THE POPULATION DISTRIBUTION OF PIG-TAILED MACAQUE (*Macaca nemestrina*) AND LONG-TAILED MACAQUE (*Macaca fascicularis*) IN WEST CENTRAL SUMATRA, INDONESIA

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ABSTRACT

Two macaque species, the Pig-tailed Macaque (*Macaca nemestrina*) and Long-tailed Macaque (*Macaca fascicularis*), occur sympatrically in and around the lowland and mountainous forests of the Barisan Range in the Kerinci-Seblat National Park in west-central Sumatra. We present and discuss line-transect data on the density, distribution and group size of the two macaques. *M. fascicularis* was the scarcer, found only in hill dipterocarp and lowland forests.

Keywords: *Macaca nemestrina, Macaca fascicularis*, population distribution, density, group size.

INTRODUCTION

The continuous and extensive conversion of tropical rainforests, home to the world's highest species diversity, is widely believed to be a key threat to the survival of wild populations of terrestrial and arboreal animals, including arboreal non-human primates (Eudey, 1987; Weisenseel *et al*., 1993; Laurance *et al*., 2002). It is also now believed that the local numbers of wild Pig-tailed Macaques (*Macaca nemestrina*) and Long-tailed Macaques (*Macaca fascicularis*) in Southeast Asia are continuing to decline due to habitat alteration and loss (MacKinnon, 1986). According to IUCN Red List of Threatened Species, *M. nemestrina* and *M. fascicularis* are respectively listed as Vulnerable and Least Concern (IUCN, 2008).

Both *M. nemestrina* and *M. fascicularis* have recently become seriously threatened and fragmented by human encroachment and habitat loss (from illegal and legal logging, traditional and modern crop plantations, land clearance for agriculture and new settlements/ transmigration, forest fires and droughts), as well as hunting for the illegal pet trade. Trading for export by quota for both macaque species still occurs and Sumatra is the main supply source for biomedical research (MacKinnon, 1986; Bowden & Smith, 1992). Presently, there are many cases of land conflict use between macaques and humans and, as a result, both macaque species are regarded as crop pests by farmers. Furthermore, in Sumatra, primary tropical rainforest, especially in the lowlands, have disappeared rapidly (Achard *et al*., 2002; Kinnaird *et al*., 2003; Linkie *et al*., 2004), with most of the land being converted to commercial timber concessions, or cultivated lands and human settlements (FAO, 1981; Holmes, 2001; Jepson *et al*., 2001).

To protect and manage macaque populations and their habitats effectively, the status of macaque populations in protected and unprotected areas must be evaluated continuously (Struhsaker *et al*., 1975; Wilson & Wilson, 1975a & 1975b; MacKinnon, 1986). Unfortunately, in Sumatra, there has been little effort to date to survey or census primate species, which include gibbons, langurs, macaques, slow lorises, and western tarsiers, either inside or outside of protected areas.

The Kerinci-Seblat National Park (TNKS), in the extreme west central region of Sumatra (Figure 1), is one of the Indonesian "treasure houses" of faunal and floral diversity (MacKinnon & Suwelo, 1984). It covers about 1.3 million hectares (Mha) and is the largest national park on Sumatra, and among the largest protected areas in Southeast Asia (MacKinnon, 1986). The park spans four administrative provinces: Jambi, West Sumatra, Bengkulu, and South Sumatra. Primary and secondary rainforests in the national park are occupied by *M. nemestrina* and *M. fascicularis* and five other arboreal primate

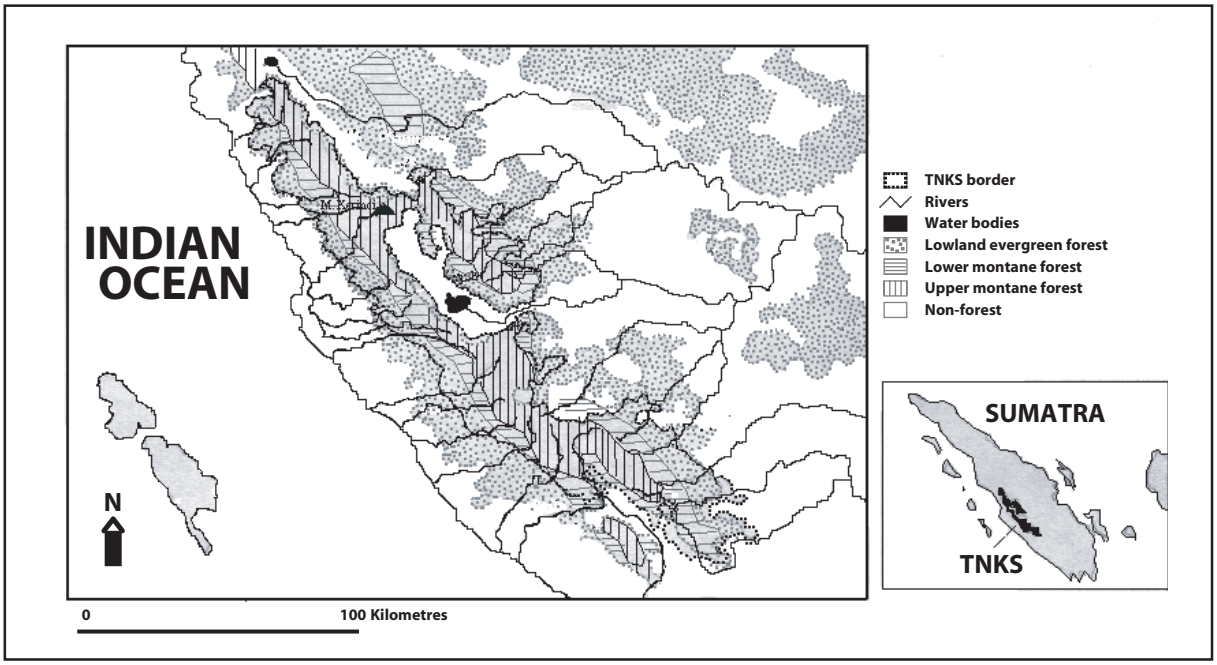

Figure 1. Map of Kerinci-Seblat National Park / Taman Nasional Kerinci-Seblat (TNKS) showing surveyed habitat types.

species (Siamang, *Symphalangus syndactylus*; Agile Gibbon, *Hylobates agilis*; Banded Langur, *Presbytis melalophos*; Silvered Langur, *Trachypithecus cristatus*; Slow Loris, *Nycticebus coucang*), in addition to being an important habitat for many other endangered species.

We examined the population status and distribution of macaques in TNKS by direct observation and line transect methods in four different habitat types (lowland, hill dipterocarp, sub-montane and montane forests), at varying elevations.

STUDY SITES AND METHODS

1. Study Sites

Survey routes were designed to cover a variety of habitat types inside and outside of TNKS. A total of 25 sites were surveyed (Figure 2, Table 1), of which most have never been visited by other researchers. Only 20% of the total area of TNKS is lowland forest <600 m above mean sea level (amsl). Nonetheless, most survey sites were within TNKS and in lowland evergreen forests, because lowland forest is currently believed to be the habitat type most seriously threatened by a variety of human activities. Several sites close to areas recently cleared for traditional and modern crop plantation as well as sites in selectively-logged forests within or near TNKS were also chosen as survey priorities.

2. Methods

We employed the line-transect method to estimate the density and population status of both macaque species through direct observation. We conducted these censuses from 1996 to 1999, while simultaneously surveying for other nonhuman primates.

We derived our methods for censusing macaques from published methods (Southwick & Cadigan, 1972; Wilson & Wilson, 1975a; Burnham *et al*., 1980; Marsh & Wilson, 1981; NRC, 1981; Peres, 1999), and adapted them to the field situation. Transects were established along existing trails on hill ridges, slopes and valleys in deep forest (85.9%) and old logged forest (8.4%) and along river banks (5.6%). Existing human or animal trails/paths were used; new trails were occasionally prepared by trimming small trees. We usually avoided steeper terrain due to difficulty in detecting animals. After the transect system was established, trail lengths were measured by pacing or using a pedometer calibrated to the observer's stride. Trails were an average of 0.5-1.0 m wide in dense forest

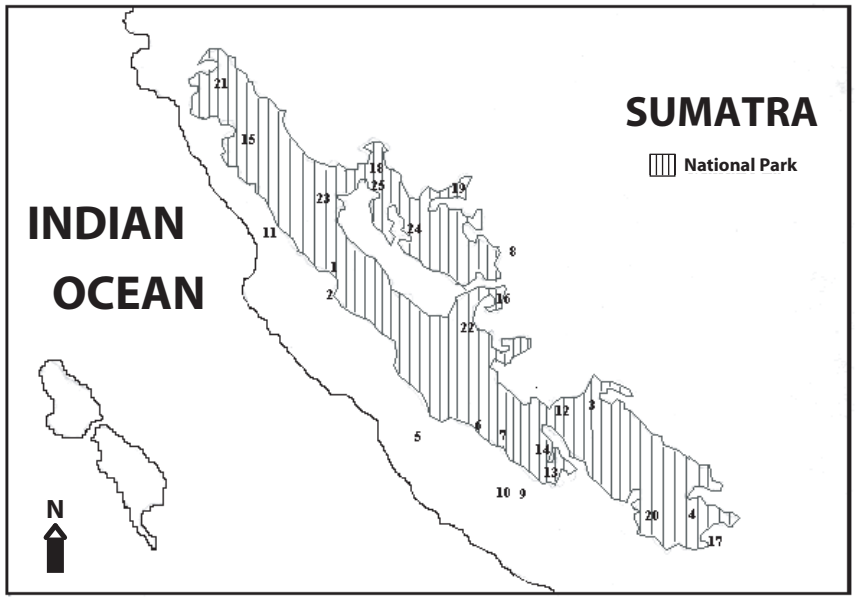

Figure 2. Map of TNKS showing survey sites.

Table 1. Site, elevation, and forest status for the 25 survey routes.

Site/habitat type	Province	Altitude (m)	Forest	Forest status
Lowland		**<450**		
Sungai Gambir	West Sumatra	250 medium	Disturbed	National Park
Sungai Melanca	West Sumatra	250 medium	Primary	Conversion
Napal Licin	South Sumatra	300 steep	Primary	National Park
Air Lakitan	South Sumatra	350 steep	Primary	National Park
Air Ikan	Bengkulu	250 medium	Disturbed	Production
Ipuh Ilau	Bengkulu	350 medium	Primary	National Park
Seblat Merah	Bengkulu	350 flat	Primary	National Park
Sungai Petekun	Jambi	250 steep	Primary	Protection
Air Santan Ketahun	Bengkulu	250 medium	Disturbed	Production
Napal Putih	Bengkulu	250 medium	Disturbed	Protection
Batang Pelangai	West Sumatra	250 medium	Disturbed	Protection
Hill		**450-900**		
B. Narso	Jambi	450 medium	Primary	Protection
Air Sulit	Bengkulu	450 steep	Primary	National Park
Air Melam	Bengkulu	450 steep	Primary	National Park
Air Langgai	West Sumatra	400 steep	Primary	National Park
Sungai Siporak	Jambi	450 medium	Primary	National Park
Bukit Kelam	South Sumatra	500 steep	Primary	National Park
B. Asam-Suir	West Sumatra	500 steep	Primary	National Park
Sungai Sebiang Bungo	Jambi	450 steep	Primary	National Park
Submontane		**900-1400**		
Air Dingin	Bengkulu	900 medium	Primary	National Park
Ngalau Gadang	West Sumatra	1100 steep	Primary	National Park
Air Hangat	Jambi	900 steep	Primary	National Park
Montane		**1400-2400**		
Betung Mudik	Jambi	1600 steep	Primary	National Park
Pelayang Gedang	Jambi	1500 steep	Primary	National Park
Danau Tujuh	Jambi	2100 steep	Primary	National Park

and 1.0-1.5 m wide in secondary forest, but trails were wider in recently logged forests as they followed old logging roads.

The average trail length surveyed on a given day was 2.6 km (range = 1.6-4.8 km). We walked slowly (average speed <1 km/h) with a local field assistant familiar with the terrain and the local wildlife. We frequently stopped for several minutes to listen for animal sounds, or when we encountered primates, to determine the group size and group spread. We started the census walk in the morning between 06:30 and 07:30 and finished by the middle of the day.

To estimate primate densities, it was first necessary to estimate the effective width of the strip surveyed (effective strip width, or ESW) (Marsh & Wilson, 1981; NRC, 1981; Peres, 1999). We estimated the maximum reliable detection distance (1/2 ESW) for density calculations for each species and habitat type using two methods: King's method, based on the "animal-to-observer", or direct distance, and Kelker's method, based on "animal-to-nearest trail", or perpendicular distance. In both methods, the maximum reliable distance is determined from the frequency-distribution curve of sightings, which generally shows an obvious plateau, followed by marked drop in frequency (Marsh & Wilson, 1981; NRC, 1981; Garcia, 1993; Brugiere & Fleury, 2000). We planned to estimate the maximum reliable detection distance as the last distance category before a drop of at least 50% in sighting frequency (NRC, 1981). Maximum reliable perpendicular, and the direct distance were then used to estimate the ESW.

RESULTS

1. Detection Distance and Effective Strip Width (ESW)

Because few sighting-distance data were collected for either macaque species, the cut-off cannot be shown in the histogram distribution of perpendicular distance (Figure 3a and b). Thus, we used the maximum distance at which they were sighted rather than maximum reliable distance to estimate ESW.

A. Maximum reliable animal-to-trail or perpendicular distance

The maximum perpendicular detection distance recorded for *M. nemestrina* was 20 m in montane forest (mean = 10.5, sd = 7.7, n = 2) thus ESW was computed as 40 m. In sub-montane (mean = 17.0, sd = 7.1, n = 2) and hill dipterocarp (mean = 13.5, sd = 8.0, n = 11) forests, the maximum distance was recorded as 30 m (Figure 3a) and the ESW was 60 m for both forest types (Table 2). In lowland forest, all groups of this species were recorded within 40 m as an effective distance and its ESW was 80 m (range = 0-45 m, mean = 15.8, sd = 8.3, n = 17). *M. fascicularis* was the scarcer species and was recorded only in hill dipterocarp and lowland forests. In both forest types, animal sightings were recorded within 35 m in hill dipterocarp forest (mean = 15.7, sd = 10.2) and lowland forest (mean = 14.9, sd = 9.0).

Table 2. Effective Strip Width (ESW) used for mean density calculations.

ESW (m)	Species	
	Pig-tailed Macaque	Long-tailed Macaque
Perpendicular distance		
Montane Forest	60	-
Sub-montane Forest	60	-
Hill Dipterocarp Forest	60	60
Lowland Forest	80	60
Direct distance		
Montane Forest	60	-
Sub-montane Forest	80	-
Hill Dipterocarp Forest	80	80
Lowland Forest	80	80

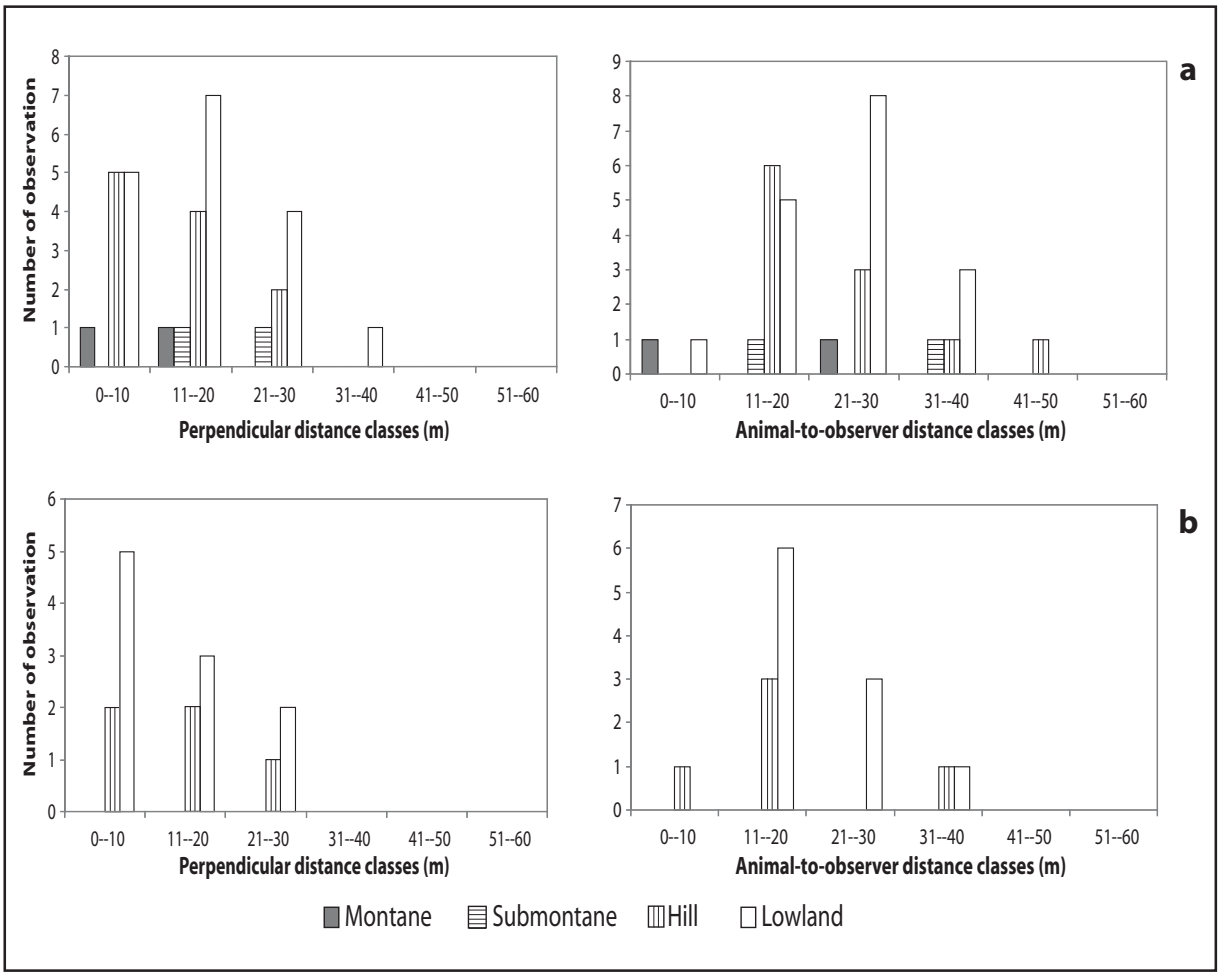

Figure 3. Observed perpendicular and animal-to-observer distance for Pig-tailed Macaque (a) and Long-tailed Macaque (b).

B. Maximum reliable animal-to-observer or direct distance

Sightings at a maximum distance of 30 m were recorded for *M. nemestrina* in montane forest (mean = 17.5, sd = 10.6). In three other forest types namely, sub-montane (mean = 22.5, sd = 10.6), hill dipterocarp (mean = 25.9, sd = 10.9), and lowland (mean = 25.6, sd = 8.1), sightings were recorded at a maximum distance within 40 m. *M. fascicularis* was recorded only in hill dipterocarp forest (mean = 19.0, sd = 9.6) and lowland forests (mean = 23.0, sd = 5.9) and had a maximum sighting of 40 m in both.

2. Pig-tailed Macaque and Long-tailed Macaque Densities

Group density estimates were calculated from data collected from a total of 311.2 km of line transects in four habitat types: lowland forests (eleven sites), hill dipterocarp forests (eight sites), sub-montane forests (three sites), and montane forests (three sites). Group densities calculated using perpendicular distance were higher than those produced using direct distance for *M. fascicularis* in lowland and for *M. nemestrina* in sub-montane and hill dipetrocarp forests (Table 3).

The estimated group densities (estimated by averaging the estimates produced using each method) for *M. nemestrina* had high densities in lowland forest (1.7 groups/km^2) and hill dipterocarp forest (1.5 groups/km^2); lower densities were found in montane (0.7 groups/km^2) and sub-montane forests (0.8 groups/km^2). *M. fascicularis* had lower densities and was found only in hill dipterocarp forests (0.5 groups/km^2) and lowland forests (1.1 groups/km^2).

3. The Distribution of Pig-tailed and Long-tailed Macaques in and around TNKS

We assessed the distribution of the two macaque species in censuses comprising 400 km of transects in 120 routes at 25 locations, ranging in altitude from 200 to 2,200 m amsl in and around TNKS forest complex. In montane forests, only *M. nemestrina* was observed. Like *S. syndactylus* and *P. melalophos*, they were observed at all elevations (from sea level to 1,900 m amsl) although seldom in montane and sub-montane forests, and most sightings in hill dipterocarp and lowland forests. The average elevation used by the Pig-tailed Macaques in and around TNKS was 477 m amsl (range = 225-1,900, n = 32), estimated from 25 survey sites.

Groups of Long-tailed Macaques were absent from montane forest and scarce at higher elevations such as sub-montane forest. In Kerinci-Seblat forest complex, groups were found only in lowland and hill dipterocarp forests (at six locations), and not above 800 m amsl. The maximum elevation for this species was at Air Hangat at 700 m amsl and its mean elevation was 382 m amsl.

4. Macaque Group Sizes

We recorded macaque group whenever they were sighted. The average group size of both macaque species was much larger than those found in *S. syndactylus*, *H. agilis* and *P. melalophos* in Kerinci-Seblat. In hill dipterocarp forest, *M. nemestrina* had an average group size of 10.5 individuals (range = 1-20 individuals, SE = 1.6, n = 11), larger than in montane, sub-montane and lowland forests (Figure 4). In montane forests, the average group size was 7 individuals (range = 6-8 individuals, SE = 10, n = 2), whilst in sub-montane forests the average group size was 9.5 individuals (SE = 0.5, n = 2). In lowland forest, the average group size of 8.5 individuals (range = 1-13, SE = 14, n = 17) being slightly smaller than in sub-montane forests and slightly larger than in the montane forests.

M. fascicularis had an average group size (9.6 individuals; range = 1-17 individuals, SE = 2.9, n= 5) that was slightly larger in the hill dipterocarp forests than in the lowland forests (9.0 individuals; range = 4-16 individuals, SE = 1.4, n = 10) (Figure 4).

DISCUSSION

Both *M. nemestrina* and *M. fascicularis* were rarely seen in any of the habitat types in and around Kerinci-Seblat National Park (TNKS) and, as a result, low densities were observed for both in this study. *M. fascicularis* is usually most abundant in swamp forest (Crocket & Wilson, 1980), and Chivers and Davies (1978) reported that this species has high densities in riverine and edge habitat in peninsular Malaysia. Furthermore, the densities of *M. nemestrina* were markedly lower in all habitats types than those reported for peninsular Malaysia (Chivers & Davies, 1978).

Table 3. Group density estimates for Pig-tailed Macaque and Long-tailed Macaque in and around Kerinci-Sablat National Park.

Habitat type	N		km² surveyed		Density ± SE (groups/km²)	
	Pig-tailed Macaque	Long-tailed Macaque	Pig-tailed Macaque	Long-tailed Macaque	Pig-tailed Macaque	Long-tailed Macaque
Reliable primate-to-trail						
Montane	2	0	2.9	0	0.7 ± 0.8	-
Submontane	2	0	2.2	0	1.0 ± 1.0	-
Hill dipterocarp	11	4	6.3	6.3	1.7 ± 0.5	0.6 ± 0.3
Lowland	17	10	9.8	7.3	1.7 ± 0.9	1.3 ± 0.4
Reliable primate-to-observer						
Montane	2	0	2.9	0	0.7 ± 0.5	-
Submontane	2	0	2.9	0	0.7 ± 0.7	-
Hill dipterocarp	11	4	8.4	8.4	1.3 ± 0.3	0.4 ± 0.2
Lowland	17	10	9.8	9.8	1.7 ± 0.5	1.0 ± 0.3

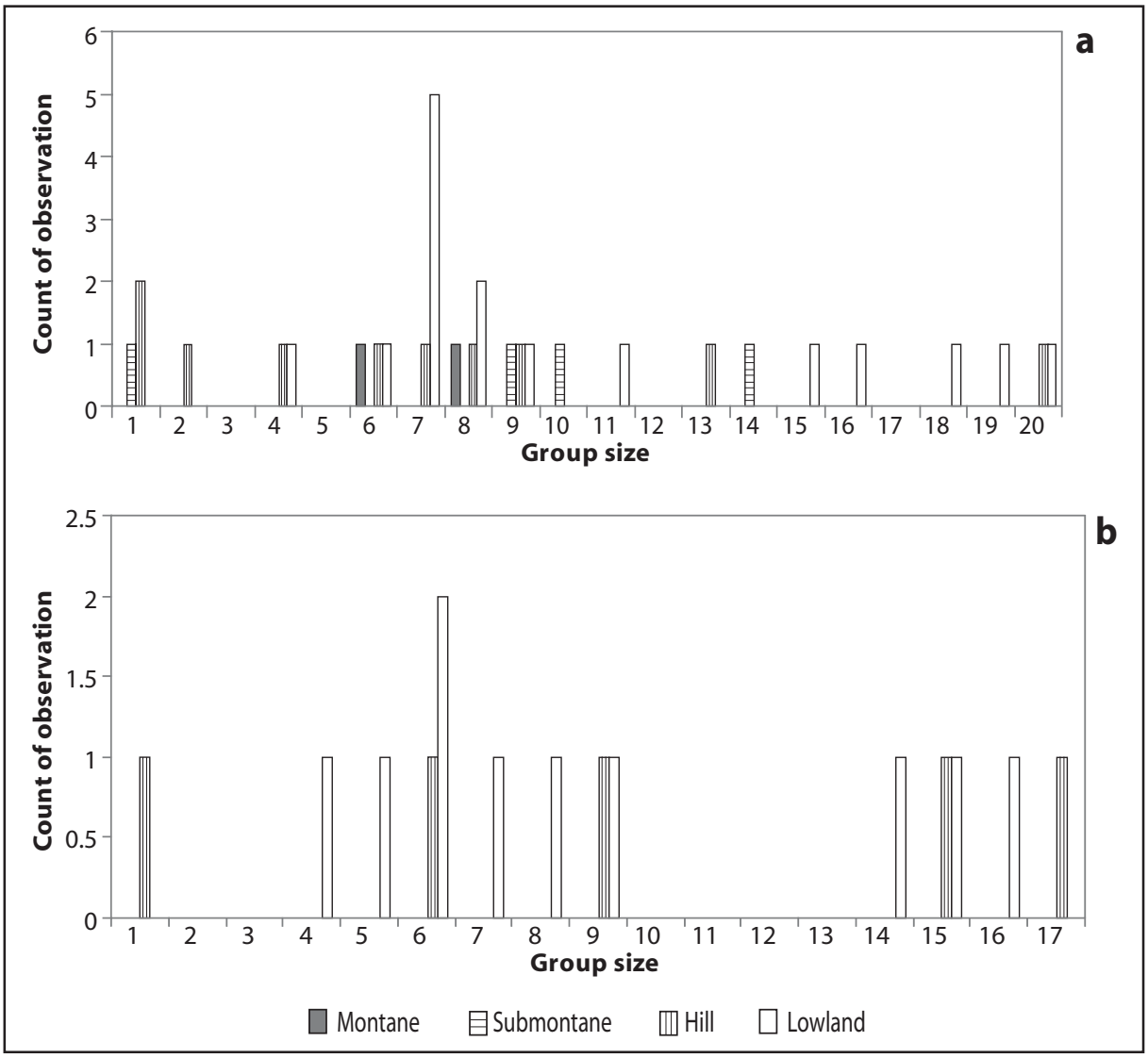

Figure 4. Group size for Pig-tailed Macaques (a) and Long-tailed Macaques (b) in montane, sub-montane, hill dipterocarp, and lowland forests.

Although semi-terrestrial, *M. nemestrina* is hard to study in the field (Marsh & Wilson, 1981; Robertson, 1986). The highest densities of this primate found at TNKS were in the lowland and hill dipterocarp forests (Table 4). The densities observed seemed less than those reported in 1970s by Rijksen (1978) at the Ketambe study area, Gunung Leuser National Park. Wilson and Wilson (1976) observed higher population densities of *M. nemestrina* throughout Sumatra than that observed in the TNKS' primary lowland forest, and at 25.5 range of group densities of *M. nemestrina* in the Krau Game Reserve in peninsular Malaysia, were similar in five different habitat types, i.e. at 0.1-0.3 groups/km^2. Meanwhile, Marsh and Wilson (1981), who also studied *M. nemestrina* in peninsular Malaysia, reported mean densities of 0.1 and 0.9 groups/km^2 in lowland and swamp forests, respectively.

Like other macaques, *M. nemestrina* lives in large groups with normally 15-40 individuals and an average 23 individuals (Caldecott, 1983; Robertson, 1986). Even larger groups were observed at Lima Belas, peninsular Malaysia (Caldecott, 1983) where the increase is associated with more immature in the group.

For *M. fascicularis* at Krau Game Reserve, the highest densities were found in riverine forest, while densities were reduced in lowland and disturbed forest (Chivers & Davies, 1978). On the other hand, Marsh and Wilson (1981) found that

mean densities of *M. fascicularis* in lowland forest were higher than previously reported by Chivers and Davies (1978), but the highest densities found in peninsular Malaysia were in freshwater swamp forest (Marsh & Wilson, 1981) (Table 4). According to Crockett and Wilson (1980), who studied ecology and abundance of *M. fascicularis* and *M. nemestrina* in various habitat types in Sumatra, found that the highest group densities of *M. fascicularis* were in *Rhizophora* mangrove forest. The next favored habitat of this macaque was secondary hill dipterocarp forests, followed by mixed mangrove forest and riverine parts of the lowland forests.

In this study, group densities of *M. fascicularis* in the lowland forests were slightly higher than reported for the same habitats at the Krau Game Reserve (Chivers & Davies, 1978), but lower than those reported by Marsh and Wilson (1981) for peninsular Malaysia or for primary lowland forest in Sumatra (Crockett & Wilson, 1980). In hill dipterocarp forest, the density of *M. fascicularis* at TNKS was 85% less than that reported by Crockett and Wilson (1980) for throughout Sumatra. Crockett and Wilson (1980) found higher densities and group sizes of *M. fascicularis*, with the largest average group sizes in secondary lowland habitats. Yet, the group size average of this species in TNKS is still lower than those reported by Southwick and Cadigan (1972) in the urban areas of peninsular Malaysia.

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Table 4. Comparative densities and group size in Pig-tailed and Long-tailed macaques on Sumatra and in Malaysia.

Site	Density/km²				Group Size		Source
	Pig-tailed		Long-tailed		Pig-tailed	Long-tailed	
	Group	Individuals	Group	Individuals			
TNKS							
Lowland	1.7	14.7	1.3	10.7	8.5(1-13)	9.6(1-17)	this study
Hill	1.5	15.7	0.6	6.6	10.5(1-20)	9.0(4-16)	this study
Sub-montane	1.0	5.9	-*)	-	9.5	-	this study
Montane	0.7	4.8	-	-	7.0(6-8)	-	this study
KETAMBE	-	19.0	-	-	4.04	6.4	Rijksen, 1978
SUMATRA							
Lowland	2.48	36.7	1.31	24.4	18.3(16-21)	46.0	Wilson & Wilson, 1976, Crockett & Wilson, 1980
Hill	2.24	33.2	5.26	97.8	16.0	-	Crockett & Wilson, 1980
Mangrove	-	-	6.47	120.3	21.0	13.0	Crockett & Wilson, 1980
MALAYSIA							
Swamp	0.9	-	4.8	-	-	-	Chivers & Davies, 1978; Marsh & Wilson, 1981
Lowland	0.1	-	1.4	-	-	29.8(14-70)	Bernstein, 1967; Chivers & Davies, 1978; Marsh & Wilson, 1981
Urban	-	-	-	-	-	24.0(7-44)	Southwick & Cadigan, 1972
KRAU GAME RESERVE							
Disturbed	0.1	-	0.6	-	-	-	Chivers & Davies, 1978
Riverine	0.3	-	1.4	-	-	-	Chivers & Davies, 1978
Lowland	0.3	-	0.2	-	20.0	24.0	Chivers & Davies, 1978
Hill	0.2	-	-	-	-	-	Chivers & Davies, 1978
Sub-montane	0.3	-	-	-	-	-	Chivers & Davies, 1978
LIMA BELAS ESTATES	-	15-40	-	-	50.0(45-55)	-	Caldecott, 1983

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