats are also hunted for sport by urban residents seeking country pursuits (e.g. large fruit bat hunting at Subic Bay, Philippines, S. Stier, pers. comm.) and tourists seeking exotic eating experiences (e.g. Pacific flying fox, *Pteropus tonganus*, hunting is offered as a recreation option at hotels in Vanuatu; A. Brooke pers. comm. in Hamilton and Helgen 2008). However, the most widespread reason for bat hunting, by far, is for consumption; all 167 species that are hunted are, at least in part, wanted for their meat as a source of protein. Bat meat ranges in value from a highly sought-after delicacy served at special ceremonies and traditional celebrations (e.g. *Pteropus mariannus* in the Mariana Islands) to “finger food” consumed in social drinking settings (e.g. many bat species in Southeast Asia, Mildenstein 2012; and in West Africa, M. Abedi-Lartey pers. comm.). Elsewhere, it provides an alternative source of protein for local people for whom meat is an expensive commodity (Jenkins and Racey 2008) and in extreme cases, bats are consumed as starvation food (Goodman 2006).

The intensity and frequency of bat harvesting varies from year round to periodical depending on the seasonality of the species, hunters’ lifestyles, and/or local legislation. On the Islands of São Tomé and Príncipe, bats are hunted opportunistically for food all year round (Carvalho et al. 2014). In Southeast Asia, regular harvest of bats occurs in Indonesia and the Philippines (T. Mildenstein, unpublished data). A migratory species, the African straw-colored fruit bat (*Eidolon helvum*) is hunted whenever it is present in Accra (Fig. 12.1) and Kumasi, Ghana, between November and March (Kamins et al. 2011). Reduced hunting intensity in March is likely due to the northward migration of forest resident bats and/or the shift in hunters’ occupation to farming. Similarly, in Madagascar, local legislation specifies two hunting seasons—one for fruit bats, and another for Commerson’s leaf-nosed bat (*Hipposideros commersoni*) (Jenkins and Racey 2008), though actual hunting intensity is driven more by local availability (e.g. the lychee season for fruit bats). In some localities in east and western Nigeria, year round harvest of the Egyptian rousette (*Rousettus aegyptiacus*) is known (Fig. 12.1) (I. Tanshi pers. obs.), and *E. helvum* was documented as hunted during peak population periods in the southwest (Funmilayo 1978; Halstead 1977).



Fig. 12.1 Collection and sales of bats in Africa **a** *R. aegyptiacus* collected by a hunter with sticks from a limestone cave in Etapkini near Calabar, Nigeria (credit I. Tanshi), **b** Fruit bat kebab on sale in Kumasi, Ghana (credit M. Abedi-Lartey), **c** *E. helvum* and *H. monstrosus* on sale in a small market by the River Congo in Kisangani, DRC (credit Guy-C. Gembu)

Bushmeat is preferred to domestic livestock in many places because of the taste and perceived higher nutritional value (Mbeti et al. 2011, T. Mildenstein unpublished data). In locations where domestic meats and fish are generally preferred, such as Madagascar (Randrianandrianina et al. 2010), bushmeat becomes more important in periods of food shortage (Jenkins and Racey 2008). Similarly, on the island of Yap (Micronesia), hunting is socio-economically based, and bats are less desirable than seafood. Only people of lower social ranks with no access to the coast hunt fruit bats (Falanruw 1988). Consumption of bushmeat varies indirectly with the availability of other protein sources (e.g. in west Africa: Brashares et al. (2004)). In areas where bats are eaten, they are rarely the only available source of protein. The exception to this is in times of food insecurity, when people turn to bats as a food source, especially following natural disasters (e.g. typhoons: Aldabra flying fox, *Pteropus aldabrensis*, Mickleburgh et al. 2008a; Vanuatu flying fox, *Pteropus anetianus*, Helgen and Hamilton 2008a; Ontong Java flying fox, *Pteropus howensis*, Helgen and Allison 2008; Rodrigues flying fox, *Pteropus rodricensis*, Mickleburgh et al. 2008b; Samoan Flying Fox, *Pteropus samoensis* and *P. tonganus*, Brooke 2001, and *P. mariannus*, Esselstyn et al. 2006,

USFWS 2009) and during civil unrest (e.g., Bougainville monkey-faced fruit bat, *Pteralopex anceps antrata*, S. Hamilton, pers. comm.). Similarly, species found in low-lying areas (e.g. *P. aldabrensis* and *P. howensis*) may become increasingly important food to local communities as rising sea-levels destroy other food sources (Mickleburgh et al. 2008a; Helgen and Allison 2008).

Twenty years ago marked the end of a long period of international trade in the Pacific with many pteropodids being imported into Guam and the Northern Mariana Islands. Once local bat populations were depleted, bats were imported from other island groups and mainland Southeast Asia (e.g. Wiles and Payne 1986; Wiles 1992; Stinson et al. 1992). Protracted international effort eventually led in 1987–1989 to the addition of pteropodid species to the Appendices of the Convention on International Trade of Endangered Species (CITES), which has stopped legal trade of bats between nation states, although a black market still occurs (e.g. into Europe, Samuel 2013).

Currently, hunting of bats for trade tends to be locally-based, and not international, but varies widely in intensity. An extensive commercial chain of bat trade exists outside markets in Ghana (Kamins et al. 2011). Other high levels of trade, include that of the large flying fox (*Pteropus vampyrus*) in Kalimantan, Indonesia (Harrison et al. 2011) and of the Malagasy flying fox (*Pteropus rufus*) in Madagascar (Jenkins et al. 2007; Oleksy et al. 2015b). More commonly, bats are traded locally and on a lesser scale, with relatively few individuals sold in markets (e.g. *P. vampyrus* in the Philippines, Sheffers et al. 2012; and in Southeast Asia, Mickleburgh et al. 2009). Prices per bat range from <1 USD in Southeast Asia (Indonesia: Heinrichs 2004; the Philippines: T. Mildenstein unpublished data) to more than 130 USD when acquired through black market trading (e.g. *P. marianus* on Guam and the Northern Mariana Islands, USFWS 2009).

12.2.2 Hunting Overview by Region

12.2.2.1 Africa

In total, 55 species of bats are hunted in Africa, including mainly abundant large-bodied fruit bats (Mickleburgh et al. 2009) such as *E. helvum*, Franquet's epauletted fruit bat (*Epomops franqueti*), Gambian epauletted fruit bat (*Epomophorus gambianus*), hammer-headed fruit bat (*Hypsignathus monstrosus*), *R. aegyptiacus* and medium-sized species like Angolan soft-furred fruit bat (*Myonycteris angolensis*) (formerly *Lissonycteris*), Peter's lesser epauletted fruit bat (*Micropteropus pusillus*) and to a lesser degree insectivorous bats such as the large slit-faced bat (*Nycteris grandis*), Maclaud's horseshoe bat (*Rhinolophus maclaudi*), Ruwenzori horseshoe bat (*Rhinolophus ruwenzori*) and *Hipposideros* species. Although insectivorous bats are considered to be less palatable in many regions and may appear to be under low hunting pressure, (Kamins et al. 2011; Dougnon et al. 2012) this is not necessarily the case. Goodman (2006) showed that in addition to fruit bats,

mainly the Malagasy straw-colored fruit bat (*Eidolon dupreanum*), *P. rufus*, and the Malagasy rousette (*Rousettus madagascariensis*), insectivorous *H. commersoni* is frequently hunted, especially during periods of food shortages. In addition, while fruit bats are probably the most commonly hunted group, 64 % of the 55 bat species hunted in Africa are animalivores (Appendix).

Hunting bats for food is common in West and Central African states where it can be a major threat to their populations (Funmilayo 1978; Mickleburgh et al. 2009; Kamins et al. 2011). Frequent bat hunting is recorded from Benin Republic, Ghana, Guinea, Liberia and Nigeria (Funmilayo 1978; Anstey 1991; Kamins et al. 2011; Dougnon et al. 2012) (Fig. 12.1), as well as in Cameroon, Congo Republic, Democratic Republic of Congo (DRC), Equatorial Guinea and Gabon. High levels of hunting have also been reported in the past from islands off Africa—the Comoros, Madagascar, Mauritius and Rodrigues and São Tomé and Príncipe as well as Pemba Island, Tanzania (Jenkins and Racey 2008; Carvalho et al. 2014), although conservation efforts have reduced this pressure in some of these islands (Trehwella et al. 2005).

While occasional bat hunting occurs in Mali and Zambia, there is almost no hunting in East Africa, except eastern Uganda, and bat hunting is rare in South Africa (Mickleburgh et al. 2009). Bats are also persecuted because of negative perceptions in Ethiopia (Mickleburgh et al. 2009) but that is not the focus of this chapter.

Although, Halstead (1977) reported the potential for sustainable harvesting of bats at the Ile Ife campus, over-exploitation of *E. helvum* in southwestern Nigeria was also evident (Funmilayo 1978). People in rural areas in southern Nigeria admit to eating bats occasionally, whereas in parts of eastern Nigeria, *R. aegyptiacus* is hunted intensively (Fig. 12.1). Over 3000 individuals of this species have been collected in one night from a cave in Buanchor village by several hunters who hunt more than once a month (I. Tanshi, unpublished).

North Africa and West and Central Asia. Bat hunting is less prevalent in North Africa and West and Central Asia. Of the 98 bat species that occur in this region, five are known to be hunted and these are for medicinal purposes, of the 98 bat species that occur in this region, five (all Vespertilionidae) are known to be hunted: long-fingered Myotis (*Myotis capaccinii*), Geoffroy's myotis (*Myotis emarginatus*), whiskered myotis (*Myotis mystacinus*), Natterer's myotis (*Myotis nattereri*), Maghrebian myotis (*Myotis punicus*) (Table 12.1, Appendix).

12.2.2.2 Asia

In Asia, hunting is known to affect 64 species, which represents the largest absolute number of hunted bat species in a region.

Southeast Asia. The hunting pressure on bats is greatest in Southeast Asia, where 56, or 17 % of the region's bat species are hunted (Table 12.1, Appendix). Bat hunting is widespread in 10 out of the 11 countries (Brunei, Cambodia, Indonesia, East Timor, Laos, Malaysia, Myanmar, Philippines, Thailand, and Vietnam). Only in Singapore are bats not thought to be hunted heavily (Mildenstein 2012; IUCN 2014).

Table 12.1 Proportion of bats hunted by region (Calculated by total number of extant bats species hunted divided by the total number of bat species in the region)

Taxon	Region	Total#	On Red List	Not on list	Total hunted	%hunted
Chiroptera		1146	97	70	167	14.6
	Caribbean islands	106	0	0	0	0.0
	East Asia	130	3	4	7	5.4
	Europe	42	0	0	0	0.0
	Meso America	177	0	0	0	0.0
	North Africa	41	3	1	4	9.8
	North America	49	0	0	0	0.0
	North Asia	43	0	0	0	0.0
	Oceania	173	25	15	40	23.1
	South America	249	0	8	8	3.2
	South and Southeast Asia	365	43	20	63	17.3
	SE	333	36	20	56	16.8
	South	114	8	5	13	11.4
	Sub-Saharan Africa	249	25	26	51	20.5
West and Central Asia	94	1	0	1	11	

High levels of hunting occur in Indonesia, where there is a long history of bat consumption (Fujita 1988) and large numbers of individuals are still sold in markets (e.g. *P. vampyrus*, Harrison et al. 2011; Sulawesi fruit bat, *Acerodon celebensis*, gray flying fox, *Pteropus griseus*, black flying fox, *Pteropus alecto*, Heinrichs 2004). Hunting pressure is also high in the Philippines, with a third (24/75) of its species known to be hunted. Although Philippine bats are protected from hunting by the Philippine Wildlife Act and the Philippine Cave Management Act, these laws are not well enforced, and hunting for personal consumption and local trade is widespread.

In Malaysia, hunting of some species is regulated, which may curb some of the hunting pressure but has not reduced hunting rates to sustainable levels (Epstein et al. 2009). The laws and levels of enforcement are different for the different regions of Malaysia. All bats are legally protected in Sarawak, but this is not the case in Sabah and peninsular Malaysia. Illegal hunting still occurs in orchards and by sport hunters in Sarawak at places where enforcement is lacking. Legal protection for Old World frugivorous bats is reviewed by Abdul-Aziz et al. (2015).

In Buddhist countries (Cambodia, Myanmar, Thailand and Vietnam), most roost sites of large fruit bats are found in the gardens around temples and monasteries because of the protection the monks provide (e.g. Ravon et al. 2014; T. Mildenstein unpublished data). Whether this degree of protection is sufficient to maintain stable populations of these species has yet to be investigated (Table 12.1, Appendix).

South Asia. In Bangladesh, large fruit bats are hunted for food by members of tribal groups (Mickleburgh et al. 2009). In India and Pakistan, bats are classified as vermin and are persecuted, although they are consumed infrequently, and more often killed for medicinal purposes (Noureen 2014). The exception is the Indian flying fox (*Pteropus giganteus*), which is eaten by indigenous forest-dwelling people (Mickleburgh et al. 2009). On the Andaman and Nicobar islands, black-eared

flying fox (*Pteropus melanotus*) and *P. faunulus* are hunted and eaten on special occasions (Mickleburgh et al. 2009) (Table 12.1, Appendix).

North Asia. Bats are not specifically protected in China and many species are eaten, especially in southern China, where bats are found regularly in markets (Mickleburgh et al. 2009) (Table 12.1, Appendix). Requests from international agencies following the SARS outbreak, (which resulted in several hundred human deaths) that wildlife legislation be introduced in China prohibiting *inter alia* hunting and sale of bats have been ignored.

12.2.2.3 Pacific (Oceania)

Bats are often the only native mammals on remote Pacific Islands, and there is a long history of bat species being hunted in many of these areas. Bats are eaten on American Samoa, the Cook Islands and Niue, the Federated States of Micronesia, Fiji, Guam and the Northern Mariana Islands, New Caledonia, Palau, the Solomon Islands, and Vanuatu (Chambers and Esrom 1991; Mickleburgh et al. 2009). In total, 40 bat species are affected, 23 % of Oceania's bats, making this the region with the highest proportion of hunted bat species on the planet. The value of bat meat is highly variable in Oceania. It is a sought-after delicacy on Guam and the Mariana Islands, where the bats are strictly protected by the United States' Endangered Species Act (USFWS 2009). In contrast, in the nearby Federated States of Micronesia, the same bat species are rarely eaten (Mickleburgh et al. 2009). In American Samoa, (another United States territory), bats were consumed regularly in the past (Brooke 2001) but are now highly protected. Bat meat is also a delicacy in the Cook Islands, Niue, and Raratonga (Brooke and Tshapka 2002) and is a popular food on Fiji, New Caledonia, and Vanuatu (Mickleburgh et al. 2009).

12.2.2.4 South America

Bat hunting is much less common in South America, occurring in highly localized areas and affecting eight species in the families Phyllostomidae (7 spp.) and Vespertilionidae (1 sp.) (Table 12.1, Appendix).

12.3 Why Bat Hunting is a Conservation Problem

12.3.1 Negative Impacts on Bat Populations and Ecosystems

Bats are particularly vulnerable to the effects of hunting for a number of reasons. They are long-lived for their body size (five species live >30 years, Racey 2015) and reproduce slowly, with generally one young per year. They have a slow rate of

fetal growth and long gestation periods (Racey and Entwistle 2000). Females and young bats are thus sensitive to hunting disturbance during a large portion of the year.

Bats are nocturnal, making them susceptible to hunting at their roost sites by day when humans can easily find them. This is especially a concern for the highly sought-after fruit bats in the Old World, which tend to roost conspicuously, aggregating in large numbers in the forest canopy (e.g. Mildenstein et al. 2008). Whether roosting colonies are in caves, cliffs, or trees, hunting at the roost site is likely to affect the entire colony. Hunting disturbance at the roost site causes injury to many bats from the spread of shot gun pellets, large-scale infant mortality when pups fall from fleeing mothers (Mildenstein and Stier unpublished data; R. Ulloa, pers. comm.), and higher stress levels as resting bats are startled and forced to flee from hunters (Van der Aa et al. 2006). In their survey of *P. rufus* in Madagascar, Mackinnon et al. (2003) recorded a high incidence of abandonment of historical roosts, which they attributed, at least in part, to high hunting pressure.

Finally, bat colonies are characterized by high roost site fidelity (e.g. Banack 1996; Brooke et al. 2000; Gumal 2004; Stier and Mildenstein 2005). Hence, bats may be reluctant to leave when hunting starts and may find it difficult to find alternative roost sites after fleeing hunters. Because bats are likely to eventually return to the preferred roost site, they are predictable prey for hunters. The overall effect of hunting at roost sites is reduction of bat population densities to a fraction of local carrying capacity (e.g. Mildenstein 2012).

These population-level impacts may also have negative ecological consequences. Some bat species play prominent roles in insect population control, pollination, seed germination and dispersal, and in many areas, bat species are essential to forest regeneration (e.g. large fruit bats are primary seed dispersers for hemi-epiphytic figs, Shanahan 2001; Oleksy et al. 2015a). On isolated islands, where there is little ecological redundancy, bats are often recognized as keystone species due to their unique roles in seed dispersal (Shilton and Whittaker 2009). Mortality due to hunting may, therefore, have cascading effects on ecological communities (e.g. Mildenstein 2012) and ecosystem function (e.g. McConkey and Drake 2006).

12.3.2 Negative Impacts on Humans

The negative impacts of bat hunting extend beyond natural ecosystems to human communities. Bats in their natural ecological roles perform valuable ecosystem services beneficial to humans (e.g. insect suppression: Cleveland et al. 2006, pollination: Bumrungsri et al. 2008b, 2009, seed dispersal maintaining local watersheds: Banack 1998; Stier and Mildenstein 2005), all of which are reduced when bats are hunted. Bat colonies have also proved valuable as eco-tourism attractions supporting local economies (e.g., in Costa Rica, Lao People's Democratic Republic, Madagascar, the Philippines, and North America; examples in Pennisi et al. 2004). However, hunted bats that are wary of human presence often do not

maintain colonies in locations easily viewed by people. Hence, reductions in bat populations as a result of hunting could have expensive ramifications on local communities' water supplies, agriculture, and eco-tourism industries.

Finally, the hunting of bats may also expose human communities to potentially zoonotic pathogens (Leroy et al. 2005). In the past decade, considerable attention has been paid to bats as natural reservoirs of emerging infectious diseases (Calisher et al. 2006). Studies that link infectious disease outbreaks to bats demonstrate the spillover potential through contact with bats or exposure to faeces and urine in bat habitats (reviewed by Plowright et al. 2015). Most notable are the Ebola virus outbreaks, which have attracted international attention. Leroy et al. (2009) suggest that the 2007 emergence of Ebola virus in the Occidental Kasai province of DRC could be attributable to the consumption of freshly killed bats. The authors trace the virus spread from a first patient with bat bushmeat contact to an outbreak of the disease in 260 persons resulting in 186 deaths in 2007. The re-emergence of the disease in 2014 may also have arisen from contact with bats (Saéz et al. 2015) and has proven far more deadly.

12.4 Overhunting as a Growing Concern for Conservation

Human communities have long exploited bat populations for consumption. Current hunting pressure, however, is likely to be much greater than historical pressure with increases in human population density, greater accessibility to natural areas, technological advances in bat capture methods and transport options, and relaxed adherence to cultural taboos (Brooke and Tschapka 2002; Millner-Gulland and Bennett 2003). Hence, bat hunting is likely to be unsustainable (Bradshaw et al. 2009), especially when coupled with other anthropogenic stressors (such as those described throughout this book).

Overhunting (commonly also “unregulated” hunting, although not all unregulated hunting is unsustainable, nor regulated hunting sustainable) is a globally-recognized threat to many wild species of animals (Robinson and Bennett 2000; Milner-Gulland and Bennett 2003). For bats, overhunting has been a conservation concern for over three decades (Lemke 1986; Mickleburgh et al. 1992, 2002, 2009; IUCN 2014). However, there has been a substantial lag time in our identification of which species are affected and assessment of the impact of hunting.

Twenty years ago, the conservation status of nearly half (78/160) of the Old World fruit bats was unknown due to lack of data (compiled from Mickleburgh et al. 1992). Today only 11 % (21/183) of the extant Old World fruit bat species on the Red List are considered data deficient (IUCN 2014). (These two reviews may differ slightly in their definitions of data deficient species.) This general increase in knowledge about bats includes a better understanding of the extent of hunting pressure. In the first conservation review, 49 (31 % of the total 160 known) Old World fruit bat species were recognized as hunted (Mickleburgh et al. 1992). Two

decades later, nearly twice as many species ($N = 92$) are known to be hunted, representing over half of the 183 recognized species of Old World fruit bats (IUCN 2014) (Table 12.1).

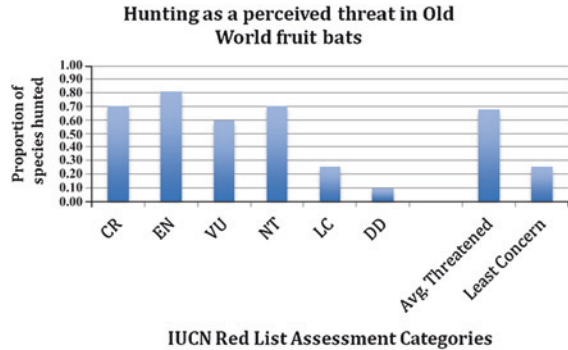
Although there has been relatively little research explicitly focused on quantifying hunting impacts, the general level of concern about hunting effects on bat conservation has increased. Using Old World fruit bats as an example, in the first review, hunting was not considered a threat for most (60 %) of the hunted species (Mickleburgh et al. 1992). Now, all but five of these hunted species (25/30, 83 %) have been moved up to a higher threat status because of perceived pressures that hunting causes (IUCN 2014). Overhunting is a recognized factor in the loss of three (and probably also the little known fourth) of the now extinct fruit bat species (IUCN 2014) and a cause behind local extirpations within species' historic distributions (e.g. Polynesian sheath-tailed bat, *Emballonura semicaudata*, from Vanuatu, Helgen and Flannery 2002). Similarly, the declines of seven of the ten fruit bat species listed as critically endangered are attributed directly to hunting; the remaining three species are still virtually unknown (IUCN 2014) (Table 12.2).

The increased concern about bat hunting may be due to greater hunting pressure, or may just represent our increased awareness of hunting impacts. What is clear is that bat conservation biologists now explicitly attribute species declines and increased extinction risk to hunting. Seven hunted bat species previously assumed to be unaffected by hunting (Mickleburgh et al. 1992) now have hunting listed as a major threat (IUCN 2014). Most (68 %) of the species that are hunted, are listed as threatened by that hunting, while only 15 % of the hunted species are expected not to be affected. However, it should be pointed out that for the remaining 38 % of hunted species, reviews remain ambivalent about whether hunting is a problem. Similarly, in the review of bats as bushmeat carried out in 2004 (Mickleburgh et al. 2009), 59 % of questionnaire respondents said bat hunting

Table 12.2 Comparison of the conservation status of old world fruit bat species across two decades from two sets of species accounts: 1992 IUCN Action Plan (Mickleburgh et al. 1992); 2014 IUCN Red List; and for comparison, the 2009 Bats as Bushmeat review (Mickleburgh et al. 2009)

	IUCN Action Plan 1992	IUCN Red List 2014	Bushmeat Review 2009
# species considered	160	183	138 reports
# species hunted (% total)	49 (31 %)	92 (50 %)	82 (59 %)
# species perceived as threatened by hunting (% total hunted)	20 (40 %)	63 (68 %)	44 (54 %)
# data deficient species (% total species)	78 (49 %)	21 (11 %)	
# hunted species listed as LC (% total hunted)	29 (59 %)	10 (5.3 %)	
# hunted species not listed as hunted on IUCN list (% total hunted)	Unknown	18 (20 %)	

Fig. 12.2 Proportion of pteropodid species in IUCN categories listed as hunted. 69 % of species in threatened categories (*CR*, *EN*, *VU*, *NT*) list hunting as a threat, compared to 25 % of species in the “least concern” (*LC*) category



occurred in their region, and over half (54 %) of those species hunted were perceived to be negatively affected (Table 12.2).

The general consensus among biologists and managers is that hunting is a major conservation threat. Despite lacking measures of hunting impacts, there are many examples of population declines and extirpations of bats that are hunted (e.g. loss of historical bat roosts and reduced population sizes in Madagascar, Mackinnon et al. 2003; and in the Philippines, Heideman and Heaney 1992). Biologists studying Old World fruit bats currently rank hunting as the top conservation concern for this taxon (Mildenstein 2012). The IUCN Red List also reflects this concern. Fruit bat species that are known by the IUCN to be hunted are almost three times more likely to be listed as threatened ($N = 58$ spp. in IUCN categories: *CR*, *EN*, *VU*, *NT* compared to 21 species in the “*LC*” category) (Fig. 12.2). However, there still appears to be an information gap at the international level. Nearly 42 % (70/167) of the hunted species listed in this review are not listed by the IUCN Red List as threatened by hunting. Half of these (35 spp.) may be for lack of awareness, as they are not known to be hunted at all by the IUCN. The other half are described as hunted by the IUCN but not considered to be threatened by that hunting. In other words, these 35 species are described as hunted in their Red List species accounts, but then hunting is not included in the list of threats (compiled from IUCN 2014).

12.5 How Hunting Affects Bats

The least known area of bat biology is population dynamics, so it is difficult to extrapolate from hunting mortality rates to a quantitative assessment of hunting impacts on bat populations. Hence, one of the main conservation recommendations for protecting hunted species is the direct study of the population-level impacts of hunting (IUCN 2014).

Hunting does not necessarily lead to population declines in wild species. There are some examples of hunted bats that appear to have stable population sizes or

where the effects of hunting are minimal. In these cases, hunting pressure is small relative to the bat population size due to effective law enforcement (e.g. *P. mariannus* on Rota, Mariana Islands, Mildenstein and Mills 2013), due to cultural/religious taboos (e.g. related to Muslim beliefs: *R. oblioviosus* and *P. seychellensis* in the Comoros Islands, Sewall et al. 2003, 2007; *P. vampyrus* in the southern Philippines, Mildenstein 2012), and/or for the reasons given for the 35 species on the Red List that are hunted but not considered threatened by that hunting (see Appendix).

To evaluate the impacts of hunting on a bat population, research must compare the direct and indirect mortality rates of hunting with that population's capacity for growth. Falling short of these data-intensive lines of evidence, biologists have found other ways to provide inferences of hunting impacts, e.g., expert opinion, models of hunting and population growth, indices to measure population growth and/or hunting mortality, and by comparing hunted to non-hunted populations. Below, we describe the research that has contributed to knowledge of the impacts of hunting on bat populations to date.

12.5.1 Expert Opinion

Expert opinion surveys can be an efficient means of gathering information on conservation priorities when research is lacking. Because of the paucity of data on hunting impacts, much of the current concern about bat hunting is based largely on expert opinion derived from anecdotal evidence and observations of bat hunting impacts on local scales. Red List risk assessments for lesser known bats are often the result of consensus among biologists who have worked on the species. Conservation recommendations for most bat species that are hunted are based on perceived relationships between apparent bat population declines and levels of hunting that appear to be unsustainable (e.g. *Pteropus flanneryi*, Helgen et al. 2008a).

Surveys of bat biologists have been used to provide overviews of bats that are hunted and where. Most recently, Mickleburgh et al. (2009) conducted a literature review and global survey of bat biologists in 2004 to collate what is known about bat hunting. From 109 questionnaire respondents, there were 138 reports of bat consumption from which the authors provided a synthesis of bat hunting, identifying West Africa and Asia as the principal regions of conservation concern.

Expert opinion surveys have also shed light on hunting as the main threat and priority for conservation management to address. Mildenstein (2012) conducted surveys through questionnaires at two Southeast Asia regional bat conferences to learn about threats to fruit bat species. According to the 78 participants representing all Southeast Asian countries except East Timor, hunting is the main direct threat to fruit bats across this region.

Caveats. While expert opinion is a readily available source of information to identify conservation priorities in lieu of data, it does not replace systematically-acquired knowledge. There are many examples of subsequent research leading to

recommendations that differ from expert opinion, especially when species-specific ecological distinctions are concerned (e.g. how to conserve co-occurring specialist and generalist species, Mildenstein 2012). It is incumbent upon conservation biologists to conduct research to verify priorities identified through expert opinion to focus conservation resources and efforts on the most urgent issues.

12.5.2 Determining Hunting Impacts on Bat Populations

To directly study the impacts of hunting, research must measure and compare hunting mortality rates to a bat populations' size and capacity for growth. To date, there are only a few studies that have tried to evaluate the sustainability of bat hunting. The first was Halstead's (1977) on the Ile-Ife campus of the University in Nigeria, which was unfortunately cut short by his return to the UK. Brooke and Tschapka (2002) modeled what would be "sustainable take" on Niue, based on the current bat population size and estimated reproductive rates. Comparing their modeled sustainable take to the numbers of bats hunted on Niue, they determined current hunting rates were unsustainable. Epstein et al. (2009) estimated potential harvest rates of *P. vampyrus* in Malaysia as a function of the number of hunting licenses issued. Incorporating these hunting mortality rates into their estimated bat population growth matrix, they projected declines in the Malaysian bat population using even the most conservative measures of hunting pressure. On Madagascar, Goodman (2006) extrapolated total hunting pressure on hipposiderids from a single hunter he interviewed. Comparing this estimated mortality rate to the local bat population surveyed, he then inferred hunting levels were detrimental, because take exceeded the breeding potential of the local bat populations.

Caveats. Rarely will information be available on harvest levels, population sizes, and reproductive rates for the same bat species. The studies described here work around missing information by using indices of bat harvest levels (e.g. licenses), estimates of reproduction rates from better known congeners, and models of sustainable take based on rules of thumb from other harvested species (e.g. "RR" production method, named after its authors, Robinson and Redford 1991).

When indices, estimates, and models based on other species are used, there are caveats to consider. Researchers should be sure that the relationship between the index and the measure of interest is known and does not vary. Estimates based on similar species may differ from the species of interest. With population growth rates in particular, ignoring density-dependent factors could lead to inaccurate estimates of reproduction and population growth capability. Finally, models for determining sustainable hunting rates, such as the RR method used by Brooke and Tschapka (2002), predict a sustainable take rate of 40 % of the annual growth for species with life spans the length of fruit bats. However, this rate is based on similar species with potentially different life histories and may not take into account the other stressors that bats face today.

12.5.3 Measuring Hunting Mortality Rates

Surveys from local markets, hunters, and consumers can be used to gain insights into hunting rates and trends. Studies use a variety of methods to estimate hunting pressure on bats. In the Mariana Islands, Esselstyn et al. (2006) interviewed hunters of *P. mariannus* and found a 34 % increase in hunting pressure after a recent typhoon. In Madagascar, Goodman (2006) used his interview of a single bat hunter as a sample to extrapolate local hunting pressure on hipposiderids. In Niue, Brooke and Tschapka (2002) used government permit records to identify households with guns potentially used for hunting, and then interviewed a third of these potential hunters about their bi-monthly harvest rates. The authors used their results from this sample to extrapolate to hunting pressure over all hunters during the two month hunting season on the island. Kamins et al. (2011) interviewed a total of 551 Ghanians including hunters, vendors and consumers, demonstrating a high off-take of >128,000 *E. helvum* per year. A recent study on the same population used annulus markers in teeth to age bats and develop a static life table to determine age structured survival rates (Hayman et al. 2012). Markets were surveyed in Sulawesi to determine bat consumption rates of local people and number of bats exported to neighboring provinces for trade (Sheherazade and Tsang 2015). A questionnaire survey in 13 villages in Madagascar resulted in an estimate of 6500 bats taken each year (Razakarivony 2003) and staff at a roadside restaurant in western Madagascar reported serving about 30 *P. rufus* each day, which extrapolates to 10,000 a year (Racey et al. 2009). The largest roost counted during surveys at that time consisted of 5000 individuals (Mackinnon et al. 2003) which cast doubt on the reported rate of bat consumption. Nevertheless about 30 live *P. rufus* were present in panniers in the food storage area of the restaurant during a casual visit (Racey et al. 2009). Also in Madagascar, Oleksy et al. 2015b) interviewed hunters to learn about bat numbers taken as well as the location, time of night, and season in which the hunting occurred, to measure harvest rates.

Caveats. When using surveys of people's knowledge and opinions to collect information for conservation, it is important to remember the limitations of this source of information. Hunters can provide insight into numbers of bats killed, but not all of these are sold. So, when the study question involves bat trade, researchers must extend surveys to the end consumers of bats. To address this problem, the surveys by both Kamins et al. (2011) and Harrison et al. (2011) employed questionnaire approaches where all actors at different stages of the commodity chain were interviewed instead of restricting data collection only to market surveys.

There is a potential for market surveys to underrepresent the extent of fruit bat hunting, especially when many bats are not sold in regular or bushmeat markets (Kamins et al. 2011). Mbete et al. (2011) interviewed householders in Brazzaville and assembled a long list of bushmeat species consumed together with details of the markets from which they were purchased. Bats were conspicuous by their absence and enquiries (by PA Racey) revealed that they were 'marketed differently'.

In addition, hunter interviews have received conflicting reports on the accuracy of information gathered. For example, some studies report that hunters overestimate what they take, as has been shown for geese in the United States where goose hunting is legal (Andersen et al. 1996). Similarly, hunters who are being interviewed for their unique traditional knowledge may want to please or impress their interviewers, which could lead to overestimated harvest rates (e.g. indigenous Aeta people in the Philippines, T. Mildenstein and S. Stier, unpublished reports). However, in places where the species hunted is of perceived conservation concern, hunters may underestimate their take levels to avoid scrutiny, especially if hunting is illegal (e.g. for Mariana fruit bats, *P. mariannus*, in the Mariana Islands, T. Mildenstein unpublished reports).

To address the potential for inaccurate reports by hunters, some studies provide methods for hunters to report take anonymously. The study of typhoon impacts on hunting levels in the Mariana Islands, used a local hunter to collect data from other hunters (Esselstyn et al. 2006). In Madagascar, Oleksy et al. (2015b) provided a subpopulation of hunters with notebooks and monetary incentives to keep track of hunting off-take over time and return the information anonymously at the end of the study.

12.5.4 Estimating Hunting Impact from Population Declines

In cases where hunting mortality rates are unknown and/or difficult to measure, study of population trends in hunted areas can provide an indication of hunting impacts. Hunting is often assumed to be the cause behind measured population declines. For example, biologists interviewed local people at more than 30 bat roosting sites in Pakistan where bats were hunted, and the consensus of local knowledge suggested there were large-scale declines in bat populations in areas where hunting was common (Venkatesan 2007). The inference power of this type of study is stronger, however, if a comparison can be made to areas free from hunting. In comparisons of areas with and without hunting, bat population densities were 5–10 times larger when roost sites were protected (in the Philippines, Mildenstein 2012) and up 100 times larger when their entire habitat was protected (in the Mariana Islands, Mildenstein and Mills 2013).

Other studies have used indices of bat population size that are directly linked to hunted bats for measuring trends. Harrison et al. (2011) used questionnaires to survey hunters and market vendors across 12 key population centers in Kalimantan, Indonesia to gain insight into hunting intensity, seasonality, and market dynamics. They used capture rates by hunters and sales rates in markets as indices of the population size of bats in the wild. From reductions in the numbers of bats captured and the decreasing number of bats brought to market for sale, they inferred that the bat population in the wild was declining.

Caveats. Again, caution is warranted when inferences are based on surveys of people's opinions and care should be taken in planning surveys and interviews

especially when researchers lack sociological training (St. John et al. 2013; see also Nuno and St. John 2014 for a review of survey techniques). Similarly, it is important to remember that population reductions in areas with hunting are the net result of many stressors, natural and human-caused (e.g. chapters of this book), and may not correlate directly with hunting pressure.

12.6 Conservation Management to Mitigate Hunting Impacts

12.6.1 Enforcement of Hunting Prohibition

For threatened populations, the elimination of hunting as a threat can produce population-level results within decades (see also roost site protection). For areas that have been not hunted, bat population sizes can be large, with densities (individuals/hectare of habitat) that are hundreds of times that of the same species in similar areas with hunting pressure (e.g. Mariana Islands, Mildenstein and Mills 2013; Tacio 2015). Similarly, eliminating hunting allows bat populations to recover. In American Samoa, typhoons and overhunting sent populations of *P. samoensis* and *P. tonganus* into a sharp decline, eventually triggering a hunting ban in 1992 (Craig et al. 1994a, b). Two decades later, the population sizes of these bats is much larger and considered stable (Brooke and Wiles 2008, A. Miles pers. comm.).

12.6.2 Regulated Hunting

Theoretically, hunting can be sustainable if regulated tightly to ensure population declines due to harvest do not exceed what bat populations can naturally replace given the range of environmental variability to which they are subjected (methods in Mills 2012). Although several countries permit hunting, bat hunting has generally proved difficult to regulate for sustainability for a number of reasons. In some places, hunting laws are hard to understand and therefore not followed by hunters. In Madagascar for example, bats can be hunted legally between May and August or February to May, depending on the species (Jenkins and Racey 2008). In addition, according to the regulations, hunting is allowed only during the day, and game species cannot be hunted at their roost. Hence bat hunting is technically impossible, but hunters harvest bats despite the rules (Racey et al. 2009).

In other countries, hunting regulations are poorly designed from a conservation perspective. In peninsular Malaysia, bat hunting is legal and numbers harvested are said to be regulated. However, while limits on the number killed are issued by the provincial government where the hunter resides, the license owners are allowed to hunt in multiple provinces which creates a potential for seasonal take that far exceeds the bat populations' capacities for regeneration (Epstein et al.

2009). In Niue, bat hunting is allowed for two months per year. Hunting levels are not regulated because of the assumption that the bat supply is unlimited. However, bats roost in sacred forest grounds that are taboo for humans to enter, making it impossible to obtain a count of the population size. Based on models of similar species, harvest rates exceed what is expected to be sustainable (Brooke and Tschapka 2002).

In other countries, harvest laws are not enforced or followed. For example, the main threat to the ornate flying fox (*Pteropus ornatus*) in New Caledonia is local hunting for food (Brescia 2007). There is a short legal fruit bat hunting season, which includes only the weekends of April with a quota of five bats/hunter. However, based on reports, there is widespread and substantial illegal hunting, including the commercial harvesting of these fruit bats (Brescia 2007).

Finally, there are a few countries where hunting is legal and unregulated. In Pakistan and India, bats are considered “vermin” or “pests” and hunting is actually encouraged by the government without concern for long-term sustainability or conservation (Noureen 2014).

Whenever hunting regulation is being considered, managers should be aware that sustainable off-take will have to be much lower than projected recruitment for a number of reasons. Current bat population sizes, distribution, and number of populations are a fraction of historical numbers. For example, mixed colonies of *P. vampyrus* and golden-crowned flying fox (*Acerodon jubatus*) in the Philippines are thought to once have been present on every major island in populations numbering in the hundreds of thousands (Heideman and Heaney 1992). Now, these bats have been extirpated from most islands. Fewer than 15 mixed colonies remain, often with less than 2000 individuals and dangerously small numbers of the endangered *A. jubatus*. (Mildenstein 2012). In addition to already being at historically low population sizes, other human-caused stressors (persecution, habitat fragmentation, global climate change and other perturbations described in this book) continue to act on bat populations, exacerbating detrimental effects of harvest. Hence, it is prudent for managers to be conservative when establishing regulated harvest limits, and to carefully monitor populations and adapt regulatory management as needed to meet sustainable goals.

12.6.3 Control of Guns, Ammunition, and Other Bat Hunting Tools

Gun control is expected to have a positive effect on bats. In those countries where private gun ownership is not allowed, *Pteropus* often benefits. After a coup d'état in the Seychelles in 1977, all guns were confiscated and the numbers of Seychelles flying fox (*Pteropus seychellensis*) rose having previously been of some conservation concern (Racey 1979; Nicoll and Racey 1981). A similar story occurred in Palau following the death of the President by gunshot wounds (A. Brooke, pers. comm.).

In Myanmar, private gun ownership is a crime with reportedly severe penalties. Perhaps as a result, bat populations are large and easily approached. Bats are still harvested. For example, *Pteropus* are catapulted to provide medicine for asthma, *Rousettus* is often netted at cave entrances and sold in a market close to Mandalay, and insectivorous bats are also caught at cave entrances, fried and sold as beer snacks (U Khin Maung Gyi, pers. comm.). However, the harvest rates and overall disturbance to bats in Myanmar are thought to be much lower without guns.

Bat hunting may also be regulated through control of capturing equipment. For example, in Sarawak, as in many countries, it is illegal to sell or buy mist nets without a permit. This method of protecting bats, however, is only effective if hunters use commercially-manufactured nets. Many bat hunters avoid the high cost and regulation of mist nets and make their own nets or hook and line traps from monofilament line and other inexpensive fishing materials (e.g. in the Philippines, Mildenstein 2012).

12.6.4 Roost Site Protection

Bats are most vulnerable at their day roosting sites. So, it is not surprising that bat populations settle in areas where they are most protected. In Buddhist countries like Cambodia, Myanmar, Thailand, and Vietnam, large fruit bats are commonly found in the gardens surrounding temples and monasteries (T. Mildenstein, unpublished data). The presence of monks and religious activities turn these areas into de facto sanctuaries for bats that would otherwise experience hunting pressure. In nearby non-Buddhist countries, such as Indonesia and the Philippines, the same fruit bat species colonize other “safe” spots such as privately protected lands and parks, especially in the forest interior, using topographical features that afford protection from people (e.g. along rivers, within mangrove islands, and on cliff edges, Mildenstein 2012). Active protection of roost sites alone (i.e. hunting still occurs away from the roost) has been shown to result in as much as ten times the number of roosting fruit bats for the same amount of forest habitat, and is especially important for sensitive species such as ecological specialists (Mildenstein 2012). Because of this, and the fact that roost sites are geographically predictable, conservation management by local government units and non-government organizations often target roost site protection.

Case Studies. Conservation efforts for the Pemba flying fox (*Pteropus voeltzkowi*) included roost protection through the setting up of community conservation clubs (Robinson et al. 2010). The recovery following these conservation programs led to the downgrading of the species’ Red List threat assessment from Critically Endangered to Vulnerable.

Until recently, permanent nets were a regular method of hunting in the roost at Analalava, Madagascar by the people of Ambatondrazaka. The national NGO, Madagasikara Voakajy, initiated community-based protection of the fruit bat roost by incorporating payment for local rangers in a local peanut cooperative it funded.

Currently, hunting at the roost has ceased and the colony has increased from 200 to nearly 2000 individuals (Razafimanahaka 2013).

In Malaysia, the Wildlife Conservation Society has worked with local communities and the government in Sarawak to establish protected roosting areas of *P. vampyrus*. (M. Gumal, pers. comm. 2015). Four out of the five maternity roosting sites identified by Gumal (2004) are now protected for *P. vampyrus*, including: Loagan Bunut National Park, Sedilu National Park, Limbang Mangroves National Park, and Bruit National Park. A fifth maternity roost site at Bukit Sarang is in the preliminary proclamation stage for a National Park (M. Gumal pers. comm.).

In the Philippines, the Filipinos for Flying Foxes project is building on the successes of Bat Count-Philippines by developing bat roost site sanctuaries with local governments. The collaborating organizations (Philippine Biodiversity Conservation Foundation and Mabuwaya Foundation) are establishing community-managed roost site sanctuaries across the distribution of the endemic and endangered *A. jubatus* and studying bat population size increases and roost site fidelity in these newly protected roost sites (SOS 2012).

12.6.5 Education and Awareness Raising

One of the first steps toward conservation management of hunted bats is educating local communities. Bats are important to human communities in a number of ways, particularly for the valuable ecosystem services they provide, but local communities are often unaware of these. Because hunting, like other human-caused stressors, is tied directly to population declines in bats, it is important that human communities are aware of the trade-offs between temporary gains from bat exploitation and the risk of losing bats entirely from the region. Following a knowledge/attitude/behavior approach to understanding responsible environmental behavior (Hines et al. 1987), communities may come to appreciate bats and support bat conservation only after understanding their role in the environment (see Kingston 2016).

12.6.5.1 Knowledge

People are generally aware of bats present near their local communities. Bats are not cryptic animals, especially fruit bats that aggregate in large numbers by day using conspicuous roosting sites, and they often forage at night in fruiting and flowering trees on farms and in residential areas. Hence, local people's knowledge of bats often surpasses that of outside biologists, especially with respect to bat roosting locations, foraging habits, seasonal behaviors, and even threats (e.g. local community members' awareness of subtle seasonal changes in fruit bat diet of *P. mariannus*, Mildenstein and Mills 2013). It is, therefore, surprising how little is known about bat conservation status in these same areas. Population size and

growth trends tend to be unknown by biologists and managers, much less by the non-scientific members of the local community. So, even though local people are aware of the disturbance they may be causing, they often have no idea of the severity of population-level consequences. Because bats appear to be numerous, popular belief is that humans can have only minimal impact on their populations. For example, the greater short-nosed fruit bat (*Cynopterus sphinx*) is believed by experts to be threatened by hunting in parts of its range, but in other parts, <1 % of local people surveyed believe the species could be threatened by their hunting (Johnson et al. 2003). Similarly, throughout the Philippines, bats are eaten regularly with little understanding of the impacts that harvest is causing. Hunters who join biologists on bat population counts commonly overestimate the population size by three orders of magnitude prior to the count and then are shocked when the counted population is in the hundreds or low thousands (Mildenstein et al. 2007; Mildenstein 2012).

Education and awareness programs. One of the most hunted bats in sub-Saharan Africa, *E. helvum* is the focus of members of the Eidolon Monitoring Network (EMN) who conduct education activities in areas near bat colonies (J. Fahr, pers. comm.). In Kenya and Nigeria, scientists and volunteers of the EMN carry out education programs in schools (Fig. 12.3) and among the general public (Tanshi et al. 2013). Education on islands around Africa has proven effective in drawing local attention to bat protection. Examples include the recovery program



Fig. 12.3 Conservation education and bat population monitoring by volunteers in Eidolon Monitoring Network in Benin City, Nigeria, school students engage in conservation outreach event, **a** volunteers prepare conservation outreach materials, **b** volunteers counting straw-coloured fruit bats *Eidolon helvum* at King square, Ring Road, Benin City, **c** undergraduate student volunteers Eidolon Population Monitoring team from University of Benin, Benin City, Nigeria

for the *P. voeltzkowi* in Pemba Tanzania, for *P. rufus* in Madagascar, *P. rodricensis* in Rodrigues and the Comoro flying fox (*Pteropus livingstonii*) in the Comoros (Wilson and Graham 1992; Trehwella et al. 2005; O'Connor et al. 2006; Robinson et al. 2010; H. Doulton, pers. comm.).

12.6.5.2 Behavior—Local Commitment to Conservation of Bats and Bat Habitat

Finally, once communities that value bats become aware of the threats bats face, they may start to change their behaviors to support bat conservation (but see Kingston 2016). A multi-faceted education and awareness program in the Comoros Islands is a good example of how outreach can lead to changes in attitude and behavior that support conservation. Local citizens became involved in monitoring bat populations and directing conservation management (Trehwella et al. 2005).

12.6.5.3 Capacity Building of Local Rangers/PA Managers

Many programs include training and capacity building in their bat conservation efforts. Bat Count—Philippines held a national workshop in 2004 to train protected area managers in bat identification and monitoring techniques (Mildenstein et al. 2007; Mildenstein 2011). The project, Filipinos for Flying Foxes, is now working with local communities to establish sustainable management practices for bats (SOS 2012). The project trains local rangers and management staff to monitor their bat populations and encourages them to self-regulate their hunting pressure. In Dalaguete, Cebu, rangers have continued forest protection despite the inconsistencies in availability of their modest stipends provided by the local government (SOS 2012). In Divilacan, Northern Sierra Madre, Luzon, rangers receiving bat conservation training have elevated bat roost protection to the top priority in their regular monitoring activities (SOS 2012).

12.6.6 Stakeholder Engagement and Citizen Science

Collaborative conservation is more likely to be sustainable. In community-based conservation management, stakeholders from a variety of factions within the community are required to work together to implement effective conservation practices. This often creates unlikely partnerships that bridge normal political, socioeconomic and religious divides. For example, former rebels work with local government officials to monitor bats in southern Mindanao, Philippines, a region known for often violent stand-offs between the Philippine government and Islamic separatists (LM Paguntalan pers. comm., SOS 2012). Uniting stakeholders toward

the common goal of bat conservation, however, creates collaborative programs that prove to be robust to the changes that commonly lead to the demise of wildlife conservation programs (e.g. change in political administrations).

Validity of data. A frequent concern when working with citizen scientists, is that data gathered by untrained biologists may be less accurate and obscure the signal that is being studied (reviewed in Johnson 2008). However, community-based bat counts are perhaps a best case scenario for the use of citizen science. The data gathered are the number of bats observed, requiring just the ability to count and no other special training or equipment. Because bats, especially fruit bats, tend to aggregate, the population being counted is all in one place, by-passing many sources of error arising from sampling approaches to abundance assessment. Finally, the goal of community-based counts is detection of population trends across time, so that local communities can track impacts that hunting may be causing. Studies of count error in untrained observers show that while training and experience has a positive effect on count accuracy, counts made by untrained observers are as likely to detect population trend direction as those made by experienced biologists (Mildenstein 2012; Mildenstein and Mills 2013; Barlow et al. 2015).

Case studies. Population monitoring and roost protection for *P. rufus* in Madagascar provides a good example of the effectiveness of citizen science and participatory conservation efforts. Following the decline in populations of *P. rufus* in Madagascar from overhunting and habitat loss, the NGO Madagasikara Voakajy engaged local communities at four roost sites for the protection of the species. With the help of the local government, roost sites were designated for protection and firebreaks with bare ground areas constructed around roost sites. Local volunteers were trained to monitor the roosts of *P. rufus* using binoculars and hand tally counters and have continued to do so. In addition, the engagement of local people led to an interesting partnership where habitat restoration through tree planting is ongoing, while local farmers receive support through a crop seed loan system. Similarly, the local community is enforcing sustainable land use within the protected roost areas. The project organizers ascribe the success of the project to environmental education and outreach efforts, highlighting the benefits of local community engagement through citizen science and partnerships that improve local economies (Mahefatiana Ralisata pers. comm.).

In Asia, Filipinos for Flying Foxes also trains local bat stakeholders as citizen scientists. By providing these community members with the skills and experience to monitor their bat populations, the project is encouraging local stakeholders to conduct regular counts and to self-regulate their hunting pressure. So far, the project has visited more than 35 communities near to fruit bat roosts, and trained more than 200 local stakeholders in surveying and monitoring techniques. It is encouraging that after training, monitoring has continued by the local communities. Twelve communities have counted bats subsequent to training, and five of these have regularly conducted annual counts for 10 years after their training (Mildenstein 2011).

On Guam in the Mariana Islands, *P. mariannus* is a threatened species that must be monitored regularly by the US government under the US Endangered Species Act. Guam's last colony of *P. mariannus* has declined precipitously since the establishment of the invasive brown treesnake (*Boigia irregularis*, USFWS 2009). In the past 10 years the bats have no longer been aggregating in the historical colony location but rather are seemingly scattered in the forest, making population abundance assessments using traditional roost counting methods impossible. Given limited human resources and adherence to historical practices, biologists contracting with the US government have conducted fruit bat surveys sequentially using one or two observers from single observation sites in the forest on a survey morning. These surveys yield occasional bat sightings and location information but provide no basis on which to estimate the population size of the bats, which is essential to generate funding and motivate protective management of this formally-recognized USA national endangered species. In 2014, a different approach to surveying was initiated. Using 85 trained citizen scientists placed at observation stations throughout the forest, simultaneous observation permitted a survey of about 10 % of the forest habitat on Andersen Air Force Base. This collaborative project between the University of Guam and the U.S. Navy resulted in the first population size estimate for the threatened *P. mariannus* since the early 2000s. The survey also brought together local stakeholders representing 25 government and non-government organizations (including schools, environmental clubs, hunters, and local media) toward the common goal of supporting the conservation of a local endangered species (Fig. 12.4; Mildenstein et al. 2014).



Fig. 12.4 Citizen science support enabled the first population count of Mariana fruit bats on Andersen Air Force, Guam in nearly a decade. (Survey participants are showing the number of bats they counted on their raised fingers) (credit SSgt. M. White)

12.7 Recommendations for Conservation of Hunted Bats

12.7.1 *More Research is Needed to Understand Hunting Impacts*

One of the major challenges to bat conservation is lack of knowledge of how hunting affects bats, their population size, and distribution. Collecting these data requires trained biologists, sociologists, statisticians, and well-planned survey techniques and questionnaires that can address sensitive questions. For many regions and species, there is little or no population information on bats, so that population trends are unknown. Managers are therefore encouraged to start monitoring programs by which hunting impacts on population size can be tracked over time. Some bat conservation initiatives provide useful models for population size assessment and monitoring (e.g. Southeast Asian Bat Conservation Research Unit, Filipinos for Flying Foxes, WCS Malaysia, United States Department of Defense in the Mariana Islands, FFI Cambodia). Using the population size estimation and monitoring described, more studies are also needed that investigate the direct and indirect impacts of hunting on bat populations. For example, long term monitoring projects of both people and bats, could show trends in the correlations between number of hunted bats and bat population responses.

Finally, more needs to be learned about the people hunting bats and the conditions that lead to increased hunting (Cawthorn and Hoff 2015). If it is understood why people hunt (e.g. for protein? for livelihoods? to vary their diet? for



Fig. 12.5 Members of the women's peanut cooperative in Madagascar, which grows peanuts to supplement local protein supplies and uses a portion of the proceeds to pay rangers to protect fruit bat roosts (Razafimanahaka 2013)

tradition?) and what are the patterns in hunting intensity (e.g. seasonal, food insecurity), conservation managers can find creative solutions for mitigating hunting impacts (e.g. Razafimanahaka 2013; Fig. 12.5).

12.7.2 Research to Understand How to Protect Bats

There is a need to evaluate methods employed in bat protection programs. For example, roost site protection has been correlated with greater bat density (Mildenstein 2012). It is important to follow this up with research that demonstrates the effectiveness of this strategy and advises managers how to proceed. Important questions are: what is the bats' fidelity to protected roost sites? How quickly do bat populations increase with roost site protection? How quickly do bats become habituated to human presence?

Protection of habitat outside the roost area is also important, although much more difficult to enforce. Studies of the relationship between foraging habitat and bat population sizes would guide managers in their habitat-based conservation strategies.

Equally important is to understand where protection efforts are failing. There are many examples of regulated bat hunting leading to population declines. It is important to understand where laws and implementation are falling short and why.

12.7.3 Education/Outreach

Education and outreach in local communities is essential to successful hunting management campaigns. Many hunters do not perceive bats as a limited resource and are unaware of the effect they may be having on bat species' extinction risks. An obvious first step to bat conservation in hunted areas is therefore the dissemination of information on the bat population size, basic biology, and monitoring techniques, so that hunters can assess the impacts they are having.

Local communities should understand the benefits of bats and the valuable ecological services they provide, including their contribution to forest regeneration through seed dispersal. Communities that appreciate bats may be more likely to pursue conservation management. If people understand the array of risks of ignoring declining populations, they will be more inclined to exert effort to protect bats.

Local communities should also understand the human health risks of bat hunting and consumption. Bat handling, trade, preparation, and consumption by humans create a direct transmission route for disease spillover into human communities and warrants consideration in bat protection programs. Education about these risks is needed, as only a small percentage of participants in bat hunting and

trade are aware of their risk of exposure to disease in Asia (Harrison et al. 2011) and Africa (Subramanian 2012). Finding a balance between the needs for bat conservation, sustainable harvesting and public health management is an important approach in the regions where regulated bat hunting is a goal (Halstead 1977).

Change in perceptions and attitudes towards conservation and wildlife in general require an effective outreach approach. Thus, education and public awareness projects should be designed to engage the audience as has been demonstrated to be effective in Madagascar (Racey 2013) and Latin America (Navarro 2013). The involvement of all stakeholders and policy makers in conservation outreach projects is crucial to the effectiveness of education programs by facilitating the enactment and enforcement of protective legislation (Robinson et al. 2010).

12.7.4 *Protect Colony Locations at the Roost*

Bat conservation through roost protection by local communities has been demonstrated to be effective for the recovery of previously declining populations (Mildenstein 2012; Fig. 12.6). The adoption of such roost protection programs in other countries could hold the key to sustaining populations. This is especially true for areas where fruit bat hunting is intense. If successful roost site protection programs could be demonstrated and published, these could be used as models for other areas (e.g. *P. rufus* populations in Madagascar—M. Ralisata pers. comm.; *P. vampyrus* in Malaysia, M. Gumal, pers. comm.; *P. vampyrus* and *A. jubatus* populations in the Philippines, SOS 2012).



Fig. 12.6 Tourists viewing formerly hunted fruit bats at their protected roost site in Mambukal Resort, Negros Occidental, Philippines (credit LM Paguntalan)

12.7.5 *Regulated Hunting*

In many areas where hunted bats are threatened, hunters do not want to extirpate bat populations, but they also do not want to lose the ability to hunt bats (Mildenstein 2012; Cawthorn and Hoffman 2015). In fact, some roost site protection campaigns are successful, because hunting outside the roost site is not discussed or prohibited, making it easier for hunters to respect roost site sanctuaries (T. Mildenstein pers. obs.; SOS 2012). Once communities understand that human disturbance has population-level impacts and that conservation management must balance negative impacts with the bats' innate ability to add to their population, community-level planning of a sustainable hunting program can ensue. Targets must be established for minimum population sizes and numbers of viable populations before hunting can be allowed. After thresholds are reached, sustainable harvest levels must be determined using adaptations of the well-developed harvest management practices for other species.

Finally, an effective enforcement and harvest regulation program must be designed that starts out conservatively, carefully tracking impacts of hunting on bat populations and making adjustments to hunting allowances as needed. Halstead (1977) described how regulated hunting of *E. helvum* at the University of Ile Ife in south western Nigeria can be mutually beneficial to the bat population, local community livelihoods, and managers of property where roosts are present. In places where hunting laws are in place but not respected or enforced, education and outreach are instrumental in garnering public support (as Madagascar Voakajy has done for roosts of *P. rufus* in Madagascar).

12.7.6 *Encourage Local Researchers and NGO's*

A key to effective and sustainable conservation is to develop the capacity of local people, including local researchers and the establishment of local NGOs (Racey 2013). Few detailed studies report reliable estimates of bat hunting impacts on bat populations. Some studies may indeed have been conducted but remain as Masters or PhD theses or published as grey literature or in local journals, thereby limiting the distribution of such information. Because valuable results are not often published or accessible, current efforts to revise species account entries in the IUCN Red List have had to rely heavily on experts gathering unpublished information to determine conservation priorities for hunted species (T. Mildenstein, unpublished data). It is important that biologists are encouraged to publish their findings, even in lesser developed countries where there are few if any personal incentives for doing so (Milner-Gulland et al. 2010).

Finally, the establishment of local non-profit organizations creates a network for stakeholders and a bridge between local interests and conservation management. Such organizations play a critical role in ensuring the sustainability of conservation projects across political administration changes by engaging the local

stakeholders and coordinating conservation activities in harmony with local needs (e.g. Figs. 12.5 and 12.6).

12.8 Conclusion

Conservation biologists' understanding of the role hunting plays in bat population declines has changed over the last three decades. Conservation concerns were originally focused on large scale hunting operations and especially international commercial trade (e.g. *Pteropus* spp. in the Pacific and Southeast Asia). After international trade was largely shut down in the late 1980s, conservation managers turned their attention to hunting within countries, still focusing on commercially hunted species as a highest priority (e.g. Mickleburgh et al. 1992).

Although commercially harvested species are still a high priority today, conservationists' concerns are no longer limited to species found in markets. With more research and experience, conservation managers have become increasingly aware of the negative impacts caused by hunting even on small scales, i.e. for personal use and/or local trade. Especially detrimental is hunting at roost sites, which can lead to a tenfold increase in population declines (Mildenstein 2012). This is probably because hunting disturbance at roosts also affects non-target individuals, including mothers and babies which are especially sensitive to disturbance. For hunted bat taxa (e.g. Old World fruit bats), hunting now ranks as a top threat among bat conservation biologists.

Research that quantifies the relationship between hunting rates and bat population declines is still lacking, but general awareness about the breadth of bat hunting effects has increased. The number of bat species known to be hunted is larger than in earlier reviews. Similarly, biologists now recognize that hunting is usually a threat to bats; the number of species documented as threatened by hunting is much larger now and includes many species that are not commercially hunted. However, for 28 % of the species known to be hunted according to IUCN Red List species accounts, hunting was either not considered to be a threat or not evaluated at all. Finally, information about a quarter (38/167) of the species listed as hunted by this review has come from sources other than the IUCN Red List, where there is no mention of hunting for those species. More research on population sizes and trends, hunting impacts, and effective management tools will provide very important information for bat conservation.

Research should also address the role of bat meat in local people's diets. Studies that focus on seasonal patterns in bat consumption and the dependency on bats as a source of protein would provide managers with information that would guide policy and conservation actions complementary to the dietary needs of local communities. Similarly, research on the use of bats for medicinal purposes should investigate patterns of bat use and ailments that bat consumption is said to cure. Study of the effects of bat use on ailing consumers in situ as well as in randomized trials could play a significant role in conservation by helping tease out whether the medicinal

properties of bats have a real effect or are a myth. These investigations should begin with asthma and other chest complaints since anecdotes about the curative effects of bats for such conditions are widespread across the Old World tropics.

Along with conservation-focused research, public education and capacity building of local managers must also be encouraged to counter what is clearly a major threat to bat populations in the Old World tropics. Greater awareness about bats' reproductive characteristics of one young a year together with the ecological services bats provide will strengthen local communities' commitment to supporting conservation management. Hunters, in particular, begin to cooperate, even tracking their harvest rates as a community, when they realize that bats are a limited resource and that populations may be extirpated altogether if hunting pressure is not halted or highly regulated (Mildenstein 2011). Local managers can be empowered to track bat conservation and hunting with training in the simple and inexpensive field techniques needed to monitor bat population abundance, and these local stakeholders are key to creating sustainable monitoring programs.

Hunting has already led to the loss of four bat species in the last few decades. Without research, public education and awareness, and bolstering local managers' capacity to protect bats, unregulated hunting may well claim more many species.

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Appendix. List of Hunted Bat Species Showing Primary Use (Food or Medicine), Summarized by Region and Country. We Followed IUCN Regional Classification

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
East Asia	China	<i>Cynopterus sphinx</i>	LC		x	Bates et al. (2008d), Mickleburgh et al. (2009)
	China	<i>Eonycteris spelaea</i>	LC	x		Francis et al. (2008c), Stebbings (1987)
	China	<i>Hipposideros pomona</i>	LC	x	x	Bates et al. (2008a)
	China	<i>Pteropus giganteus</i>	LC	x	x	Molur et al. (2008a), Mickleburgh et al. (2009)
	China	<i>Rousettus leschenaultii</i>	LC	x	x	Molur et al. (2002), Bates and Helgen (2008), Mickleburgh et al. (2009)
	Japan	<i>Pteropus pselaphon</i>	CR	x		Ishii and Maeda (2008)
	Taiwan	<i>Pteropus dasymallus</i>	NT	x		Heaney et al. (2008d)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
North Africa	Algeria, Morocco, Tunisia, Libya	<i>Myotis punicus</i>	NT		x	Aulagnier et al. (2008)
	Algeria, North Africa	<i>Myotis emarginatus</i>	LC		x	Hutson et al. (2008h)
	North Africa	<i>Myotis capaccinii</i>	VU		x	Hutson et al. (2008g)
	North Africa	<i>Myotis nattereri</i>	LC		x	Hutson et al. (2008a)
Oceania	American Samoa, Cook Islands and Niue, Fiji, New Caledonia, Vanuatu	<i>Pteropus tonganus</i>	VU	x		Hamilton and Helgen (2008),
	American Samoa, Fiji, Samoa	<i>Pteropus samoensis</i>	NT	x		Brooke and Wiles (2008)
	Fiji	<i>Mirimiri acrodonta</i> / <i>Pteralopex acrodonta</i>	CR			Flannery (1995b)
	Fiji, Vanuatu	<i>Chaerephon bregullae</i> / <i>Tadarida bregullae</i>	EN	x		Flannery (1995b), Palmeirim (2014)
	Fiji, Vanuatu	<i>Notopteris macdonaldi</i>	VU	x		Flannery (1995b), Palmeirim et al. (2007), Palmeirim (2008)
		<i>Pteropus ualanus</i>	VU	x		Wiles et al. (2008)
	Indonesia, Papua New Guinea	<i>Dobsonia moluccensis</i>	LC	x		Hutson et al. (2008j)
	Micronesia, Federated States of	<i>Pteropus yapensis</i>	VU	x		Wiles et al. (2008b)
	Micronesia, Federated States of; Caroline Islands	<i>Pteropus insularis</i> / <i>Pteropus phaeocephalus</i>	CR	x		Helgen and Wiles (2010)
	Micronesia	<i>Pteropus molossinus</i>	VU	x		Buden et al. (2008)
	Micronesia, Guam and Commonwealth of Northern Mariana Islands	<i>Pteropus mariannus</i>	EN	x		Falanrui and Manmaw (1992), Allison et al. (2008), Lemke (1992)
	New Caledonia	<i>Notopteris neocaledonica</i>	VU	x		Brescia (2008a), Boissenin and Brescia (2007)
	New Caledonia	<i>Pteropus ornatus</i>	VU	x		Brescia (2008b)
	New Caledonia	<i>Pteropus vetulus</i>	VU	x	x?	Brescia (2008c), Flannery (1995b)
	Palau	<i>Pteropus pelewensis</i>	NT	x		Wiles (2008), Wiles et al. (1997)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	Papua New Guinea	<i>Pteropus hypomelanus</i>	LC	x		Francis et al. (2008a), Fujita and Tuttle (1991), Fujita (1988)
	Papua New Guinea	<i>Aproteles bulmerae</i>	CR	x		Flannery (1995b), Hutson et al. (2008m)
	Papua New Guinea	<i>Miniopterus magnater</i>	LC	x		Bonaccorso and Reardon (2008b), Cuthbert (2003a, b)
	Papua New Guinea	<i>Nyctimene aello</i>	LC	x		Bonaccorso and Helgen (2008), Cuthbert (2003a, b)
	Papua New Guinea	<i>Nyctimene cyclotis</i>	DD	x		Cuthbert (2003a)
	Papua New Guinea	<i>Pteralopex flanneryi</i>	CR	x		Helgen et al. (2008a)
	Papua New Guinea	<i>Pteropus neohibernicus</i>	LC	x		Salas et al. (2008)
	Papua New Guinea	<i>Rousettus amplexicaudatus</i>	LC	x		Csorba et al. (2008g), Utzurum (1992)
	Papua New Guinea	<i>Syconycteris australis</i>	LC	x		Cuthbert (2003a)
	Papua New Guinea, possibly Cambodia and Vietnam	<i>Miniopterus pusillus</i>	LC	x		Cuthbert (2003a, b)
	Papua New Guinea, Solomon Islands	<i>Pteralopex anceps</i>	EN	x		Helgen et al. (2008c)
	Papua New Guinea, Vanuatu	<i>Miniopterus macrocneme</i>	DD	x		Bonaccorso and Reardon (2008a)
	Solomon Islands	<i>Pteralopex atrata</i>	EN	x		Helgen and Hamilton (2008b)
	Solomon Islands	<i>Pteralopex taki</i>	EN	x		Hamilton et al. (2008a)
	Solomon Islands	<i>Pteropus cognatus</i>	EN	x		James et al. (2008)
	Solomon Islands	<i>Pteropus nitendiensis</i>	EN	x		Leary et al. (2008a)
	Solomon Islands	<i>Pteropus rennelli</i>	VU	x		Hamilton et al. (2008b)
	Solomon Islands	<i>Pteropus tuberculatus</i>	CR	x		Leary et al. (2008b)
	Solomon Islands, Papua New Guinea	<i>Pteropus rayneri</i>	NT	x		Hamilton and Leary (2008), Bowen et al. (1997)
	Vanuatu	<i>Emballonura semicaudata</i>	EN	x		Bonaccorso et al. (2008), Chambers and Esrom (1991)
	Vanuatu	<i>Miniopterus tristis</i>	LC	x		Chambers and Esrom (1991)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	Vanuatu	<i>Pteropus anetianus</i>	VU	x		Mickleburgh et al. (1992), Helgen and Hamilton (2008a), Chambers and Esrom (1991)
	Vanuatu	<i>Pteropus fundatus</i>	EN	x		Helgen and Hamilton (2008c), Chambers and Esrom (1991)
	Vanuatu, others?	<i>Aselliscus tricuspидatus</i>	LC	x		Bonaccorso et al. (2008), Chambers and Esrom (1991)
	Vanuatu, Papua New Guinea	<i>Miniopterus australis</i>	LC	x		Chambers and Esrom (1991)
South America	Bolivia	<i>Artibeus sp.</i>	LC			Lizarro et al. (2010)
	Bolivia	<i>Carollia perspicillata</i>	LC	x		Lizarro et al. (2010)
	Bolivia	<i>Desmodus rotundus</i>	LC			Lizarro et al. (2010)
	Bolivia	<i>Myotis sp.</i>	?			Lizarro et al. (2010)
	Brazil	<i>Glossophaga sp.</i>	LC or DD	x		Mickleburgh et al. (2009)
	Brazil	<i>sp. 1</i>		x		Lévi-Strauss (1979), Setz and Sazima (1987), Setz (1991)
	Brazil	<i>sp. 2</i>		x		Lévi-Strauss (1979), Setz and Sazima (1987), Setz (1991)
	Brazil	<i>sp. 3</i>		x		Lévi-Strauss (1979), Setz and Sazima (1987), Setz (1991)
South Asia	Bangladesh	<i>Pteropus giganteus</i>	LC	x	x	Mickleburgh et al. (2009), Molur et al. (2008a)
	India	<i>Hipposideros speoris</i>	LC		x	Molur et al. (2008b)
	India	<i>Latidens salimalii</i>	EN	x		Molur and Vanitharani (2008)
	India	<i>Megaderma lyra</i>	LC	x	x	Csorba et al. (2008a)
	India	<i>Megaderma spasma</i>	LC	x	x	Csorba (2008e)
	India	<i>Nyctalus montanus</i>	LC		x	Molur and Srinivasulu (2008)
	India	<i>Pteropus faunulus</i>	VU		x	Kingston et al. (2008); Singaravelan et al. (2009)
	India	<i>Pteropus melanotus</i>	VU	x		Hutson et al. (2008d), Mickleburgh et al. (2009)
	India	<i>Taphozous melanopogon</i>	LC	x		Csorba et al. (2008f), Molur et al. (2002)
	India	<i>Taphozous theobaldi</i>	LC	x	x	Bates et al. (2008e), Molur et al. (2002)
	India, Sri Lanka	<i>Hipposideros lankadiva</i>	LC	x	x	Molur et al. (2008c)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	South Asia wide	<i>Rousettus leschenaultii</i>	LC		x	Molur et al. (2002), Bates and Helgen (2008), Mickleburgh et al. (2009)
	South Asia wide	<i>Cynopterus sphinx</i>	LC	x		Bates et al. (2008d), Molur et al. (2002)
South East Asia	Brunei (Borneo), Cambodia, Lao PDR, Malaysia, Thailand, Vietnam	<i>Chaerephon plicatus/Tadarida plicata</i>	LC	x		Csorba et al. (2014)
	Brunei, Indonesia, Malaysia, Philippines, Thailand	<i>Pteropus vampyrus</i>	NT	x		Bates et al. (2008f), Clayton and Milner-Gulland (2000)
	Cambodia, Indonesia, Lao PDR, Philippines, Thailand, Vietnam	<i>Cynopterus brachyotis</i>	LC	x		Lacerna and Widmann (1999)
	Cambodia, Indonesia, Lao PDR, Thailand, Vietnam	<i>Cynopterus sphinx</i>	LC	x	x	Bates et al. (2008d), Johnson et al. (2003)
	Cambodia, Philippines, Thailand, Vietnam	<i>Eonycteris spelaea</i>	LC	x		Mickleburgh et al. (2009)
	Cambodia, Thailand	<i>Pteropus lylei</i>	VU	x		Bumrungsri et al. (2008b); Mickleburgh et al. (2009)
	Indonesia	<i>Acerodon celebensis</i>	LC	x		Hutson et al. (2008c), Clayton and Milner-Gulland (2000)
	Indonesia	<i>Acerodon humilis</i>	EN	x		Hutson et al. (2008b), Clayton and Milner-Gulland (2000)
	Indonesia	<i>Acerodon mackloti</i>	VU	x		Hutson et al. (2008i)
	Indonesia	<i>Cheiromeles parvidens</i>	LC	x		Csorba et al. (2008b)
	Indonesia	<i>Harpyionycteris celebensis</i>	VU	x		Hutson et al. (2008l)
	Indonesia	<i>Neopteryx frosti</i>	EN	x		Hutson et al. (2008k)
	Indonesia	<i>Pteropus alecto</i>	LC	x		Bergmans and Rozendaal (1988), Hutson et al. (2008n)
	Indonesia	<i>Pteropus caniceps</i>	NT	x		Hutson and Helgen (2008a)
	Indonesia	<i>Pteropus chrysoproctus</i>	NT	x		Hutson and Helgen (2008b)
	Indonesia	<i>Pteropus griseus</i>	DD	x		Heinrichs and Zahnke (1997)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	Indonesia	<i>Pteropus lombocensis</i>	DD	x		Clayton and Milner-Gulland (2000), Helgen and Salas (2008a)
	Indonesia	<i>Pteropus melanopogon</i>	EN	x		Helgen and Salas (2008b)
	Indonesia	<i>Pteropus ocularis</i>	VU	x		Helgen and Salas (2008c)
	Indonesia	<i>Pteropus pohlei</i>	EN	x		Helgen and Bonaccorso (2008a)
	Indonesia	<i>Pteropus temminckii</i>	VU	x		Helgen and Bonaccorso (2008b)
	Indonesia	<i>Rousettus bidens</i>	VU	x		Helgen et al. (2008d)
	Indonesia	<i>Rousettus celebensis</i>	LC	x		Ruedas et al. (2008b)
	Indonesia	<i>Styloctenium wallacei</i>	NT	x		Ruedas et al. (2010), Mickleburgh et al. (2009)
	Indonesia	<i>Thoopterus nigrescens</i>	LC	x		Ruedas et al. (2008a), Mickleburgh et al. (2009)
	Indonesia, Thailand	<i>Rousettus leschenaultii</i>	LC	x	x	Mickleburgh et al. (2009)
	Lao PDR	<i>Hipposideros scutinares</i>	VU	x		Francis and Bates (2008)
	Lao PDR	<i>Tadarida latouchei</i>	DD	x		Francis and Maeda (2008)
	Lao PDR, Philippines, Thailand	<i>Taphozous melanopogon</i>	LC	x		Csorba (2008f), Magnus (2001)
	Lao PDR, Thailand, Vietnam	<i>Hipposideros armiger</i>	LC	x		Bates et al. (2008b)
	Malaysia	<i>Cheiromeles torquatus</i>	LC	x		Csorba et al. (2008c)
	Malaysia, Philippines, Thailand	<i>Pteropus hypomelanus</i>	LC	x		Francis et al. (2008a), Fujita and Tuttle (1991), Fujita (1988)
	Myanmar	<i>Hipposideros pomona</i>	LC	x	x	Bates et al. (2008a)
	Myanmar	<i>Rhinolophus marshalli</i>	LC	x		Bates (2003)
	Myanmar, Thailand	<i>Craseonycteris thonglongyai</i>	VU	x		Bates (2003)
	Philippines	<i>Acerodon jubatus</i>	EN	x		Mildenstein et al. (2008), Heaney and Heideman (1987)
	Philippines	<i>Acerodon leucotis</i>	VU	x		Ong et al. (2008b)
	Philippines	<i>Dobsonia chapmani</i>	CR	x		Heaney et al. (2008b), Heaney and Heideman (1987)
	Philippines	<i>Eonycteris robusta</i>	NT	x		Ong et al. (2008e)
	Philippines	<i>Harpyionycteris whiteheadi</i>	LC	x		Ong et al. (2008d), Mickleburgh et al. (2009)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	Philippines	<i>Hipposideros coronatus</i>	DD	x		Gomez et al. (2008)
	Philippines	<i>Hipposideros pygmaeus</i>	LC	x		Heaney et al. (2008a)
	Philippines	<i>Macroglossus minimus</i>	LC	x		Mickleburgh et al. 2009, Francis et al. (2008b)
	Philippines	<i>Nyctimene rabori</i>	EN	x		Mickleburgh et al. (2009)
	Philippines	<i>Ptenochirus jagori</i>	LC	x		Heaney and Heideman (1987)
	Philippines	<i>Pteropus dasymallus</i>	NT	x		Heaney et al. (2008d)
	Philippines	<i>Pteropus leucopterus/ Desmalopex leucopterus</i>	LC	x		Ong et al. (2008a)
	Philippines	<i>Pteropus pumilus</i>	NT	x		Heaney et al. (2008c), Mickleburgh et al. (2009)
	Philippines	<i>Pteropus speciosus</i>	DD	x		Rosell-Ambal et al. (2008)
	Philippines	<i>Rhinolophus rufus</i>	NT	x		Ong et al. (2008c)
	Philippines	<i>Styloctenium mindorensis</i>	DD	x		Esselstyn (2008)
	Philippines, Thailand	<i>Hipposideros lekaguli</i>	NT	x		Csorba (2008d)
	Philippines, Thailand	<i>Rousettus amplexicaudatus</i>	LC	x		Csorba (2008g), Uzzurum (1992)
	SE Asia	<i>Megaderma spasma</i>	LC	x	x	Csorba (2008e)
	Thailand	<i>Hipposideros halophyllus</i>	EN	x		Bates et al. (2008b)
	Vietnam, Cambodia	<i>Megaderma lyra</i>	LC	x	x	Csorba et al. (2008a)
Sub Saharan Africa	Unspecified	<i>Epomophorus labiatus</i>	LC	x		Mickleburgh et al. (2008b)
	Unspecified	<i>Hipposideros gigas</i>	LC	x		Mickleburgh et al. (2008p)
	Unspecified	<i>Hipposideros jonesi</i>	NT	x		Mickleburgh et al. (2008g)
	Unspecified	<i>Hipposideros marisae</i>	VU	x		Mickleburgh et al. (2008h)
	Unspecified	<i>Hipposideros ruber</i>	LC	x		Mickleburgh et al. (2008i)
	Unspecified	<i>Hipposideros vittatus</i>	NT	x		Mickleburgh et al. (2008f)
	Unspecified	<i>Mops midas/Tadarida midas</i>	LC	x		Jenkins et al. (2014)
	Unspecified	<i>Myotis morrisi</i>	DD	x		Jacobs et al. (2008a)
	Unspecified	<i>Rhinolophus alcyone</i>	LC	x		Jacobs et al. (2008b)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	Unspecified	<i>Rhinolophus guineensis</i>	VU	x		Fahr (2008a)
	Unspecified	<i>Rhinolophus hillorum</i>	NT	x		Jacobs et al. (2010)
	Unspecified	<i>Rhinolophus silvestris</i>	DD	x		Cotterill (2008)
	Unspecified	<i>Rhinolophus ziama</i>	EN	x		Fahr (2008d)
	Unspecified	<i>Rousettus lanosus</i>	LC	x		Mickleburgh et al. (2008n)
	Unspecified	<i>Taphozous mauritanus</i>	LC			Hutson et al. (2008e)
	Benin	<i>Epomophorus gambianus</i>	LC	x		Mickleburgh et al. (2008r)
	Benin, Cameroon, Congo Rep., Cote d'Ivoire, DRC, Equatorial Guinea, Ghana, Liberia, Nigeria, Tanzania, Uganda, Zambia	<i>Eidolon helvum</i>	NT	x	x	Halstead (1977), Kamins et al. (2011), Mickleburgh et al. (2008l)
	Benin, The Democratic Republic of the Congo, Equatorial Guinea, Nigeria	<i>Epomops franqueti</i>	LC	x		Colyn et al. (1987), Fa et al. (1995), Juste et al. (1995), Bennett Hennessey (1995)
	Comoros Islands	<i>Pteropus livingstonii</i>	EN	x		Trewhella et al. (1995)
	Congo Republic	<i>Lissonycteris angolensis</i>	LC	x		Wilson and Wilson (1991), Mickleburgh et al. (2008c)
	Congo Republic	<i>Nycteris grandis</i>	LC	x		Mickleburgh et al. (2008k), Bennett Hennessey (1995)
	Côte d'Ivoire	<i>Chaerephon ansorgei</i> / <i>Tadarida ansorgei</i>	LC	x		Mickleburgh et al. (2008e)
	Equatorial Guinea	<i>Micropteropus pusillus</i>	LC	x		Juste et al. (1995), Fa (2000)
	Equatorial Guinea, Nigeria	<i>Rousettus aegyptiacus</i>	LC	x		Fa et al. (1995), Fa (2000), Benda et al. (2008)
	Guinea	<i>Hipposideros lamottei</i>	CR	x		Mickleburgh et al. (2008q)
	Guinea	<i>Rhinolophus maclaudi</i>	EN	x		Fahr (2008b), Fahr et al. (2002), Fahr and Ebigo (2003)
	Guinea	<i>Rhinolophus ruwenzorii</i>	VU	x		Fahr et al. (2002), Fahr and Ebigo (2003), Fahr (2008c)
	Madagascar	<i>Chaerephon jobimena</i> / <i>Tadarida jobimena</i>	LC	x		Andriafidison et al. (2014a)

IUCN region	Country in which hunted	Species	Status	Food	Medicine	Source
	Madagascar	<i>Eidolon dupreanum</i>	VU	x		Andriafidison et al. (2008a), Jenkins and Racey (2008)
	Madagascar	<i>Emballonura atrata</i>	LC	x		Jenkins et al. (2008b)
	Madagascar	<i>Hipposideros commersoni</i>	NT	x		Goodman (2006), Jenkins and Racey (2008)
	Madagascar	<i>Miniopterus gleni</i>	LC	x		Andriafidison et al. (2008b), Goodman (2006), Goodman et al. (2008)
	Madagascar	<i>Miniopterus majori</i>	LC	x		Jenkins and Rakotoarivelo (2008)
	Madagascar	<i>Miniopterus manavi</i>	LC	x		Andriafidison et al. (2008c), Golden (2005)
	Madagascar	<i>Mops leucostigma</i>	LC	x		Andriafidison et al. (2014b)
	Madagascar	<i>Mormopterus jugularis</i>	LC	x		Andriafidison et al. (2008d)
	Madagascar	<i>Myzopoda aurita</i>	LC	x		Jenkins et al. (2008a)
	Madagascar	<i>Pteropus rufus</i>	VU	x		Andriafidison et al. (2008e), Jenkins and Racey (2008)
	Madagascar	<i>Rousettus madagascariensis</i>	NT	x		Andriafidison et al. (2008f), Jenkins and Racey (2008)
	Madagascar	<i>Scotophilus robustus</i>	LC	x		Andriafidison et al. (2008g)
	Madagascar	<i>Triaenops furculus</i>	LC	x		J. Razafimanahaka pers. comm
	Madagascar	<i>Triaenops rufus</i>	LC	x		Goodman (2006), Andriafidison et al. (2008h)
	Mauritius	<i>Pteropus niger</i>	VU	x		Hutson and Racey (2013), Mickleburgh et al. (2009)
	Mauritius	<i>Pteropus rodricensis</i>	CR	x		Mickleburgh et al. (2008d), Mickleburgh et al. (2009)
	Rwanda	<i>Rhinolophus hilli</i>	CR	x		Fahr (2010)
	São Tomé and Príncipe	<i>Chaerephon tomensis</i>	EN	x		Carvalho et al. (2014)
	São Tomé and Príncipe	<i>Miniopterus newtoni</i>	DD	x		Carvalho et al. (2014)
	São Tomé and Príncipe	<i>Myonycteris brachycephala</i>	EN	x		Carvalho et al. (2014)
	Seychelles	<i>Pteropus seychellensis</i>	LC	x		Carvalho et al. (2014)
	Tanzania (Pemba)	<i>Pteropus voeltzkowi</i>	VU	x		Mickleburgh et al. (2008m)
	The Democratic Republic of the Congo, Nigeria	<i>Hypsignathus monstrosus</i>	LC	x		Mickleburgh et al. (2008j), Mickleburgh et al. (2009)
	Unspecified	<i>Myotis mystacinus</i>	LC		x	Hutson et al. (2008f)

References

- Abdul Aziz S, Olival KJ, Bumrungsri S, Richards GC, Racey PA (2016) The conflict between fruit bats and fruit growers: species, legislation and mitigation. In: Voigt CC, Kingston T (eds), *Bats in the Anthropocene: conservation of bats in a changing world*. Springer International AG, Cham, pp. 377–420
- Allison A, Bonaccorso F, Helgen K, James R (2008) *Pteropus mariannus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Andersen WL, Thornberg DD, Whitton RM (1996) Estimating goods harvest in southern Illinois quota zones. *Wildl Soc Bull* 24:233–237
- Andriafidison D, Cardiff SG, Goodman SM et al () *Eidolon dupreanum*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008b) *Miniopterus gleni*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008c) *Miniopterus manavi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008d) *Mormopterus jugularis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008e) *Pteropus rufus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008f) *Rousettus madagascariensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008g) *Scotophilus robustus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2008h) *Triaenops rufus*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2014a) *Chaerephon jobimena*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Andriafidison D, Cardiff SG, Goodman SM et al (2014b) *Mops leucostigma*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Anstey S (1991) Wildlife utilisation in Liberia. The findings of a national survey 1989–1990. Report for WWF-UK, Godalming, UK
- Aulagnier S, Juste J, Karataş A et al. (2008) *Myotis punicus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Banack SA (1996) Flying foxes, genus *Pteropus*, in the Samoan Islands: interactions with forest communities. Dissertation. University of California, California
- Banack SA (1998) Diet selection and resource use by flying foxes (genus *Pteropus*). *Ecol* 79:1949–1967
- Barlow KE, Briggs PA, Haysom KA et al (2015) Citizen science reveals trends in bat populations: the national bat monitoring programme in Great Britain. *Biol Conserv* 182:14–26
- Bat Conservation International (2015) 1331 and counting. *Bats magazine*. Winter 2015. P 16
- Bates PJJ (2003) Conservation Status of the Bat and Bird Fauna of the Limestone Karst Areas of Mon and Kayin States, Myanmar (Burma). Unpublished Report for Fauna and Flora International 100 % Fund, Fauna and Flora International, Cambridge, UK
- Bates P, Helgen K (2008) *Rousettus leschenaultii*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Bates P, Bumrungsri S, Csorba G et al (2008a) *Hipposideros pomona*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 21 Mar 2015

- Bates P, Bumrungsri S, Francis C, Csorba G (2008b) *Hipposideros armiger*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Bates P, Bumrungsri S, Francis C et al (2008c) *Hipposideros halophyllus*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Bates P, Bumrungsri S, Molur S, Srinivasulu C (2008d) *Cynopterus sphinx*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Bates P, Bumrungsri S, Walston J et al. (2008e) *Taphozous theobaldi*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Bates P, Francis C, Gumal M et al. (2008f) *Pteropus vampyrus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Benda P, Aulagnier S, Hutson AM et al (2008) *Rousettus aegyptiacus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Bennett Hennessey A (1995) A study of the meat trade in Ouesso, Republic of Congo. Wildlife Conservation Society, New York
- Bergmans W, Rozendaal FG (1988) Notes on collections of fruit bats from Sulawesi and some off-lying islands (Mammalia, Megachiroptera). *Verh Leiden* 248:5–74
- Boissenin M, Brescia F (2007) Inventaire des colonies de mégachiroptère en Province nord de la Nouvelle-Calédonie. Institut Agronomique néo-Calédonien (IAC), Unpublished report
- Bonaccorso F, Allison A (2008) *Emballonura semicaudata*. The IUCN Red List of Threatened Species 2008: Version 2014.3. <http://www.iucnredlist.org>. Downloaded on 18 May 2015
- Bonaccorso F, Helgen K (2008) *Nyctimene aello*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Bonaccorso F, Reardon T (2008a) *Miniopterus macrocneme*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Bonaccorso F, Reardon T (2008b) *Miniopterus magnater*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Bonaccorso F, Leary T, Hamilton (2008) *Aselliscus tricuspis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Bowen-Jones E, Abrutut D, Markham B, Bowe S (1997) Flying foxes on Choiseul (Solomon Islands)-the need for conservation action. *Oryx* 31:209–217
- Bradshaw CJA, Sodhi NS, Brook BW (2009) Tropical turmoil: a biodiversity tragedy in progress. *Front Ecol Environ* 7:79–87
- Brashares JS, Arcece P, Sam MK et al (2004) Bushmeat hunting, wildlife declines, and fish supply in west Africa. *Science* 306:1180–1183
- Brescia F (2007) Amélioration des connaissances et recommandations pour la sauvegarde des populations de mégachiroptères (roussettes) en Province Nord de la Nouvelle-Calédonie. Institut Agronomique néo-Calédonien, Unpublished report
- Brescia F () *Notopterus neocaledonica*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Brescia F (2008b) *Pteropus ornatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Brescia F (2008c) *Pteropus vetulus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Brooke AP (2001) Population status and behaviours of the Samoa flying fox, *Pteropus samoensis*, on Tutuila Island, American Samoa. *J Zool* 254:309–319
- Brooke AP, Tschapka M (2002) Threats to overhunting of the flying fox *Pteropus tonganus* (Chiroptera: Pteropodidae) on Niue Island, South Pacific Ocean. *Biol Conserv* 103:343–348
- Brooke A, Wiles G (2008) *Pteropus samoensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Brooke AP, Solek C, Tualaulelei A (2000) Roosting behavior of colonial and solitary flying foxes in American Samoa (Chiroptera: Pteropodidae). *Biotropica* 32(2):338–350
- Buden D, Wiles G, Helgen K et al (2008) *Pteropus molossinus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015

- Bumrungsri S, Harbit A, Benzie C, Carmouche K, Sridith K, Racey PA () The pollination ecology of two species of *Parkia* (Mimosaceae) in southern Thailand. *J. Trop Ecol* 24:467–475
- Bumrungsri S, Suyanto A, Francis C (2008b) *Pteropus lylei*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Bumrungsri S, Spraoiaya E, Chongsiri I, Sridith K, Racey PA (2009) Does no bat mean no durian—the pollination ecology of semi-wild durian (*Durio zibethinus* L.) in Southern Thailand. *J Trop Ecol* 25:85–92
- Calisher CH, Childs JE, Field H E, Holmes KV, Schountz T (2006). Bats: important reservoir hosts of emerging viruses. *Clinical microbiology reviews*, 19(3):531–545
- Carvalho M, Palmeirim JM, Rego FC et al (2014) What motivates hunters to target exotic or endemic species on the island of São Tomé, Gulf of Guinea? *Oryx* 1–9
- Cawthorn DM, Hoffman LC (2015) The bushmeat and food security nexus: a global account of the contributions, conundrums and ethical collisions. In press at Food Security International, 20 pp
- Chambers MR, Esrom D (1991) The fruit bats of Vanuatu. *Bat News* 20:4–5
- Clayton L, Milner-Gulland EJ (2000) The trade in wildlife in north Sulawesi, Indonesia. In: Robinson JG, Bennett E (eds) *Hunting for sustainability in tropical forests*. Columbia University Press, New York, pp 473–496
- Cleveland CJ, Betke M, Federico P et al (2006) Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas. *Front Ecol Environ* 4:238–243
- Colyn M, Dudu A, Mbaelele M (1987) Exploitation du petit et moyen gibier des forests ombrophiles du Zaïre. *Nat et Faune* 3:22–39
- Cotterill FPD (2008) *Rhinolophus silvestris*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Craig P, Morrell TE, So’Oto K (1994a) Subsistence harvest of birds, fruit bats and other game in American Samoa, 1990–1991. *Pac Sci* 48:344–352
- Craig P, Trail P, Morrell TE (1994b) The decline of fruit bats in American Samoa due to hurricanes and overhunting. *Biol Conserv* 69:261–266
- Craig P, Syron W (1992) Fruit bats in American Samoa: their status and future. In: Wilson DE, Graham GL (eds) *Pacific Island Flying Foxes: Proceedings of an International Conservation Conference* pp. 145–149
- Csorba G, Bates P, Molur S, Srinivasulu C (2008a) *Megaderma lyra*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Csorba G, Bumrungsri S, Francis C et al (2008b) *Cheiromeles parvidens*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Csorba G, Bumrungsri S, Francis C et al (2008c) *Cheiromeles torquatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Csorba G, Bumrungsri S, Francis C et al (2008d) *Hipposideros lekaguli*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Csorba G, Bumrungsri S, Francis C et al (2014). *Chaerephon plicatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Csorba G, Bumrungsri S, Helgen K et al (2008e) *Megaderma spasma*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Csorba G, Bumrungsri S, Helgen K et al (2008f) *Taphozous melanopogon*. The IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. Downloaded on 21 Mar 2015
- Csorba G, Rosell-Ambal G, Ingle N (2008g) *Rousettus amplexicaudatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Cuthbert R (2003a) The impact of hunting on wildlife populations in Papua New Guinea: report 2. Unpublished Report for Fauna and Flora International 100 % Fund, Fauna and Flora International, Cambridge, UK
- Cuthbert R (2003b) The sustainability of hunting in Papua New Guinea: a preliminary analysis. Unpublished Report for Fauna and Flora International 100 % Fund, Fauna and Flora International Cambridge, UK

- Dougnon TJ, Djossa BA, Youssao I et al (2012) Bats as bushmeat in Benin: yield in carcass and meat quality of the fruit bats *Eidolon helvum* (Kerr, 1792) and *Epomophorus gambianus* (Ogilby, 1835). *Int J Sci Adv Technol* 2:81–90
- Epstein JH, Olival KJ, Pulliam JRC et al (2009) *Pteropus vampyrus*, a hunted migratory species with a multinational home-range and a need for regional management. *J App Ecol* 46:991–1002
- Esselstyn J (2008) *Styloctenium mindorensis*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Esselstyn JA, Amar A, Janeke D (2006) Impact of post-typhoon hunting on Mariana fruit bats (*Pteropus mariannus*). *Pac Sci* 60:531–539
- Fa JE (2000) Hunted animals in Bioko Island, West Africa: sustainability and future. In: Robinson JG, Bennett E (eds) *Hunting for sustainability in tropical forests*. Columbia University Press, New York, pp 168–198
- Fa JE, Juste J, Perez De Val J, Castroviejo J (1995) Impact of market hunting on mammal species in Equatorial Guinea. *Conserv Biol* 9:1107–1115
- Fahr J () *Rhinolophus guineensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Fahr J (2008b) *Rhinolophus maclaudi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Fahr J (2008c) *Rhinolophus ruwenzorii*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Fahr J (2008d) *Rhinolophus ziama*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Fahr J (2010) *Rhinolophus hilli*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Fahr J, Ebigbo NM (2003) A conservation assessment of the bats of the Simandou Range, Guinea, with the first record of *Myotis welwitschii* (Gray 1866) from West Africa. *Acta Chiropterol* 5:125–141
- Fahr J, Vierhaus H, Hutterer R, Kock D (2002) A revision of the *Rhinolophus maclaudi* species group with the description of a new species from West Africa (Chiroptera: Rhinolophidae). *Myotis* 40:95–126
- Falanruw M (1988) On the status, reproductive biology, and management of fruit bats in Yap. *Micronesica* 21:39–51
- Falanruw MC, Manmaw CJ (1992) Protection of flying foxes on Yap Islands. In: DE Wilson, GL Graham (eds), *Proceedings of an international conservation conference on pacific island flying foxes*, US Fish and Wildlife Service Biological Report 90(23). US Department of the Interior, Fish and Wildlife Service, Washington, DC, pp 150–154
- Flannery T (1995a) *Mammals of New Guinea* (Revised and Updated Edition). Reed Books, Chatswood,
- Flannery TF (1995b) *Mammals of the South-West Pacific, Moluccan Islands*. Reed Books, Chatswood, Australia and Cornell University Press, Ithaca, USA
- Francis C, Bates P (2008) *Hipposideros scutinares*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Francis C, Maeda K (2008) *Tadarida latouchei*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Francis C, Rosell-Ambal G, Bonaccorso F et al. (2008a) *Pteropus hypomelanus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Francis C, Rosell-Ambal G, Sedlock J et al. (2008b) *Macroglossus minimus*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Francis C, Rosell-Ambal G, Tabaranza B et al. (2008c) *Eonycteris spelaea*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Fujita M (1988) Flying foxes and economics. *BATS* 6:4–9

- Fujita MS, Tuttle MD (1991) Flying foxes (Chiroptera: Pteropodidae): threatened animals of key ecological and economic importance. *Conserv Biol* 5:455–463
- Funmilayo O (1978) Fruit bats for meat: are too many taken? *Oryx* 14:377–378
- Golden CD (2005) Eaten to endangerment: mammal hunting and the bushmeat trade in Madagascar's Makira Forest. Undergraduate Thesis, Harvard University
- Gomez R, Ong P, Rosell-Ambal G et al (2008) *Hipposideros coronatus*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Goodman SM (2006) Hunting of microchiroptera in southwestern Madagascar. *Oryx* 40:225–228
- Goodman SG, Rattrimomanarivo FH, Ranivo J, Cardiff S (2008) The hunting of microchiropteran bats in different portions of Madagascar. *Afri Bat Conserv News* 16:4–7
- Gumal MT (2004) Diurnal home range and roosting trees of a maternity colony of *Pteropus vampyrus natunae* (Chiroptera: Pteropodidae) in Sedilu, Sarawak. *J Trop Ecol* 20:247–258
- Halstead LB (1977) Fruit bats—an example of wildlife management. *Nigerian Field* 42:50–56
- Hamilton S, Helgen K (2008) *Pteropus tonganus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Hamilton S, Leary T (2008) *Pteropus rayneri*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hamilton S, Helgen K, James R et al. (2008a) *Pteralopex taki*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hamilton S, Helgen K, Pilgrim J (2008b) *Pteropus rennelli*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Harrison ME, Cheyne SM, Darma F et al (2011) Hunting of flying foxes and perception of disease risk in Indonesian Borneo. *Biol Conserv* 144:2441–2449
- Hayman DTS, McCrea R, Restif O et al (2012) Demography of straw-colored fruit bats in Ghana. *J Mammal* 93(5):1393–1404. doi:10.1644/11-MAMM-A-270.1
- Heaney LR, Heideman PD (1987) Philippine fruit bats: endangered and extinct. *BATS* 5:3–5
- Heaney L, Balete D, Ong P et al (2008a) *Hipposideros pygmaeus*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Heaney L, Ong P, Tabaranza B et al. (2008b) *Dobsonia chapmani*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Heaney L, Rosell-Ambal G, Tabaranza B et al (2008c) *Pteropus pumilus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Heaney L, Rosell-Ambal G, Tabaranza B, Izawa M (2008d) *Pteropus dasymallus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Heideman PD, Heaney LR (1992) *Acerodon jubatus* species account. In: Mickleburgh SP, Hutson AM, Racey PA (eds) Old world fruit bats: an action plan for their conservation. IUCN/SSC Chiroptera Specialist Group, Switzerland, pp 37–38
- Heinrichs S (2004) Sulawesi fruit bat conservation and education campaign. Unpublished report for the Fauna and Flora International 100 % Fund, Fauna and Flora International, Cambridge, UK
- Heinrichs S, Zahnke K (1997) The fruit bats of Sulawesi. *BATS* 15:11–15
- Helgen K, Allison A (2008) *Pteropus howensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Nov 2014
- Helgen K, Bonaccorso F (2008a) *Pteropus pohlei*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen K, Bonaccorso F (2008b) *Pteropus temminckii*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen KM, Flannery TF (2002) Distribution of the endangered Pacific sheath-tail bat *Emballonura semicaudata*. *Aust Mammal* 24:209–212
- Helgen K, Hamilton S (2008a) *Pteropus anetianus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen K, Hamilton S (2008b) *Pteralopex atrata*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015

- Helgen K, Hamilton S (2008c) *Pteropus fundatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Helgen K, Salas L (2008a) *Pteropus lombocensis*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Helgen K, Salas L (2008b) *Pteropus melanopogon*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen K, Salas L (2008c) *Pteropus ocularis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen K, Wiles G (2010) *Pteropus insularis*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Helgen K, Hamilton S, Leary T (2008a) *Pteralopex flanneryi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen K, Hamilton S, Leary T, Bonaccorso F (2008b) *Pteralopex anceps*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Helgen K, Kingston T, Ruedas L, Maharadatunkamsi D (2008c) *Rousettus bidens*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hines JM, Hungerford HR, Tomera AN (1987) Analysis and synthesis of research on responsible environmental behavior: a meta-analysis. *J Environ Educ* 18:1–8
- Hutson AM, Helgen K (2008a) *Pteropus caniceps*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Helgen K (2008b) *Pteropus chrysoproctus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Racey PA (2013) *Pteropus niger*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Aulagnier S, Spitzenberger F (2008a) *Myotis nattereri*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 March 2015
- Hutson AM, Kingston T, Helgen K (2008b) *Acerodon humilis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Hutson AM, Kingston T, Helgen K, Sinaga U (2008c) *Acerodon celebensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Hutson AM, Kingston T, James D et al (2008d) *Pteropus melanotus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Racey P, Ravino J et al (2008e) *Taphozous mauritanus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Spitzenberger F, Aulagnier S, Coroiu I (2008f) *Myotis mystacinus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Spitzenberger F, Aulagnier S et al (2008g) *Myotis capaccinii*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Spitzenberger F, Aulagnier S, Nagy Z (2008h) *Myotis emarginatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Suyanto A, Helgen K (2008i) *Acerodon mackloti*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Hutson AM, Suyanto A, Helgen K et al (2008j) *Dobsonia moluccensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Hutson AM, Suyanto A, Helgen K (2008k) *Neopteryx frosti*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson AM, Suyanto A, Kingston T, Helgen K (2008l) *Harpyionycteris celebensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Hutson T, Helgen K, Flannery T, Wright D (2008m) *Aproteles bulmerae*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015

- Hutson T, Suyanto A, Helgen K et al (2008n) *Pteropus alecto*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 March 2015
- Ishii N, Maeda K (2008) *Pteropus pselaphon*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- IUCN (2014) The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 24 Apr 2015
- Jacobs D, Cotterill FPD, Taylor PJ (2008a) *Myotis morrisoni*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 21 Mar 2015
- Jacobs D, Cotterill FPD, Taylor PJ (2008b) *Rhinolophus alcyone*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Jacobs D, Cotterill FPD, Taylor PJ (2010) *Rhinolophus hillorum*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- James R, Hamilton S, Helgen K (2008) *Pteropus cognatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Jenkins RK, Racey PA (2008) Bats as bushmeat in Madagascar. *Madagascar Conserv Dev* 3(1):22–30
- Jenkins RKB, Rakotoarivelo AR (2008) *Miniopterus majori*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Jenkins RK, Racey PA, Andriafidison D, Razafindrakoto N, Razafimahatratra E, Rabearivelo A, Razafimanahaka HJ (2007) Not rare, but threatened: the endemic Madagascar flying fox *Pteropus rufus* in a fragmented landscape. *Oryx* 41(2):263–271
- Jenkins RKB, Rakotoarivelo AR, Ratrimomanarivo FH, Cardiff SG (2008a) *Myzopoda aurita*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Jenkins RKB, Rakotoarivelo AR, Ratrimomanarivo FH, Cardiff SG (2008b) *Emballonura atrata*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Jenkins RKB, Racey PA, Ranivo J et al (2014) *Mops midas*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Johnson DH (2008) In defense of indices: the case of bird surveys. *J Wildl Manag* 72:857–868
- Johnson A, Singh S, Dongdala M, Vongsa O (2003) Wildlife hunting and use in the nam ha protected area: implications for rural livelihoods, biodiversity conservation. Wildlife Conservation Society, Vientiane, Lao PDR
- Juste J, Fa JE, Perezdel Val J, Castroviejo J (1995) Market dynamics of bushmeat species in Equatorial Guinea. *J Appl Ecol* 32:454–467
- Kamins AO, Restif O, Ntiama-Baidu Y et al (2011) Uncovering the fruit bat bushmeat commodity chain and the true extent of fruit bat hunting in Ghana, West Africa. *Biol Conserv* 144:3000–3008
- Kingston T (2016) Cute, creepy or crispy—how values, attitudes and norms shape human behavior toward bats. In: Voigt CC, Kingston T (eds) *Bats in the anthropocene: conservation of bats in a changing world*. Springer International AG, Cham, pp. 571–588
- Kingston T, Molur S, Srinivasulu C (2008) *Pteropus faunulus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Lacerna ID, Widmann P (1999) Biodiversity utilisation in a Tagbanua community, southern Palawan, Philippines. In: Goeltenboth F, Milan P, Asio VB (eds), *Proceedures of the international conference on applied tropical ecology*, 8–10 Sept 1998. Visayas State College of Agriculture, BayBay, Leyte, Philippines, pp 52–64
- Leary T, Hamilton S, James R (2008a) *Pteropus nitendiensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Leary T, Hamilton S, James R (2008b) *Pteropus tuberculatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Lemke TO (1986) Marianas fruit bats near extinction. *BATS* 3:1

- Lemke TO (1992) Status of the Marianas fruit bat (*Pteropus mariannus*) in the Northern Mariana Islands north of Saipan. In: Proceedings of an international conservation conference on Pacific island flying foxes. US Fish and Wildlife Service Biological Report. 90(23)
- Leroy EM, Kumulungui B, Pourrut X, Rouquet P, Hassanin A, Yaba P, Swanepoel R (2005) Fruit bats as reservoirs of Ebola virus. *Nature* 438(7068):575–576
- Leroy EM, Epelboin A, Mondonge V, Pourrut X, Gonzalez JP, Muyembe-Tamfum J, Formenty P (2009) Human Ebola outbreak resulting from direct exposure to fruit bats in Luebo, Democratic Republic of Congo, 2007. *Vector-Borne Zoonotic Dis* 9(6):723–728
- Lévi-Strauss C (1979) *Tristes Tropiques*. Edicoes 90, Lisbon, Portugal
- Lizarro D, Galarza MI, Aguirre LF (2010) Traffic and trade of Bolivian bats. *Rev Bol Ecol y Cons Amb* 27:63–75
- Mackinnon JL, Hawkins CE, Racey PA (2003) Pteropodidae, in Goodman SP, Benstead JP (eds) *The natural history of Madagascar*. University of Chicago Press, Chicago, pp 1299–1302
- Magnus N (2001) Bushmeat utilisation in Phu Kheio Wildlife Sanctuary, Northeast Thailand. MSc thesis, University of Alberta, Edmonton, Canada
- Mbete RA, Banga-Mboko H, Racey PA et al (2011) Household bushmeat consumption in Brazzaville. *Trop Conserv Sci* 4:187–202
- McConkey KR, Drake DR (2006) Flying foxes cease to function as seed dispersers long before they become rare. *Ecol* 87:271–276
- Mickleburgh SP, Hutson AM, Racey PA (1992) Old world fruit-bats—an action plan for their conservation. IUCN, Gland
- Mickleburgh SP, Hutson AM, Racey PA (2002) A review of the global conservation status of bats. *Oryx* 36:18–34
- Mickleburgh SP, Hutson AM, Bergmans W et al. (2008a) *Pteropus aldabrensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Nov 2014
- Mickleburgh S, Hutson AM, Bergmans W (2008b) *Epomophorus labiatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W (2008c) *Lissonycteris angolensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W (2008d) *Pteropus rodricensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Cotterill FPD (2008e) *Chaerephon ansorgei*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Cotterill FPD (2008f) *Hipposideros vittatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Fahr J (2008g) *Hipposideros jonesi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 21 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Fahr J (2008h) *Hipposideros marisae*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 21 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Fahr J (2008i) *Hipposideros ruber*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Fahr J (2008j) *Hypsignathus monstrosus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Fahr J (2008k) *Nycteris grandis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015

- Mickleburgh S, Hutson AM, Bergmans W, Fahr J, Racey PA (2008l) *Eidolon helvum*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Howell K (2008m) *Pteropus voeltzkowi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W, Howell K (2008n) *Rousettus lanosus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W et al (2008o) *Pteropus seychellensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh S, Hutson AM, Bergmans W (2008p) *Hipposideros gigas*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Mickleburgh S, Hutson AM, Bergmans W, Fahr J (2008q) *Hipposideros lamottei*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Mickleburgh S, Hutson AM, Bergmans W (2008r) *Epomophorus gambianus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Mickleburgh SP, Waylen K, Racey PA (2009) Bats as bushmeat: a global review. *Oryx* 43:217–234
- Mildenstein TL (2011) Bat count Philippines, final report to the conservation leadership program. Available on-line at http://www.conservationleadershipprogramme.org/media/2014/11/001706F_Philippines_FinalReport_Bat-Count-Philippines_21stJune2011.pdf
- Mildenstein TL (2012) Conservation of endangered flying foxes in the Philippines: effects of anthropogenic disturbance and research methods for community-based conservation. Ph.D. thesis, University of Montana, United States
- Mildenstein TL, Mills LS (2013) Mariana fruit bat conservation through research and local capacity building. Final Report for Cooperative Agreement Number: N40192-11-2-8005, prepared for NAVFAC Marianas
- Mildenstein TL, Cariño AB, Stier SC (2007) Bat count 2003, final report to conservation leadership programme. Available on-line http://www.conservationleadershipprogramme.org/media/2014/11/001003_2003_Philippines_FR_-Bat-Count-2003.pdf
- Mildenstein T, Cariño A, Paul S et al (2008) *Acerodon jubatus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Mildenstein TL, Alexander IR, Miller R (2014) Mariana fruit bat monitoring on Andersen Air Force Base. Final Report for Cooperative Agreement Number: N40192-13-2-8007, prepared for NAVFAC Marianas and U.S. Air Force Base
- Mills LS (2012) Conservation of wildlife populations: demography, genetics, and management, 2nd edn. Blackwell Publishing, Oxford
- Milner-Gulland EJ, Bennett EL (2003) Wild meat: the bigger picture. *Tren Ecol Evol* 18:351–357
- Milner-Gulland EJ, Fisher M, Browne S, Redford KH, Spencer M, Sutherland WJ et al (2010) Do we need to develop a more relevant conservation literature? *Oryx* 44:1–2
- Molur S, Srinivasulu C (2008) *Nyctalus montanus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Molur S, Vanitharani J (2008) *Latidens salimalii*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Molur S, Marimuthu G, Srinivasulu C et al. (2002) Status of South Asian Chiroptera: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report. Zoo Outreach Organization/CBSG-South Asia, India
- Molur S, Srinivasulu C, Bates P, Francis C (2008a) *Pteropus giganteus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015

- Molur S, Yapa W, Srinivasulu C (2008b) *Hipposideros speoris*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Molur S, Yapa W, Srinivasulu C (2008c) *Hipposideros lankadiva*. The IUCN Red List of threatened species. Version 2015.2. www.iucnredlist.org. Downloaded on 27 July 2015
- Navarro L (2013) Communication and education about bats: a powerful tool for changing misconceptions. Under the 43rd international bat research conference. San José, Costa Rica
- Nicoll ME, Racey PA (1981) The Seychelles fruit bat *Pteropus seychellensis*. *Afr J Ecol* 19:361–364
- Noureen S (2014) Ecology, roosting habits and reproduction in the Megachiroptera bats of pothwar region, Pakistan. Ph.D. Dissertation, Arid Agriculture University Rawalpindi, 240 pp
- Nuno A, St. John FAV (2014) How to ask sensitive questions in conservation: a review of specialized questioning techniques. *Biol Conserv* 89:5–15
- O'Connor T, Riger P, Jenkins RKB (2006) Promoting fruit bat conservation through education in Madagascar. *J Int Zoo Educ Assess* 42:26–33
- Oleksy R, Racey PA, Jones G (2015a) High-resolution GPS tracking reveals habitat selection and the potential for long-distance seed dispersal by Madagascar flying foxes *Pteropus rufus*. *Glob Ecol Cons* 3:678–692
- Oleksy R, Randrianandrianina F, Jenkins RKB (2015b) Commercial hunting of foraging fruit bats in Western Madagascar. *Afr Bat Conserv News* 37:3–5
- Ong P, Rosell-Ambal G, Tabaranza B et al (2008a) *Pteropus leucopterus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Ong P, Rosell-Ambal G, Tabaranza B et al (2008b) *Acerodon leucotis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 17 Mar 2015
- Ong P, Rosell-Ambal G, Tabaranza B, Heaney L (2008c) *Rhinolophus rufus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Ong P, Rosell-Ambal G, Tabaranza B et al (2008d) *Harpionycteris whiteheadi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Ong P, Rosell-Ambal G, Tabaranza B et al (2008e) *Eonycteris robusta*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Palmeirim J (2008) *Notopteris macdonaldi*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 March 2015
- Palmeirim J (2014) *Chaerephon bregullae*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 15 Mar 2015
- Palmeirim JM, Champion A, Naikatini A et al (2007) Distribution, status and conservation of the bats of the Fiji Islands. *Oryx* 41(4):509–519
- Pennisi LA, Holland SM, Stein TV (2004) Achieving bat conservation through tourism. *J Ecot* 3:195–207
- Plowright RK, Eby P, Hudson PJ et al (2015) Ecological dynamics of emerging bat virus spillover. *Proc Biol Sci* 282:2014–2124
- Racey PA (1979) Two bats in the Seychelles. *Oryx* 15:148–152
- Racey PA (2013) Bat conservation: past, present and future. In: Adams RA, Pedersen SC (eds) *Bat evolution, ecology, and conservation*. Springer, Berlin, pp 517–532
- Racey PA (2015) The uniqueness of bats. In: Wang L, Cowled C (eds) *Bats and viruses*. Wiley, New York
- Racey PA, Entwistle AC (2000) Life history and reproductive strategies in bats. In: Crighton E, Krutzsch PH (eds) *Reproductive biology of bats*. Academic Press, NY, pp 363–414
- Racey PA, Goodman SM, Jenkins RKB (2009) The ecology and conservation of malagasy bats. In: Fleming TH, Racey PA (eds) *Island bats—ecology, evolution and conservation*. Chicago University Press, p 369–404
- Randrianandrianina FH, Racey PA, Jenkins RKB (2010) Hunting and consumption of mammals and birds by people in urban areas of western Madagascar. *Oryx* 44:411–415
- Ravon S, Furey NM, Hul V, Capelle J (2014) A rapid assessment of flying fox (*Pteropus* spp.) colonies in Cambodia. *Camb J Nat Hist* 2014:14–18

- Razafimanahaka J (2013) When peanuts help to conserve fruit bats. Madagasikara Voakajy Newsletter on-line. http://www.madagasikara-voakajy.org/index.php?option=com_content&view=article&id=161:when-peanuts-help-to-conserve-fruit-bats&catid=19:livelihoods&Itemid=4
- Razakarivony HV (2003) Etude d'impact de la prédation humaine sur la roussette *Pteropus rufus* (Tiedemann, 1808) dans la région de Morondava. Memoire DEA, Département de Biologie Animale, Université d'Antananarivo
- Roberts TJ (1997) The mammals of Pakistan, 2nd edn. Oxford University Press, Pakistan
- Robinson JG, Bennett EL (2000) Carrying capacity limits to sustainable hunting in tropical forests. In: Robinson JG, Bennett EL (eds) Hunting for sustainability in tropical forests. Columbia University Press, New York, pp 13–30
- Robinson JG, Redford KH (1991) Sustainable harvest of neotropical forest mammals. In: Robinson JG, Redford KH (eds) Neotropical wildlife use and conservation. University of Chicago Press, Chicago, pp 415–429
- Robinson JE, Bell DJ, Saleh FM et al (2010) Recovery of the Vulnerable Pemba flying fox *Pteropus voeltzkowi*: population and conservation status. *Oryx* 44:416–423
- Rosell-Ambal G, Heaney L, Helgen K (2008) *Pteropus speciosus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Ruedas L, Kingston T, Helgen K, Sinaga J (2008a) *Thoopterus nigrescens*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Ruedas L, Kingston T, Sinanga U, Maharadatunamsi D (2008b) *Rousettus celebensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Ruedas L, Kingston T, Sinanga U (2010) *Styloctenium wallacei*. The IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Saéz AM, Weiss S, Nowak K et al (2015) Investigating the zoonotic origin of the West African Ebola epidemic. *EMBO Mol Med* 7:17–23
- Salas L, Helgen K, Hamilton S (2008) *Pteropus neohibernicus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Samuel H (2013) Frozen porcupines and bats confiscated in Paris exotic food raid. The Telegraph, World News, 6 Dec 2013. Accessed on-line <http://www.telegraph.co.uk/news/worldnews/europe/france/10500982/Frozen-porcupines-and-bats-confiscated-in-Paris-exotic-food-raid.html>
- Setz EZF (1991) Animals in the Nambiquara diet: methods of collection and processing. *J Ethnobiol* 11:1–22
- Setz EZ, Sazima I (1987) Bats eaten by Nambiquara Indians in Western Brazil. *Biotropica* 19:190
- Sewall BJ, Granek EF, Trehwella WJ (2003) The endemic Comoros Islands fruit bat *Rousettus obliviosus*: ecology, conservation, and red list status. *Oryx* 37(3):344–352
- Sewall BJ, Granek EF, Moutui MFE, Trehwella WJ, Reason PF, Rodríguez-Clark KM, Säid I, Carroll JB, Masfield W, Toilibou N, Vély M, Faissoili BM, Feistner TC, Wells S (2007) Conservation action plan for livingstone's flying fox: a strategy for an endangered species, a diverse forest and the Comorian people, 52 pp
- Shanahan M, So S, Gompton SG, Gorlett R (2001) Fig-eating by vertebrate frugivores: a global review. *Biol Rev* 76: 529–572
- Sheffers BR, Corlett RT, Diesmos A, Laurance WF (2012) Local demand drives a bushmeat industry in a Philippine forest preserve. *Trop Conserv Sci* 5(2):133–141
- Sheherazade J, Tsang SM (2015) Quantifying the bat bushmeat trade in North Sulawesi, Indonesia, with suggestions for conservation action. *Glob Ecol Cons* 3:324–330
- Shilton LA, Whittaker RJ (2009) The role of pteropodid bats in reestablishing tropical forests on Krakatau. In: Fleming TH, Racey PA (eds) Island bats. Chicago University Press, Chicago, pp 176–215

- Simmons N (2005) Order Chiroptera. In: Wilson DE, Reeder DM (eds) Mammal species of the world: a taxonomic and geographic guide. John Hopkins University Press, Baltimore, pp 312–529
- Sinavaiana C, Enright J (1992) The cultural significance of the flying foxes in Samoa: a legendary view. In: Wilson DE, Graham GL (eds) Proceeding of an international conservation conference on Pacific Island flying foxes. US Fish and Wildlife Service Biological Report, vol 90, pp 36–38
- Singaravelan N, Marimuthu G, Racey PA (2009) Do fruit bats deserve to be listed as vermin in the Indian Wildlife (Protection), Amended Acts? A critical review. *Oryx* 43(04):608–613
- SOS (2012) Filipinos for flying foxes project page. International Union for Conservation of Nature (IUCN) Save Our Species Fund. http://www.sospecies.org/sos_projects/mammals/filipinos_for_flying_foxes/
- Stebbing B (1987) Bats, tequila and the King of Siam. *BBC Wildlife*, Jan 1987, 4–8
- Stier SC, Mildenstein TL (2005) Dietary habits of the world's largest bats. *J Mammal* 86:719–728
- Stinson DW, Glass PO, Taisacan EM (1992) Declines and trade in fruit bats on Saipan, Tinian, Aguijan, and Rota. In: Wilson DE, Graham GL (eds) Pacific island flying foxes: proceedings of an international conservation conference, vol 90. US Fish and Wildlife Service Biological Report No 23, pp 61–67
- St. John FAV, Keane AM, Milner-Gulland EJ (2013) Effective conservation depends upon understanding human behaviour. In: MacDonald DW, Willis KJ (eds) Key topics in conservation biology. Wiley, New York
- Subramanian (2012) Zoonotic disease risk and the bushmeat trade: assessing awareness among hunters and traders in Sierra Leone. *Ecohealth* 4:471–482
- Tacio HD (2015) To the batcave: a visit to Samal Island's world record-holding bat colony. *GMA News Online*, Philippines. <http://www.gmanetwork.com/news/story/269418/lifestyle/travel/to-the-batcave-a-visit-to-samal-island-s-world-record-holding-bat-colony>
- Tanshi I, Labiran AJ, Chukwuyem SF et al (2013) Bat conservation in Nigeria: volunteer contribution to bat population survey and public awareness. In: Olajuyigbe SE, Coker OM, Olaleru F (eds) Proceedings of the 4th annual biodiversity conference. Lagos, Nigeria
- Trewhella WJ, Reason PF, Bullock RJ et al (1995) Conservation of *Pteropus livingstonii*: catching fruit bats in the Comores. *Myotis* 32–33:297–305
- Trewhella WJ, Rodriguez-Clark KM, Corp N et al (2005) Environmental education as a component of multidisciplinary conservation programmes: lessons from conservation initiatives for critically endangered fruit bats in the Western Indian Ocean. *Conserv Biol* 19:75–85
- Tuladhar-Douglas W (2008) The use of bats as medicine among the Newars. *J Ethno* 28:69–91
- USFWS (2009) Draft revised recovery plan for the Mariana fruit bat or fanihi (*Pteropus mariannus mariannus*), pp 1–83
- Van der Aa PJH, Lorica MRP, Komdeur J (2006) The hormonal and behavioral response to the presence and activities of humans in three co-roosting flying fox species (*Acerodon jubatus*, *Pteropus vampyrus* and *P. hypomelanus*) in Boracay and Mambukal in the Philippines. *Acta Zool Sini* 52:827–837
- Venkatesan A (2007) Status of Indian flying fox *Pteropus giganteus* in Bengaluru. *Bat Net News* 8:13–15
- Voigt CC, Kingston T (2016) Bats in the Anthropocene: conservation of bats in a changing world. Springer International AG, Cham
- Wiles GJ (1992) Recent trends in the fruit bat trade on Guam. In: Wilson DE, Graham GL (eds) Pacific island flying foxes: proceedings of an international conservation conference, vol 90. U.S. Fish and Wildlife Service Biological Report No 23, pp 52–60
- Wiles G (2008) *Pteropus pelewensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Wiles GJ, Payne NH (1986) The trade in fruit bats *Pteropus* spp. on Guam and other Pacific islands. *Biol Conserv* 38:143–161

- Wiles GJ, Engbring J, Otobed D (1997) Abundance, biology and human exploitation in the Palau Islands. *J of Zool Lond* 241:203–227
- Wiles G, Helgen K, Allison A (2008a) *Pteropus ualanus*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Wiles G, Helgen K, Allison A (2008b) *Pteropus yapensis*. The IUCN Red List of threatened species. Version 2014.3. www.iucnredlist.org. Downloaded on 18 Mar 2015
- Wilson DE, Graham GL (eds) (1992) Pacific Island flying foxes: proceedings of an international conservation conference, vol 90. US Fish and Wildlife Biological Report 23. U.S. Department of the Interior, United States
- Wilson VJ, Wilson BLP (1991) La chasse traditionnelle et commerciale dans le sud-ouest du Congo. *Tauraco Res Rep* 4:279–289