Part I

The status and distribution of long-tailed macaques

1 *The common monkey of Southeast Asia: Long-tailed macaque populations, ethnophoresy, and their occurrence in human environments*

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The long-tailed macaque (*Macaca fascicularis*) population spreads over one of the widest geographical ranges of any primate, trailing only humans (*Homo sapiens*) and rhesus macaques (*M. mulatta*) (Wheatley, 1999) (Figure 1.1). According to Fooden (1995, 2006), the population extends across the majority of mainland Southeast Asia. They occur in the southeastern most part of Bangladesh, spreading south along the coast of Myanmar, east through the southern two-thirds of Thailand, all of Cambodia, the southeastern tip of Laos, and through the southern half of Vietnam. Through Thailand, the population extends past the Isthmus of Kra, and occurs all through Sundaland (i.e., peninsular Malaysia and the Indonesian archipelago west of the Wallace line) and into the Philippines. Long-tailed macaques also occur on smaller islands. For example, long-tailed macaques occur off the northern coast of Sumatra on the most southern Indian Nicobar Islands, as well as occurring on small islands off the west coast, such as Simeulue and Lasia. Other island habitats include Maratua, off Kalimantan, Karimunjawa, off Java, Koh Khram Yai, off Thailand, and Con Son, off Vietnam. They certainly occur on many other small islands, as the region is covered with tens of thousands of islands.

Long-tailed macaques are found predominantly on the western side of the Wallace line and are considered Asian fauna. Despite this, populations in Wallacea exist on the eastern side of the line, which are possibly the result of historical human introductions (e.g., Lombok, Nusa Tenggara, and East Timor) (Kawamoto *et al*., 1984). Confirmed cases of recent human introductions of macaques across the Wallace line have occurred on an island off Sulawesi (Froehlich *et al*., 2003) and on West Papua (Kemp and Burnett, 2007). In

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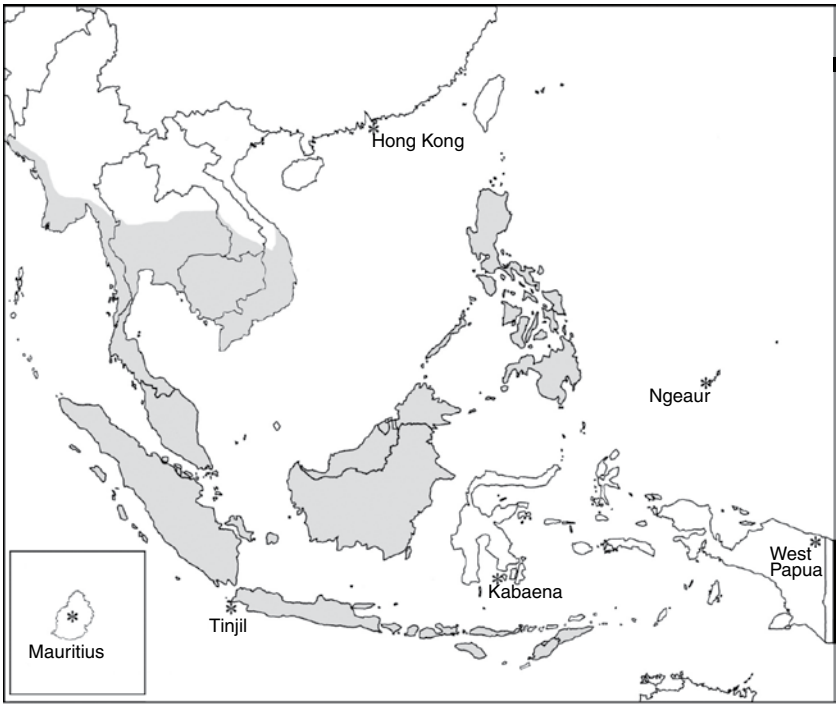

Figure 1.1. A map of Southeast Asia showing the approximate distribution of *M. fascicularis* shaded in gray. The regions they have colonized over the last several centuries are marked by asterisks and labeled by name. Mauritius is inlayed on the map, is located off the east coast of Africa, and is not to scale.

addition, there are also confirmed cases of recently human-introduced populations in other regions far from their natural range such as Mauritius (Sussman and Tattersall, 1986), Hong Kong (Southwick and Southwick, 1983), and Palau (Poirer and Smith, 1974). An intentional introduction to a formerly unpopulated island within the boundaries of their natural range occurred on Tinjil Island to establish a breeding colony (Kyes, 1993).

The population size of *M. fascicularis* is not well known (Southwick and Siddiqi, 1994). In the 1980s, Kathy Mackinnon (1986) provided population estimates for primates in Indonesia and estimated that there were 3,726,860 long-tailed macaques. A year later, it was estimated that there were 309,360 macaques in mainland Southeast Asia (Mackinnon and Mackinnon, 1987). Using these figures, Fooden (1995) estimated that the entire natural population of long-tailed macaques in the 1980s was somewhere around 5 million individuals. Eleven years later, he reassessed his estimation and suggested there

are approximately 3 million long-tailed macaques in existence today (Fooden, 2006). If these numbers are accurate, there has been a 40 percent total population decline in about a quarter of a century. Also pointing towards population decline, Mackinnon and Mackinnon (1987) reported that 63 percent of primate habitat in Indonesia was no longer suitable for inhabitation as early as the 80's, and Khan *et al*. (1982) pointed out a 23 percent decline in the population of *M. fascicularis* between 1957 and 1975 in Malaysia. *M. fascicularis* numbers are relatively high compared to other extant non-human primates, but they are continually declining, suggesting monitoring of their population may be necessary in the near future (Wheatley and Putra; 1994b; Eudey, 2008).

Southwick and Siddiqi (1994) pointed out that Mackinnon's estimates may not have taken into account the patchy distribution of long-tailed macaques and so the figures reported may overestimate actual population levels. Mackinnon (1986) admits that population census techniques can be subjective, but that best efforts were taken to accurately depict population densities despite attempting to census a species that is unevenly distributed through a vast range. Therefore, even with the best correction techniques it is still possible that populations were overestimated. Regions that are most easily surveyed, rivers and forest edges, are where long-tailed macaques predominantly range, making it possible that extrapolations into unsurveyed regions, where they may not be, might overestimate the population size. We must also consider that long-tailed macaques are among the most easily observable of wildlife because they are conspicuous and prefer habitats near human settlements and along forest edges. Consequently, it is much easier to physically count entire regional populations than many other species. Population counts based on extrapolations from populations intermixed into human settlements and/or on forest borders may not be accurate, as what is observed may represent the large percentage of their population with little extrapolation needed.

We can predict that long-tailed macaques are decreasing in number in their total population. However, it is possible that a larger proportion of the population is now interfacing with human settlement, as there are a number of reports highlighting increased occurrence of human-macaque conflict in several regions of South Asia (Eudey, 2008; Fuentes, 2006; Fuentes *et al*., 2008; Malaivijitnond *et al*., 2005; Malaivijitnond and Hamada, 2008; Sha *et al*., 2009a; Sha *et al*., 2009b; Wong and Chow, 2004). Increased conflict is suspected to be a consequence of human-induced habitat disturbance, which is causing forest loss, expansion of edge habitat, and production of mosaic environments. The rapid development occurring in Southeast Asia presents a challenge to wildlife management programs because it has produced more environments suitable to sustaining long-tailed macaques. As a result, the consequences of human-macaque overlap may become more prominent in more

Table 1.1. *Reported habitat types inhabited by long-tailed macaques*

Bamboo forest	Mangrove forest
Beach	Mixed forest
Broadleaf forest	Montane forest
Coastal regions	Primary forest
Deciduous forest	Rain forest
Dipterocarpel forest	Riverine
Dry forest	Rocky shores
Edge habitats	Scrub forest
Evergreen forest	Secondary forest
Grassland	Semideciduos forest
Hills	Submontane forest
Islands	Swamp forest
Lowland forest	Tropical forest

and more regions across Asia. It will be imperative to better assess how much of the long-tailed macaque population is actually residing in human settlements and repair the striking gap in our knowledge about the population-level characteristics of this supposedly common and well-understood monkey.

Habitat preferences

Long-tailed macaques are found in a wide variety of habitats including mangrove, rainforest, swamp, coastal, tropical, deciduous, evergreen, scrub, riverine, and secondary forests (Fooden, 2006) (Table 1.1). They are not equally distributed in these environments and long-tailed macaques are most commonly found along forest edges, especially in swamp forests and riverine habitats or on the edges of disturbed habitats (Bismark, 1991; Bismark, 1992; Chivers and Davies, 1978; Crockett and Wilson, 1980; Fittinghoff and Lindburg, 1980; Gurmaya *et al*., 1994; McConkey and Chivers, 2004; van Schaik *et al*., 1996; Suaryana *et al*., 2000; Supriatna *et al*., 1996). The most recent surveys of long-tailed macaques in Sumatra and Kalimantan indicate they may be less abundant in lowland and montane forests (Yanuar *et al*., 2009), and in swamp forests are difficult to find beyond 1 km from river edges (Gumert *et al*., 2010).

Anthropogenic land-use generates large amounts of forest edge, and being an edge species, long-tailed macaques are already well adapted for exploiting the fragmented forests created by current human land development. Not surprisingly, long-tailed macaques are commonly reported to inhabit the edges of a variety of anthropogenic environments (Fuentes, 2006; Fuentes *et al*., 2008, Hadi,

Table 1.2. *Types of human-macaque interface zones*

Agricultural land
Cemeteries
Eco-lodges
Metropolitan cities
Plantations
Rural villages
Roads
Small islands
Towns
Temples/Religious grounds
Recreation parks

2005; Malaivijitnond *et al*., 2005; Malaivijitnond and Hamada, 2008; Sha *et al*., 2009a; Sha *et al*., 2009b; Wong and Ni, 2000) (Table 1.2). Long-tailed macaques are also attracted to the edges of human settlements because of the availability of excess food resources, which can keep macaques around villages, towns and cities and lower their dependency on wild food sources (Sha *et al*., 2009a). Since, anthropogenic habitat alteration is continually developing new forest edges and disturbed forest habitats throughout Southeast Asia, more and more habitats are being generating that can potentially sustain populations of long-tailed macaques at close proximity to human settlements. In contrast, undisturbed habitats suitable to long-tailed macaques, particularly in unprotect forests, may be quickly becoming scarcer, potentially threatening the sustainability of regional populations of macaques in such conditions (Yanuar *et al*., 2009).

Variation amongst long-tailed macaques

Distribution of subspecies

Congruent with the great geographic distribution of *M. fascicularis*, there is also a great level of variation in physical characteristics across locations. Historically, there have been approximately 50 different scientific names given to this monkey at various times, but the current classification system suggests there are ten different subspecies of long-tailed macaques (Fooden, 1995; Fooden, 2006; Groves, 2001). Fooden's classification system is arguable, but it is adopted by Groves (2001), and his system will be reviewed here as a good point of origin for classifying the variation found in long-tailed macaques. The species group mainly consists of *M. f. fascicularis*, which inhabits all

Figure 1.2. A map of the distribution of the ten sub-species of *M. fascicularis*. The core and its fringing subspecies are shaded and labeled by letters. A = *M. f. aurea*, B = *M. f. fascicularis*, C = *M. f. philippinensis*. The isolated island subspecies are labeled with numbers. 1 = *M. f. umbrosa*, 2 = *M. f. lasiae*, 3 = *M. f. fusca*, 4 = *M. f. atriceps*, 5 = *M. f. condorensis*, 6 = *M. f. karimondjiwae*, 7 = *M. f. tua*.

of mainland Southeast Asia east of Thailand, and extends through the major islands of Indonesia and slightly extends into the southwestern region of the Philippines (Figure 1.2).

Two other subspecies lie on the eastern and western extremes of the core species' geographical distribution. The second largest ranging subspecies, *M. f. aurea*, is found northwest of the range of *M. f. fascicularis* in Myanmar, Bangladesh, and west-central Thailand. They have a contact zone with *M. f. fascicularis* along the mountain ranges that cover the border regions of Myanmar and Thailand. *M. f. philippinensis* occupies a similarly sized range on the eastern side, occupying the majority of the Philippine islands except for the western region of Mindanao, which is solely occupied by *M. f. fascicularis*. The ranges of *M. f. fascicularis* and *M. f. philippinensis* overlap in the eastern two-thirds of Mindanao and in the southern Negros Islands. Here the two subspecies are sympatric and long-tailed macaques of mixed phenotype can be found.

All of the other seven subspecies are isolated on small islands. *M. f. atriceps*, *M. f. condorensis*, and *M. f. karimondjiwae* all populate small shallow-water fringing islands. *M. f. atriceps* is found on the island of Koh Khram Yai off the southwestern coast of Thailand. *M. f. condorensis* inhabits Con Son, an island off the southeastern coast of Vietnam. *M. f. karimondjiwae* inhabits Karimunjawa Island, off the north central coast of Java. *M. f. umbrosa*, *M. f. fusca*, *M. f. lasiae*, and *M. f. tua*, all inhabit small deep-water fringing islands. *M. f. umbrosa* is found on the islands of Katchall, Little Nicobar, and Great Nicobar in the Indian Nicobar Island chain north of Sumatra. *M. f. fusca* is located on the small island of Simeulue, which is off the west coast of northern Sumatra. Nearby, *M. f. lasiae* inhabits Lasia Island. Finally, off of the east coast of Kalimantan, *M. f. tua* occupies Maratua Island.

Subspecies characterization

Fooden (1995) assessed the skins of long-tailed macaques from all over its range and found significant morphological variation between regions, and this is the basis for his subspecific classification system. The variation he found was in the dorsal pelage color, crown color, thigh color, lateral crest pattern, head length, body length, and relative tail length. One of the major patterns he observed was that monkeys on fringing islands tended to show a blackish coloration of their pelage, and that large island and mainland monkeys were lighter (Fooden, 1995). Aside from being darker, some island species exhibit other distinct variations. For example, the Philippine subspecies has distinguishing molar variation (Fooden, 1991), while the Simeulue long-tailed macaque has a shorter tail and demonstrates less sexual dimorphism than *M. f. fascicularis* (van Schaik and van Noordwijk, 1985). The Simeulue long-tailed macaque also exhibits distinct behavioral differences. They live in smaller groups that fission and have a distinct loud call that is reported to be similar to the loud call of the Siberut macaque, *M. pagensis* (van Schaik and van Noordwijk, 1985; Sugardjito *et al*., 1989). Too little is known of the other island subspecies to know if they also exhibit unique characteristics aside from being darker.

Macaca fascicularis aurea, a mainland subspecies, is distinct morphologically appearing to be larger, having darker skin, and a browner-colored pelage (Fooden, 1995; San and Hamada, Chapter 2). Although distinct morphologically, they also exhibit a striking behavioral difference from other populations of long-tailed macaques because they have been observed to customarily use stone tools to crack oysters, as well as other shellfish, snails and nuts (Carpenter, 1887; Malaivijitnond *et al*., 2007). Although other tool-use behavior has been seen idiosyncratically in *M. f. fascicularis* (Chiang, 1967; Fuentes *et al*., 2005,

Watanabe *et al*., 2007; Wheatley, 1988), none of these cases are reported to be customary traditions as in *M. f. aurea* (Gumert *et al*., 2009).

Some of the distinctions between subspecies concluded from morphological studies have been supported by a small amount of genetic work. The subspecies on the fringing islands off the coast of Sumatra show substantial genetic differentiation from the macaques on mainland Sumatra (Scheffran *et al*., 1996). There also seems to be a distinct difference in blood proteins between the macaques of the Philippines and others regions, indicating a genetic distinction between *M. f. philippinensis* and *M. f. fascicularis* (Fooden, 1991). Moreover, mitochondrial DNA work has shown that Philippine long-tailed macaques went through a bottleneck after being colonized by Indonesian long-tailed macaques, and have since largely remained genetically isolated from the Indonesian stock. (Blancher *et al*., 2008) Overall, the subspecific variation of long-tailed macaques needs to be better discerned and it will be important to investigate the differentiation across all the identified subspecies. Such information will help us understand the significance of subspecific differentiation in long-tailed macaques, and will also be a useful guide for conservation and management strategy decisions.

Population status of each subspecies

Long-tailed macaques in the Philippines, *M. f. philippinensis*, were in high abundance prior to 1960. Since that time, the population has been decimated as a result of trapping and forest conversion practices (Fooden, 1991), but no clear population estimates are provided with these claims. The population of Andaman long-tailed macaques (*M. f. aurea)* in Myanmar may not be very large, appears fragmented, and may be threatened by human development and trade (San and Hamada, Chapter 2). In Thailand, *M. f. aurea* are only reported in a few locations around Ranong province (Malaivijitnond and Hamada, 2008), and in Bangladesh they are considered a critically endangered species according to national laws (Khanam *et al*., 2005). The core subspecies, *M. f. fascicularis* is reported to be widespread but declining because local populations are disappearing in some regions, such as Cambodia (see Box 3.1), while others are expanding into more human-interface zones and thus facing higher levels of conflict (Wheatley and Putra, 1994b; Eudey, 2008). There may now be a larger percentage of the population residing around human settlements, making a large number of monkeys vulnerable to human activity.

The population levels of the small island subspecies are not well understood, but we do have some information. *M. f. umbrosa* has been assessed and is

reported to have a population of approximately 3,000 macaques spread across three islands in the Nicobars (Umapathy *et al*., 2003). This data may be outdated though as there has been no complete assessment of their loss following the 2004 tsunami (Umapathy, pers. Comm.). The Nicobar macaque is considered a crop pest, but is also listed on Schedule 1 of India's Wildlife Protection Act (Anonymous, 1993). On the island of Simeulue, *M. f. fusca* is reported to have a large population of at least 50,000 individuals, and is also considered a crop raider (Sugardjito *et al*., 1989). On Karimunjawa, *M.f. karimondjiwae* has a population of around 300 individuals that conflict with the local community (see Box 1.1). Other island populations have no data reported, and *M. f. atriceps*, for example, cannot be observed because they occur on a military occupied island in Thailand (Malaivijitnond and Hamada, 2008).

Intra-subspecific variation

A high level of morphological and genetic variation occurs within the core subspecies, *M. f. fascicularis*. This high level of variation is greater than that observed within any other macaque species (Fooden, 1995, 2006), which raises questions about the accuracy and usefulness of current subspecies categorizations. Fooden's (1995) extensive research on morphological variation showed that there is high diversity in head, body, and pelage characteristics within *M. f. fascicularis*. The variation found within the core subspecies may be most pronounced in Thailand, where there is a high level of morphological difference between regional populations (Malavijitnond *et al*., 2005). Island populations of *M. f. fascicularis* are also distinct, such as the Singaporean long-tailed macaque, which tends to be darker, smaller, and have a longer tail–body ratio (Schillaci, *et al*., 2007). Mangrove-dwelling macaques in Vietnam were found to have different body size and tail-length measurements than monkeys in Indonesia and are reported to have a characteristic "mohawk-like" hair crest pattern (Son, 2003). Studies suggest that the variation seen in body size and tail length within *M. f. fascicularis* can be accounted for by Bergmann's rule, stating body size increases with latitude, and Allen's rule, stating tail length decreases with latitude (Aimi *et al*., 1982; Son, 2003). The influence of Bergmann/Allen rules can be seen within and between subspecies, although it does not account for all variation observed and its predictions are not always supported (Fooden, 1995; Fooden and Albrecht; 1993; Schillaci *et al*., 2007). In addition, sexual dimorphism in cranial size appears to vary across geographical regions within the core area of *M. f. fascicularis* (Schillaci, 2010). An anomalous morphological distinction is the yellow long-tailed macaques in Kosumpee Forest Park in Thailand (Hamada *et al*., 2005), and there also appears to be distinct