Mammals on the Sangihe and Talaud Islands, Indonesia, and the impact of hunting and habitat loss

Jon Riley

Abstract Surveys between 1995 and 1999 brought the number of mammal species known to occur on the remote Sangihe and Talaud islands, Indonesia, from 34 to 37, of which 30 are indigenous and 22 are bats. Populations of bear cuscus *Ailurops ursinus* and Sulawesi small cuscus *Strigocuscus celebensis* are represented by endemic subspecies, whilst five little-studied species (Talaud Islands flying fox *Acerodon humilis*, Sangihe tarsier *Tarsius sangirensis*, Sangihe squirrel *Prosciurillus rosenbergi*, short-tailed Talaud melomys *Melomys caurinus* and long-tailed Talaud melomys *M. talaudium)* are endemic to the archipelago. Two squirrel species were recorded on Sangihe for the first time: Sulawesi dwarf squirrel *P. murinus* and Sulawesi giant squirrel *Rubrisciurus rubriventer*. In total, eight species occurring on the islands are categorized as globally threatened on the 2000 IUCN Red List of Threatened Species. Habitat loss and hunting are the main threats on the Sangihe islands, where only 800 ha of primary forest remain. Large areas of Karakelang, in the Talaud Islands, are still forested, and a 24,669 ha wildlife reserve has been recently established. The main pressure facing mammal species on the Talaud Islands is hunting, particularly mist-netting of fruit bats for local consumption and trade. In order to control hunting and prevent further forest loss and degradation, future conservation efforts should focus on community-based conservation, in particular raising community awareness and increasing law enforcement. Two concurrent projects are now tackling some of these issues.

Keywords Community-based conservation, fruit bats, hunting, Indonesia, mammals, Sangihe, Talaud.

Introduction

Indonesia's terrestrial biodiversity is considered to be the second highest of any country in the world (Stone, 1997). Within its archipelago of over 17,000 islands 12% (515 species) of the world's mammal species occur (Stone, 1997). This high diversity is due, in part, to the species-rich forest environment and the location of the Indonesian archipelago, with the Indomalayan fauna of tropical South-east Asia to the west and the Australo-papuan fauna to the east (White & Bruce, 1986; Whitmore, 1987). Sulawesi is one of the most important regions in Indonesia for biodiversity conservation, containing some of the highest levels of species endemism and a rich variety of ecosystems (Whitten *et al.*, 2001). Mammal diversity and endemism are particularly marked, and 98% of non-flying mammal species are endemic to Sulawesi (Musser, 1987).

This biodiversity is threatened by a number of pressures including hunting, loss and degradation of natural habitats, and wildlife trade (Lee *et al.*, 2001). Efforts to address these threats are hindered by weak conservation laws and law enforcement, poor management of protected areas, and low levels of community awareness (Lee *et al.*, 2001). The lack of information about ecosystems, landscapes and species is a further restraint to tackling threats. Although the biodiversity of the northern peninsula of Sulawesi is the best studied of all regions on the island (Lee *et al.*, 2001; Whitten *et al.*, 2001), much remains to be discovered. In the past five years, seven species of bird have been described from the region (Lambert, 1998a, b; Lambert & Rasmussen, 1998; Rasmussen, 1999; Rozendaal & Lambert, 1999; Rasmussen *et al.*, 2000).

The remote Sangihe and Talaud archipelago was, until recently, one of the least-known regions of Sulawesi (Riley, 1997). Although a review has been published (Feiler, 1990), the only recent fieldwork was by F.G. Rozendaal (Bergmans & Rozendaal, 1988; Hill & Rozendaal, 1989) and M. Shekelle (Shekelle *et al.*, 1998).

On the Sangihe islands the effects of widespread loss of primary forest on mammals have never previously been investigated, despite the occurrence of two endemic species, and one of the objectives of this study was therefore to identify which mammal species are most at risk from habitat loss. On the Talaud islands extensive

Jon Riley Wildlife Conservation Society–Indonesia Program, Sulawesi, PO Box 1131, Manado 95000, Sulawesi, Indonesia.
E-mail: wcsriley@indosat.net.id

Received 21 March 2001. Revision requested 22 August 2001. Accepted 1 March 2002.

© 2002 FFI, *Oryx*, **36**(3), 288–296 DOI: 10.1017/S0030605302000510 Printed in the United Kingdom

areas of primary forest remain, but there has been no modern survey of the status of mammals, or of the threats that they face, despite the occurrence of three endemic species. The study described here aimed to provide information to support concurrent conservation efforts, including community-awareness work and efforts to upgrade the status of protected areas on the islands (Riley, 1997).

In this paper I present information about the mammal species observed on the islands between 1995 and 1999, in particular their distributions, and make population estimates for three terrestrial species on Sangihe. I describe the threats faced by mammals on the Sangihe and Talaud Islands, as determined by field observations and interviews with local people. Finally I identify strategies that should be employed during future mammal conservation initiatives in the archipelago in the light of work undertaken to date.

The Sangihe and Talaud Islands

The small island groups of Sangihe and Talaud form a chain, which extends from near the tip of northern Sulawesi towards the southern tip of Mindanao in the Philippines (Fig. 1). A total of 34 species of mammal were previously known from the archipelago, this represents an impoverished fauna lacking many species found on Sulawesi (Feiler, 1990; Corbet & Hill, 1992; Flannery, 1995). Sangihe Island is *c.* 700 km^2 and has fertile soil and a steep topography, as a result of its volcanic origin. Mt Awu (1,340 m), an active volcano, dominates the northern half of the island, while to the south is the extinct volcanic caldera of Mt Sahendaruman

ORY12401-1

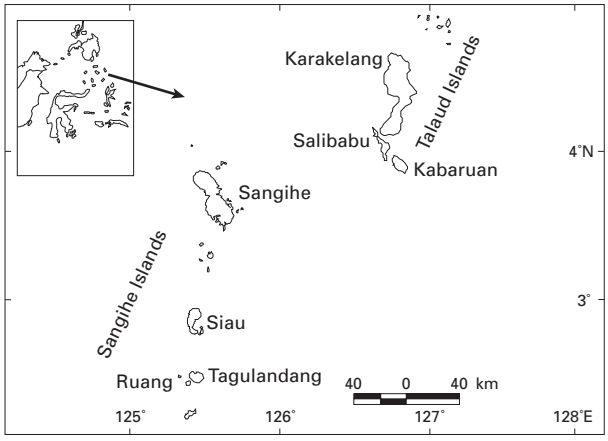

Fig. 1 The Sangihe and Talaud Islands in the western Pacific. The inset shows their position to the north of Sulawesi and south of Mindanao.

(1,031 m). The island is dominated by monocrop coconut *Cocos nucifera* plantations in the east, whilst in more mountainous areas nutmeg *Myristica fragrans*, clove *Eugenia aromatica*, and other crop trees are found in the understorey. Sangihe had largely been deforested by 1920 (Heringa, 1921; Whitten *et al*., 2001), and the only extensive forest remaining on the island is an 800 ha area centred on Mt Sahendaruman (Riley & Wardill, 2001). There are currently no strictly protected areas on Sangihe. A 4,268 ha area around Mt Sahendaruman is designated as Protection Forest *Hutan Lindung*. Little natural habitat is found in the two other areas of Protection Forest, one of 4,884 ha covering the slopes of Mt Awu, and an 1,105 ha area named Mt Otomata in the centre of the island.

Siau is *c.* 150 km^2 and is dominated by Mt Karangetang (1,320 m), an active volcano. Steep hills make up the rest of the island and what natural vegetation remains is largely restricted to the summit of Mt Tamata (1,134 m); small patches of forest elsewhere are rapidly being converted to agricultural use. There are no strictly protected areas on the island, but habitat on Mt Tamata is designated as Protection Forest. No natural vegetation remains on Tagulandang (*c.* 70 km^2), which is covered by mixed agricultural plantations dominated by coconuts.

North-east of the Sangihe group are the Talaud Islands. These islands are low-lying and non-volcanic, with extensive areas of natural forest. On Karakelang (976 km^2), a Wildlife Reserve *Suaka Margasatwa* has recently been established covering 24,669 ha in two forest blocks, and four areas of Protection Forest totaling 9,781 ha have been declared (Riley, 1997). Agricultural vegetation dominates a narrow coastal belt, a maximum of 5 km wide, and the central plain between Beo and Rainis, characteristically as small monocrop plantations mixed with secondary scrub and isolated remnant trees. Salibabu (*c.* 95 km^2) has more extensive areas of cultivated lands than Karakelang, and forest is restricted to the low, central hills.

Methods

Field surveys of mammals were conducted on five islands in the archipelago between 1995 and 1999. The surveys conducted between 24 August and 31 October 1995 took place on Sangihe, Siau, Salibabu, and Karakelang, but were cursory in nature and undertaken in addition to ornithological field work. Between 19 October 1996 and 26 March 1997 mammals were surveyed at five locations on Sangihe and three locations on Karakelang. Between 19 August 1998 and 27 June 1999 surveys were conducted at twelve locations on Sangihe, nine locations on Karakelang, and briefly on

https://doi.org/10.1017/S0030605302000510 Published online by Cambridge University Press

Salibabu and Tagulandang. No surveys were conducted on Kabaruan or Ruang, the two other large islands in the archipelago.

Quantitative surveys to obtain population density estimates of mammals on Sangihe used a variable circular plot (VCP) distance estimation technique (Reynolds *et al.*, 1980) and the field methods of Buckland *et al.* (1993) and Jones *et al.* (1995). A total of 148 point counts were conducted in primary forest and 259 counts in secondary habitats, over 50 days between 1 October 1998 and 28 February 1999. Densities were estimated using the software DISTANCE (Thomas *et al.* 1998); Buckland *et al.* (1993) provide a comprehensive explanation of this method. Sample sizes were only large enough to calculate population density estimates for three mammal species, the Sangihe tarsier *Tarsius sangirensis*, the Sulawesi dwarf squirrel *Prosciurillus murinus*, and the Sangihe squirrel *Prosciurillus rosenbergi*. To calculate total population estimates, density estimates for individual species were multiplied by the total area of habitat available to that species. The area of primary forest on Mt Sahendaruman in December 1998 was estimated to be *c.* 8 km^2 and, taking the area of Sangihe Island to be 700 km^2, secondary habitats cover 692 km^2. Qualitative data were also collected during these surveys, mainly in the form of casual sightings of mammals outside of timed counts, including information on habitat, feeding and behaviour.

Field surveys of fruit bats were conducted using mist nets and observations of roosting bats. The nets were sited in areas that are believed to maximize capture success, e.g. close to water sources, on ridge tops close to forest, and near fruiting trees (Kunz, 1988). The nets were 12 m long and were placed at varying heights up to 15 m from the ground, although most netting took place 1–5 m above ground. The nets were opened at dusk and closed at 23.00–24.00, or occasionally at dawn (05.15–05.30). Mist-netting was conducted over 40 nights at 14 locations on Sangihe, and over 29 nights at nine locations on Karakelang. The nets were checked at least every 90 mins to ensure that animals were not overheated or stressed. The time of capture was noted and morphometric measurements were made for each individual. The sex and age of bats was determined using methods detailed in Kunz (1988). Species of Microchiroptera were occasionally caught in the mist nets, but most information about this group came from searches in caves and encounters with tree-roosting animals.

Data on species distributions and threats were also collected during informal interviews with villagers. A total of 22 people on Sangihe, six on Salibabu and 29 on Karakelang were interviewed using semi-structured techniques.

Results

We recorded 23 species (two tentatively) of mammal on Sangihe, four species on Siau, one species on Tagulandang, 20 species on Karakelang, and three species on Salibabu; all species and subspecies known to be endemic to the archipelago were observed. Table 1 lists all 37 species reliably recorded on Sangihe-Talaud to date, of which 31 are indigenous, 22 are bats, and eight are globally threatened.

The bear cuscus *Ailurops ursinus* was previously known only from Salibabu (Feiler, 1990), where we did not record it. A second population, discovered on Sangihe in 1998, is distinctive in comparison to the nominate race on Sulawesi (pers. obs.; photographs in Flannery, 1995; Kinnaird, 1995). It has olive-green eyes, and its ash-grey coat resembles skins of the subspecies *A. u. melanotis* from Salibabu (Feiler, 1977; J.C. Wardill, pers. comm.); the Sangihe population is probably best classified with this subspecies. On Sangihe the bear cuscus is apparently restricted to primary forest on, and gardens immediately surrounding, the Sahendaruman caldera. On Salibabu, it was reported to occur in degraded forest and adjacent gardens. The populations of bear cuscus on both islands are probably small; we did not make any field sightings in more than 120 days of surveys on Sangihe, and the sole record was of a captive individual. We recorded Sulawesi small cuscus *Strigocuscus celebensis* on Sangihe only, where it is widely distributed but most commonly encountered in primary forest.

Eleven species of fruit bats have now been recorded from the islands, including five that are globally threatened. The four individuals of the globally Vulnerable Talaud Islands flying fox that we saw in 1999 had been trapped by hunters. We caught the golden-mantled flying fox *Pteropus pumilus* in mist-nets in primary forest and agricultural plantations across Karakelang, and it appears to be widespread. We also recorded two Near Threatened species: swift fruit bat *Thoopterus nigrescens* on Sangihe and Karakelang, and Sulawesi flying fox *Acerodon celebensis* on Sangihe. The swift fruit bat was found to be widespread in all habitats on the islands and, given that it occupies similar habitats on mainland Sulawesi, is not threatened at the present time. We caught the Sulawesi flying fox in mist-nets at three sites in southern Sangihe, and it is probably widely distributed in low numbers on the island. Surveys in north and south-east Sulawesi since September 1999 (Lee *et al.*, 2001; Riley *et al.*, 2001) have failed to record the species and, given the high levels of hunting throughout its range, the Sulawesi flying fox may warrant threatened status.

VCP data (Table 2) suggest that the Sangihe tarsier

https://doi.org/10.1017/S0030605302000510 Published online by Cambridge University Press

Table 1 Mammal species recorded on the Sangihe and Talaud Islands, Indonesia, with their Red list category and criteria according to Hilton-Taylor (2000), endemism and threats.

Family	Species	Common name	Red List category (criteria)	Endemic taxa	Island					Threats[1]	Information source for threats
					Sangihe	Siau	Tagulandang	Karakelang	Salibabu		
Phalangeridae	*Ailurops ursinus melanotis*	Bear cuscus	DD	Subspecies	X				X	H, HL	Interviews, field surveys
	Strigocuscus celebensis sangirensis	Sulawesi small cuscus	DD	Subspecies	X	X				H	Interviews, field surveys
Pteropodidae	*Pteropus hypomelanus*	Small flying fox			X	X		X	X	H	Interviews
	Pteropus griseus	Grey flying fox						X		H	Interviews
	Pteropus pumilus	Golden-mantled flying fox	VU (A2c)					X		H	Interviews
	Acerodon celebensis	Sulawesi flying fox	NT		X	X					
	Acerodon humilis	Talaud Islands flying fox	VU (A2c, D2)	Species				X	X	H	Interviews
	Rousettus celebensis	Sulawesi rousette			X	X	X	X			
	Dobsonia viridis	Greenish naked-backed bat			X	X		X		H	Interviews, field surveys
	Cynopterus brachyotis	Lesser dog-faced fruit bat			X	X		X			
	Thoopterus nigrescens	Swift fruit bat	NT		X			X			
	Nyctimene cephalotes	Pallas's tube-nosed bat			X			X			
	Macroglossus minimus	Common long-tongued fruit bat			X						
Emballonuridae	*Emballonura alecto*	Philippine sheath-tailed bat			?			X			
	Taphozous melanopogon	Black-bearded tomb bat			X			X			
	Taphozous saccolaimus	Temminck's pouch-bearing bat						X			
Megadermatidae	*Megaderma spasma*	Malaysian false vampire			X						
Rhinolophidae	*Rhinolophus celebensis*	Sulawesi horseshoe bat	NT		X			X			
Hipposideridae	*Hipposideros ater*	Dusky leaf-nosed bat			?			X			
	Hipposideros cervinus	Gould's leaf-nosed bat						X			
	Hipposideros diadema	Diadem leaf-nosed bat			X			X			

Table 1 (Continued)

Family	Species	Common name	Red List category (criteria)	Endemic taxa	Island					Threats[1]	Information source for threats
					Sangihe	Siau	Tagulandang	Karakelang	Salibabu		
Vespertilionidae	*Myotis adversus*	Grey large-footed myotis						X			
	Pipistrellus javanicus	Javan pipistrelle						X			
	Kerivoula hardwickii	Hardwicke's forest bat						X			
Tarsiidae	*Tarsius sangirensis*	Sangihe tarsier	DD	Species	X	X					
Viverriidae	*Viverra tangalunga*[2]	Malay civet			X	X					
Suidae	*Sus celebensis*[2]	Sulawesi pig						X		H	Interviews
Bovidae	*Bos javanicus*[2]	Banteng						X			
Sciuridae	*Prosciurillus murinus*	Sulawesi dwarf squirrel			X						
	Prosciurillus rosenbergi	Sangihe squirrel		*P. r. rosenbergi* (Sangihe & Siau) *P. r. tingahi* (Tagulandang & Ruang)	X	X	X				
	Rubrisciurus rubriventer	Sulawesi giant squirrel			X					H, HL	Interviews, field surveys
Muridae	*Mus musculus*[2]	Common house mouse			X	X		X	X		
	Rattus rattus[2]	House rat			X			X	X		
	Rattus argentiventer[2]	Ricefield rat			X			X			
	Lenomys meyeri	Sulawesi giant rat			X						
	Melomys caurinus	Short-tailed Talaud melomys		Species				X	X		
	Melomys talaudium	Long-tailed Talaud melomys		Species				X	X		
Total number of species			8		25	10	2	26	7		

[1]H = hunting, HL = habitat loss.
[2]Introduced species.

Table 2 Number of sightings, density estimates and estimated population sizes of *Tarsius sangirensis*, *Prosciurillus rosenbergi* and *Prosciurillus murinus* on Sangihe Island, Indonesia, as determined by variable circular plot surveys and DISTANCE analysis.

Species	Number of sightings	Density (number km^{-2})	95% Confidence interval		Population size (to nearest 100)	
			Lower	Upper	Minimum	Maximum
Sangihe tarsier						
Primary forest	30	66.9	42.1	106.2	300	500
Secondary habitat	14	21.5	12.4	37.4	8,700	15,100
Total population estimate					9,000	15,600
Sangihe squirrel						
Primary forest	51	184.1	107.6	315.2	900	1,500
Secondary habitat	47	50.5	36.7	69.6	25,700	35,300
Total population estimate					26,600	36,800
Sulawesi dwarf squirrel						
Primary forest	32	128.9	82.6	201.0	600	1,000
Secondary habitat	43	51.9	37.4	72.0	26,200	36,400
Total population estimate					26,800	37,400

T. sangirensis has a strong preference for primary forest on Sangihe, but tarsiers occur in a wide variety of secondary habitats including sago swamps, scrub, nutmeg plantations, secondary forest, and coconut plantations. The estimates of population density undoubtedly underestimate the species' true population size because the surveys were conducted mainly after animals had returned to daytime roosts.

The Sangihe squirrel *Prosciurillus rosenbergi* is the most frequently encountered mammal on Sangihe and Siau. It is found in forest up to *c.* 1,000 m and in all cultivated areas, with the highest population density in primary forest (Table 2). On Tagulandang the squirrel was common in plantations and gardens.

We recorded two species of squirrel on Sangihe for the first time. The Sulawesi giant squirrel *Rubrisciurus rubriventer* is endemic to Sulawesi and the records from Sangihe are the first from any offshore island (Corbet & Hill, 1992). All six records came from primary forest or adjacent gardens on the Mt Sahendaruman ridge, up to elevations of *c.* 900 m. The low number of field sightings suggest the species is rare on Sangihe. The second new species that we observed on Sangihe is apparently closely related to the Sulawesi dwarf squirrel *Prosciurillus murinus* from mainland Sulawesi (Corbet & Hill, 1992). VCP data show that the dwarf squirrel is common in all habitats with tall trees, with the highest density in primary forest (Table 2). As earlier workers on Sangihe did not record this common and conspicuous species (Meyer, 1897; Feiler, 1990) it may have been recently introduced.

The two *Melomys* species endemic to the Talaud islands are little-studied and known from very few specimens (Corbet & Hill, 1992; Flannery, 1995). We obtained three records in 1999, all on Karakelang, but until identification features are clarified the precise status of the two species will remain unclear. It seems likely both are arboreal species, feed mainly on fruit, and occur in primary forest and secondary habitats; both species appear secure at present.

The semi-structured interviews (Table 3) showed that 77% of the farmers that we questioned hunt wild animals. Whilst hunters across the archipelago capture almost all mammal species, hunting is a major threat to two groups in particular, cuscus (hunted by 57% of farmers on Sangihe and Salibabu) and fruit bats (hunted by 72% of farmers on Karakelang).

Discussion

Bear cuscus populations on the islands are now so small and fragmented that hunting pressure must be having a major impact. Sulawesi small cuscus populations are larger, and the species occurs in secondary habitats, but hunting pressure is high and local extinctions may already be taking place. The pressure of hunting, especially on bear cuscus, is exacerbated by habitat loss. On Salibabu and Sangihe bear cuscus are apparently restricted to small, fragmented areas of primary habitat, and whilst animals are reported to occur in adjacent secondary habitat, the species appears to be ecologically dependent on forest. The Sahendaruman forest block on Sangihe is the key site for cuscus conservation in the islands. Any further loss or degradation of this primary forest will have very serious effects on the two endemic cuscus subspecies. The threats to this forest have been discussed in detail elsewhere and recommendations for its protection have been made (Riley, 1997; Wardill *et al.*, 1997; Riley &Wardill, 2001).

Habitat loss is not yet a great pressure on the majority of other mammal species in the archipelago. The pro-

https://doi.org/10.1017/S0030605302000510 Published online by Cambridge University Press

Table 3 Information on hunting and related matters obtained from semi-structured interviews with 22 people on Sangihe, six on Salibabu and 29 on Karakelang.

Location	Dates	Profession	Mammal species hunted	Hunting method	Captive mammals reported or seen	Other information
Sangihe	Aug 1998–Feb 1999	Farmer (17)	*L . meyeri* (8) *S. celebensis* (8) *A. ursinus* (5) *R. rubriventer* (3) Fruit bats (3) *V. tangalunga* (2)	Snares (10) Air rifles (8) Nets (2)	*L. meyeri* (1) *S. celebensis* (5) *A. ursinus* (2) *V. tangalunga* skins (2)	*A. ursinus* rare or absent (7) *A. ursinus* mainly in forest, sometimes in plantations (3) *S. celebensis* common (7) Captive cuscus taken as young when mother shot (6) *V. tangalunga* uncommon in all habitats and attack livestock (2) Bats shot in fruiting trees (1)
Sangihe	Feb 1999	Restaurant owner (5)	None		*R. celebensis* (1)	Do not sell wild meat (5)
Karakelang	March–May 1999	Farmer (25)	Large fruit bats (18) Small fruit bats (15) *Sus celebensis* (3) *Melomys* rats (2)	Nets (18) Snares (5)	*D. viridis* (6) *A. humils* (2) *P. pumilus* (5) *P. griseus* (1)	Eight net locations seen Large bats for sale, small bats for consumption (3) Hunters collect bats from caves near village (3) *Sus celebensis* uncommon (2) *Sus celebensis* rare (5) *Melomys* rats in plantations and forest (2)
Karakelang	April 1999	Restaurant owner (2)	Large fruit bats (2)		*D. viridis* (2) *P. hypomelanus* (6) *A. humils* (2) *P. griseus* (1) *P. pumilus* (25)	Trappers sell large bats and consume small bats (2) Bats traded to Sulawesi (2)
Karakelang	April 1999	Market stall owner (2)	None			Do not sell wild meat (2) Bats sold in restaurants (2) Bats traded to Sulawesi (2)
Salibabu	June 1999	Farmer (6)	*Ailurops ursinus* (5)	Air rifles (5) Snares (1) Blowpipe (1)		*A. ursinus* heavily hunted (2) *A. ursinus* only in forest (5) *A. ursinus* rare (3) Hunt to order (1)

tected forests on Karakelang support all other mammal species known from the Talaud islands, and all other mammal species known from the Sangihe islands have been recorded in secondary habitats.

The Sangihe and Talaud islands, and in particular Karakelang, support important populations of fruit bats, including five threatened species (Hilton-Taylor, 2000). Many of these species are threatened by increasing levels of habitat loss and hunting pressure in their core ranges in Sulawesi and the Philippines (Heaney & Heideman, 1989; Lee *et al.*, 2001). I noted some commercial trade in fruit bats from Karakelang, but at present the trade appears to be *ad hoc*. The potential impact of rising commercial demand for fruit bats from the meat markets of Minahasa on mainland Sulawesi is, however, of concern. Studies in north Sulawesi have shown that hunting leads to significant declines in mammal populations, including fruit bats (O'Brien & Kinnaird, 1996; Lee, 2000). As fruit bat populations in mainland north Sulawesi decline, the demand for bats to supply the Minahasan market must be met from other sources. Lee *et al.* (2001) suggest that a majority of larger fruit bats sold in Minahasan markets today appear to originate from other parts of Sulawesi, sometimes from areas as distant as central Sulawesi, reflecting the patterns of trade in other mammal species (Clayton & Milner-Gulland, 2000).

Conservation initiatives are needed to address the hunting pressure faced by cuscus and fruit bat populations. These animals are heavily harvested because of local tradition, ignorance, and a lack of proper legal protection. Both cuscus species are protected under Indonesian law (Government of Indonesia Regulation No. 7, 1999), but law enforcement is weak across north Sulawesi (Lee *et al.*, 2001). Efforts need to be made to increase the legal literacy of local government officials and the wider community. Lee *et al.* (2001) recommend the creation of special police units primarily responsible for working on wildlife issues. The responsibilities of these units would include monitoring markets, restaurants

https://doi.org/10.1017/S0030605302000510 Published online by Cambridge University Press

and harbours, for trade in protected species; compiling data on wildlife trafficking; and working with prosecutors to enforce protection laws. Law enforcement efforts should also include increasing the awareness of local people, especially hunters, about protected species. At the same time local communities must be made aware of the economic importance of mammals and the influence of hunting on their populations. Fruit bats disperse the seed of a wide variety of economically valuable plant species (Fujita & Tuttle, 1991), including fruit trees that are important to the agrarian economy of Sangihe-Talaud, and are important in maintaining the islands' forests (Cox *et al.*, 1991).

A Global Environment Facility funded project, implemented by the Indonesian Department of Forestry and BirdLife International with local partners, has recently been approved for the Sangihe and the Talaud Islands, and started in February 2002. This four-year project will address environmental and conservation problems on Mount Sahendaruman and in the Karakelang Wildlife Reserves. The project will build on previous work to establish management systems that have the support of local communities, and strengthen local capacity for planning and management. An extensive public awareness campaign will create a wider constituency of support for forest conservation among the population of the islands and more widely. A second initiative, 'Hunting for Sustainability', funded by USAID and implemented by the Indonesian Department of Forestry and Wildlife Conservation Society – Indonesia Program, commenced in January 2002. This project addresses the issue of hunting and trade of protected species across South-east Asia, with the province of North Sulawesi as one focal centre. This project will review national and local conservation laws, survey and monitor the trade in wildlife in north Sulawesi, and create trained police and legal units dedicated to prosecuting cases under Indonesian conservation laws. These timely initiatives running concurrently in north Sulawesi will address the main threats – hunting and habitat loss – facing mammal populations on the Sangihe and Talaud islands.

Acknowledgements

Fieldwork would not have been possible without the support and enthusiasm of Iwan Hunowu, Yusman Hunowu and Jorys Mole. The surveys were conducted under the auspices of Action Sampiri–Sangihe and Talaud Conservation Project, and I am indebted to my colleagues James C. Wardill and Damien Hicks. The 1998–1999 Action Sampiri project was sponsored by BP Conservation Programme, BirdLife International, Fauna & Flora International, Zoologische Gesellschaft für Arten- und Populationsschutz, Vereinigung für Artenschutz und Zucht, Stiftung Avifauna Protecta, Papagaien, British Ornithologists' Union, Royal Geographical Society and June Chamberlain Charity, whilst studies of fruit bats were sponsored by The Mammal Society. Fieldwork was undertaken with permission from the Indonesian Institute of Sciences (LIPI) and sponsored by the Research and Development Centre for Biology (PPPB). Dr Alfred Feiler (Staatliches Museum für Tierkunde, Dresden), Dr Wim Bergmans (Zoölogisch Museum, Universiteit van Amsterdam), and Drs Nikky Thomas and David Harrison (Harrison Zoological Museum, Kent) kindly provided background information.

References

Bergmans, W. & Rozendaal, F.G. (1988) Notes on collections of fruit bats from Sulawesi and some off-lying islands (Mammalia, Megachiroptera). *Zoologische Verhandelingen*, **248,** 1–78.

Buckland, S.T., Anderson, S.R., Burnham, K.P. & Laake, J.L. (1993) *Distance Sampling: Estimating Abundance of Biological Populations*. Chapman and Hall, London.

Clayton, L. & Milner-Gulland, E.J. (2000) The trade in wildlife in North Sulawesi, Indonesia. In *Hunting for Sustainability in Tropical Forests* (eds E.L. Bennett & J.G. Robinson), pp. 473–498. Columbia University Press, New York.

Corbet, G.B. & Hill, J.E. (1992) *The Mammals of the Indomalayan Region*. Oxford University Press, Oxford, UK.

Cox, P.A., Elmqvist, T., Pierson, E.D. & Rainey, W.E. (1991) Flying foxes as strong interactors in South Pacific island ecosystems: a conservation hypothesis. *Conservation Biology*, **5,** 448–454.

Feiler, A. (1977) Über die intraspezifische variation des *Phalanger ursinus* (Mammalia, Marsupialia). *Zoologische Abhandlungen Staatliches Museum für Tierkunde Dresden*, **34,** 187–197.

Feiler, A. (1990) Über die Säugetiere der Sangihe- und Talaud-Inseln – der beitrag A.B. Meyers für ihre erforschung (Mammalia). *Zoologische Abhandlungen Staatliches Museum für Tierkunde Dresden*, **46,** 75–94.

Flannery, T.F. (1995) *Mammals of the South-west Pacific and Moluccan Islands*. Reed Books, Australia.

Fujita, M.S. & Tuttle, M.D. (1991) Flying foxes (Chiroptera: Pteropodidae): threatened animals of key ecological and economic importance. *Conservation Biology*, **5,** 455–463.

Heaney, L.R. & Heideman, P.D. (1989) Philippine fruit bats, endangered and extinct. *Bats*, **5,** 3–5.

Heringa, P. (1921) Rapport over de begroeiing van de Sangi-en Talaud-eilanden. *Tectona*, **14,** 733–746.

Hill, J.E. & Rozendaal, F.G. (1989) Records of bats (Microchiroptera) from Wallacea. *Zoologische Medelingen*, **63,** 97–122.

Hilton-Taylor, C. (compiler) (2000) *2000 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland and Cambridge, UK.

Jones, M.J., Linsley, M.D. & Marsden, S.J. (1995) Population sizes, status and habitat associations of the restricted-range bird species of Sumba, Indonesia. Bird Conservervation International, **5,** 21–52.

Kinnaird, M.F. (1995) *North Sulawesi: A Natural History Guide*. Wallacea Development Institute, Jakarta, Indonesia.

Kunz, T.H. (ed.) (1988) *Ecological and Behavioural Methods for the Study of Bats*. Smithsonian Institution Press, Washington, USA.

Lambert, F.R. (1998a) A new species of *Gymnocrex* from the Talaud Islands, Indonesia. *Forktail*, **13,** 1–6.

Lambert, F.R. (1998b) A new species of *Amaurornis* from the Talaud Islands, Indonesia, and a review of taxonomy of bush hens occurring from the Philippines to Australasia. *Bulletin of the British Ornithologists' Club*, **118,** 67–82.

Lambert, F.R. & Rasmussen, P.C. (1998) A new scops owl from Sangihe Island, Indonesia. *Bulletin of the British Ornithologists' Club*, **118,** 204–217.

Lee, R.J. (2000) Impact of subsistence hunting in North Sulawesi, Indonesia and conservation options. In *Hunting for Sustainability in Tropical Forests* (eds E.L. Bennett & J.G. Robinson), pp. 455–472. Columbia University Press, New York.

Lee, R.J., Riley, J. & Merrill, R. (2001) *Biodiversity and Conservation in North Sulawesi, Indonesia*. Natural Resource Management, Jakarta, Indonesia.

Meyer, A.B. (1897) Säugethiere vom Celebes- und Philippinen-Archipel. *Abhandlungen und Berichte des Zoologie und Anthr.–Ethn. Museum Dresden*, **6,** 1–36.

Musser, G.G. (1987) The mammals of Sulawesi. In *Biogeographical Evolution of the Malay Archipelago* (ed. T.C. Whitmore), pp. 74–93. Oxford Monographs on Biogeography No. 4. Oxford Science Publications, Clarendon Press, Oxford, UK.

O'Brien, T.G. & Kinnaird, M.F. (1996) Changing populations of birds and mammals in North Sulawesi. *Oryx*, **30,** 150–156.

Rasmussen, P.C. (1999) A new species of Hawk-owl *Ninox* from North Sulawesi, Indonesia. *The Wilson Bulletin*, **111,** 457–464.

Rasmussen, P.C., Wardill, J.C., Lambert, F.R. & Riley, J. (2000) On the specific status of the Sangihe White-eye *Zosterops nehrkorni* with a taxonomic review of the Black-fronted White-eye *Z. atrifrons*. *Forktail*, **16,** 69–81.

Reynolds, R.T., Scott, J.M. & Nussbaum, R.A. (1980) A variable circular plot method for estimating bird numbers. *Condor*, **82,** 309–313.

Riley, J. (1997) *Biological Surveys and Conservation Priorities on the Sangihe and Talaud Islands, Indonesia*. CSB Conservation Publications, Cambridge, UK.

Riley, J. & Wardill, J.C. (2001) The rediscovery of Cerulean Paradise-flycatcher *Eutrichomyias rowleyi* on Sangihe, Indonesia. *Forktail*, **17,** 45–56.

Riley, J., Hunowu, I., Hunowu, Y. & Maneasa, E. (2001) *Tanjung Peropa and Tanjung Batikolo Wildlife Reserves, Sulawesi Tenggara, Indonesia: Biological Surveys and Management Recommendations*. A Wildlife Conservation Society report to the Indonesian Department of Forestry, Manado, Indonesia.

Rozendaal, F.G. & Lambert, F.R. (1999) The taxonomic and conservation status of *Pinarolestes sanghirensis* Oustalet 1881. *Forktail*, **15,** 1–13.

Shekelle, M., Mukti, S., Ichwan, L.L.S. & Masala, Y. (1998) The natural history of the tarsiers of north and central Sulawesi. In *Proceedings of the Second International Conference on Eastern Indonesian-Australian Vertebrate Fauna, Lombok, December 10–13, 1996*. (eds D.M. Prawiradilaga, M. Amir & J. Sugardjito), pp. 111–112. Indonesian Institute of Sciences, Jakarta, Indonesia.

Stone, D. (1997) *Biodiversity of Indonesia: Tanah Air*. Archipelago Press, Singapore.

Thomas, L., Laake, J.L., Derry, J.F., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Strindberg, S., Hedley, S.L., Burt, M.L., Marques, F., Pollard, J.H. & Fewster, R.M. (1998) *Distance 3.5*. University of St. Andrews, UK: Research Unit for Wildlife Population Assessment.

Wardill, J.C., Riley, J., Hunowu, I. & Wangko, M.F. (1997) *A Status Assessment of the Gunung Sahengbalira Protection Forest, Sangihe, North Sulawesi*. PHPA/BirdLife International Indonesia Programme, Technical Memorandum No. 19, Bogor, Indonesia.

White, C.M.N. & Bruce, M.D. (1986) *The birds of Wallacea (Sulawesi, the Moluccas and Lesser Sunda Islands)*. Checklist No. 7, British Ornithologists' Union, London, UK.

Whitmore, T.C. (ed.) (1987) *Biogeographical Evolution of the Malay Archipelago*. Oxford Monographs on Biogeography No. 4. Oxford Science Publications, Clarendon Press, Oxford, UK.

Whitten, A.J., Mustafa, M. & Henderson, G. (2001) *The Ecology of Sulawesi*. Periplus, Jakarta, Indonesia and Oxford University Press, Oxford, UK.

Biographical sketch

Jon Riley first visited Sulawesi in 1991 as an undergraduate member of an ethnobotanical expedition from the University of York, UK. Between 1995 and 1999 he worked on the Sangihe-Talaud islands as leader of Action Sampiri – the Sangihe-Talaud Conservation Project, re-discovering the Critically Endangered endemic Cerulean paradise-flycatcher *Eutrichomyias rowleyi*. Action Sampiri was twice winner of the BP Conservation Awards. Since 1999 he has worked for the Wildlife Conservation Society – Indonesia Program, Sulawesi office, developing training programmes for local staff and conducting island-wide ecological surveys.

https://doi.org/10.1017/S0030605302000510 Published online by Cambridge University Press