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Current Situation and Status of Long-tailed Macaques (*Macaca fascicularis*) in Thailand

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ABSTRACT.– Long-tailed macaques (*Macaca fascicularis*) are the most frequently encountered primate in Thailand. They are currently considered at low risk for extinction, however, they are threatened by habitat fragmentation or loss, inbreeding or outbreeding depression and hybridization. At present, no management measures have been taken and updated information on their situation and status are urgently needed. We sent questionnaires throughout Thailand to a total of 7,410 sub-districts, and received 1,417 (19.12%) replies. We traveled to the sub-districts from which the positive replies to questionnaires on macaques were obtained, from December 2002 to December 2007 and found long-tailed macaques in 74 locations which ranged from the lower northern and northeastern (*ca.* 16° 30´ N) to the southernmost part (*ca.* 6° 30´ N) of Thailand. The distribution of long-tailed macaques at present is similar to that reported 30 years ago, but their habitats have changed from natural forests to temples or recreation parks. On average, 200 monkeys per location were counted and some populations had more than 1,000 individuals. In some locations they were regarded as pests. Local authorities took short-term management measures such as translocation and contraception. Although many troops of Thai long-tailed macaques have inflated population densities, some local troops exhibited morphological, genetic and behavioural uniqueness that may be important to conserve. Therefore, management plans and conservation strategies should be established for Thailand's long-tailed macaque population.

KEY WORDS: Human-macaque conflict, Hybridization, Long-tailed macaques, Thailand, Translocation, Wildlife management

INTRODUCTION

Long-tailed macaques (*Macaca fascicularis*) have the third most widespread geographical distribution among primates, after humans and rhesus macaques (*M. mulatta*) (Fooden, 1995). They are distributed over a wide area of Southeast Asia, including the Indo-Malay Peninsula and islands of Indonesia, Malaysia and the

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Philippines (Fooden, 1995). They inhabit a wide variety of habitats, including primary lowland rainforests, disturbed and secondary rainforests, and riverine and coastal forests of nipa palm and mangrove. Typically, they have been observed in the disturbed habitats and the forest periphery. They adapt well to human settlements and are considered sacred animals at some Buddhist and Hindu temples and pests where they damage farms and villages (Aggimarangsee, 1992; Fooden, 1995).

In Thailand, long-tailed macaques are the most frequently observed species among the 13 species of primates in Thailand (Lekagul and McNeely, 1988). This reflects their wide adaptability to various ecological conditions. Presently humans have invaded and disturbed the natural habitats of primates by forest destruction, establishing vast agricultural fields, new road construction and widespread encroachment, greatly impairing and fragmenting habitats. Populations have been isolated from each other, and the risk of inbreeding depression has increased. Additionally, anthropogenic habitat alteration has forced long-tailed macaques to share habitat with humans.

There is little information on the status of long-tailed macaques in Thailand (Fooden, 1971; Aggimarnagsee, 1992). The most up-to-date information was published in 1992 and focused on semi-tame troops of macaques living near human habituations (Aggimarangsee, 1992). Many troops of Thai long-tailed macaques are locally overcrowded (a high number of macaques in a limited habitat area), conflict with humans, and hybridize with other macaque species (Malaivijitnond et al., 2005; 2007a). Interspecific matings can disrupt co-adapted gene complexes in hybrid individuals reducing their fitness and polluting the hybrid population (Allendorf and Luikart, 2007). These problems are increasing and no management plan has been set up. Moreover, there are no reports on the current situation and status of Thai long-tailed macaques and their impact on humans. To better understand the Thai long-tailed macaque population, we collected data on the distribution and status of local troops and the habitat conditions of long-tailed macaques living close to humans throughout Thailand by questionnaires and direct field surveys.

MATERIALS AND METHODS

1. Questionnaire Survey

A questionnaire regarding 13 species of non-human primates in Thailand (Lekagul and McNeely, 1988) was sent with a brochure and stamped envelope to the leader (Kamnan) of each sub-district (Tambon). The questionnaire is translated from Thai into English in Appendix. 1. The questionnaires were sent throughout Thailand to a total of 7,410 Tambons. After receiving questionnaires, we classified locations that had a reported presence of primates in the areas (the positive reports) and mapped the distribution of five species of macaques in Thailand. We traveled to locations that had a reported presence of one of the five species of macaques, especially for long-tailed macaques.

2. Field Survey

We traveled to the Tambons where macaques were reported between December 2002 and December 2007. We recorded the location, geographical coordinates, macaque

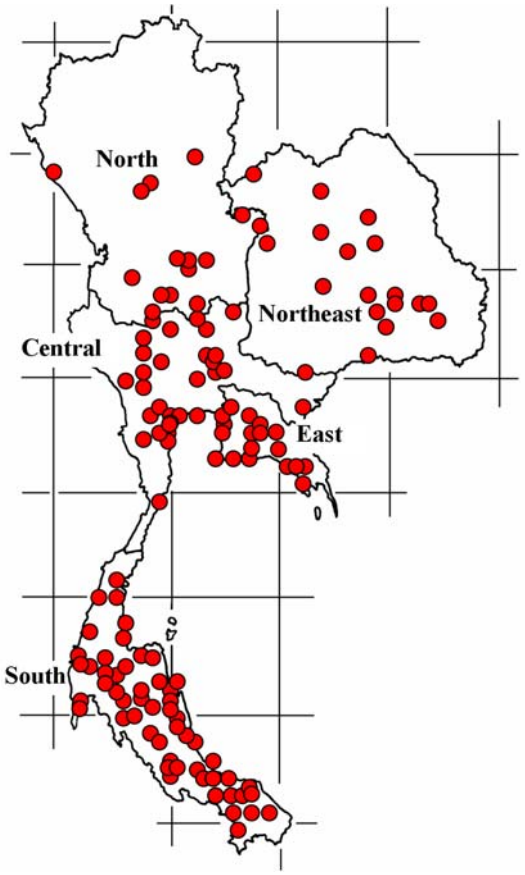

FIGURE 1. The distribution of long-tailed macaques in Thailand based on the information from questionnaires returned.

sub-species or species present, hybrid, population size, the release of heterospecific or conspecific macaques to the troop, history of the troop, impact to and conflict with humans, habitat types (natural forest or anthropogenic), morphology and behavior. Photographs were also taken for later analysis and archival reference. The duration of observation in each location varied between half a day and a week. Some locations were visited more than once. At each location, we interviewed Kamnan, senior local people, or forest rangers.

The morphological characters, e.g., patterns of crest, crown, direction of hair at the cheek, pelage colour, body size and tail length, swelling and reddening of sex skin in female monkeys, were observed. The swelling of sex skin at the base of the tail in female long-tailed monkeys were evaluated utilizing the scoring systems of Engelhardt et al. (2005). They classified swellings into five different categories and ranged from 0 to 4, defined as follows. 0: no swelling; 1: slight, even swelling of the tail root; 2: prominent, even swelling; 3: prominent swelling with small lateral lumps; 4: prominent swelling with big lateral lumps. Based on our previous report (Malaivijitnond et al., 2007b), another type of sexual swelling in the inguinal region of pubertal female long-tailed macaques was also examined.

Species and subspecies identification was based on morphological characters. *Macaca f. fascicularis* and *M. f. aurea* subspecies are identified by the trans-zygomatic and infrazygomatic pattern of cheek hair, respectively (Fooden, 1995). *Macaca f. fascicularis* is distributed throughout Thailand and *M. f. aurea* is distributed in western and southern Thailand along Myanmar and the Andaman Sea Coast (Fooden, 1995). The species-specific characters of long-tailed macaques are relative tail length (tail length/ crown-rump length) $>100\%$, crests at the crown and the swelling at the base of tail in female monkeys (Fooden, 1995). A bipartite pelage colour pattern, conspicuously lighter and more reddish and yellowish on the lower back than on the upper back, relative tail length of 35-65%, posteriorly directed crown hairs and the large area of reddening of sex skin in female monkeys are the species-specific characters of rhesus macaques (Fooden, 2000; Hamada et al.,

TABLE 1. The numbers of questionnaires (Qs) sent to and returned from the five regions of Thailand.

Region	No. of provinces	No. of Qs sent	No. of Qs returned (% of Qs sent)	No. of Qs with no primates (% of Qs returned)	No. of Qs with primates (% of Qs returned)	No. of Qs surveyed (% of Qs with primates)	No. of Qs with misidentification (% of Qs surveyed)
North	16	1488	226 (15.19%)	108 (47.79%)	118 (52.21%)	51 (43.22%)	11 (21.57%)
Central	19	1520	278 (18.29%)	150 (53.96%)	128 (46.04%)	65 (50.78%)	35 (53.85%)
Northeast	19	2795	642 (22.97%)	371 (57.79%)	271 (42.21%)	134 (49.45%)	59 (44.03%)
East	7	479	96 (20.04%)	38 (39.58%)	58 (60.42%)	17 (29.31%)	11 (64.71%)
South	14	1128	175 (15.51%)	45 (25.71%)	130 (74.29%)	45 (34.62%)	8 (17.78%)
Total	**75**	**7410**	**1,417 (19.12%)**	**712 (50.25%)**	**705 (49.75%)**	**312 (44.26%)**	**124 (39.74%)**

2006). The relative tail-length of Assamese macaques in Thailand is similar to those of rhesus macaques, but they have no such bipartite pelage colour pattern (personal observation). Pig-tailed macaques have golden brown-agouti hairs around the mid-dorsal region of the trunk with lighter colour on the underparts, slender tail and a dark brown crown patch (Fooden, 1975). Stump-tailed macaques have long, silky hairs and the pelage colour varied widely from red to brown to black. The newborn infants of stump-tailed macaques have a unique pale pink face and whitish pelage colour (Fooden, 1990; Malaivijitnond and Hamada, 2005). Monkeys with morphological characters intermediate between at least two macaque species were identified as hybrid.

RESULTS

1. Information from the questionnaire survey

The questionnaires were sent to 7,410 Tambons in 75 provinces, which is separated into five regions: North, Northeast, Central, East and South. The largest numbers of questionnaires were sent to the northeastern region (2,795 Tambons) and the smallest to the eastern region (479 Tambons; Table 1). A total of 1,417 questionnaires (19.1%) were returned. The largest number of questionnaires that were returned was from the northeastern region (642, 22.97%) and the smallest was from the northern region (226, 15.2%). The highest percentage of negative reports (no primates) came from the northeastern region (371, 57.8%). The highest frequency of positive replies was from the southern region (130, 74.3%). The distribution map

of long-tailed macaques in Thailand based on the replies received is shown in Figure 1.

2. Information from the field survey

We went to 312 locations that had a reported presence of one of the five species of macaques, especially for long-tailed macaques, representing 44.3% of the positive reports of the presence of primates in the areas (Table 1). Most surveys were conducted in the northeastern and central regions (134 and 65 Tambons or 49.5% and 50.8%). At some locations we found the local people had misidentified the macaque species presence. The frequency and nature of misidentification varied between regions. In all five regions, mainly in the northeastern and central regions, long-tailed macaques were often misidentified as rhesus macaques (Fig. 2A). In the northern and central regions, Assamese macaques were mainly misidentified as rhesus macaques, and one location in the northern region identified them as long-tailed macaques (Fig. 2B). In the northeastern region, a misidentification between rhesus and pig-tailed macaques was also found in nine locations (Fig. 2C-D). However, the identification of macaque species by southern people was mostly correct; only 8 of 45 questionnaires (17.8%) showed a misidentification (Table 1). No misidentification of stump-tailed macaques was found in those five regions.

Of the 312 Tambons surveyed, we found long-tailed macaques at 74 locations which ranged from the lower northern and northeastern (*ca.* 16° 30´ N) to the southernmost part (*ca.* 6° 30´ N) of Thailand (Table 2). In many locations, the population had several troops (2-5 troops). The most frequently encountered subspecies was *M. f. fascicularis*, at 71 of the 74 locations visited. *Macaca f. aurea* was found at only three locations of Ranong Province 9° 35 - 57´N (nos. 45, 48 and 49). The habitat types of those three locations are mangrove forests or islands located on the Andaman sea coast. It has been suggested that sub-specific hybrids between *M. f. fascicularis* and *M. f. aurea* occurred in the area around and north of the Isthmus of Kra, Ranong Province (*ca.* 10° 30´ N) (Fooden, 1995). However, we could not identify any inter-subspecific hybridization during our survey. We did not observe *Macaca f. atriceps*, which are reported by Fooden (1995) to inhabit Kram Yai Island. Currently, the island cannot be visited because it is a naval base with restricted access.

During our field surveys, long-tailed macaques were observed in primary forests, disturbed and secondary forests, riverine and coastal mangroves forests, cities, towns, villages, recreation parks, and temples. Thirty-nine of 74 locations visited were temples (or "Wat" in Thai) (Table 2 and Fig. 3). Most of these temples were near hills or forests. All eight locations visited in the north had long-tailed macaque populations around temples. Of the 39 temples surveyed, 14 were located in central Thailand (66.7%) and 12 in the south (38.7%). In the southern regions, mangrove forest was the second most frequently inhabited site after temples (12 of 31 southern locations surveyed). On average, 200 monkeys per location were counted. Five locations (nos. 9, 16, 20, 27 and 63) had more than 1,000 individuals.

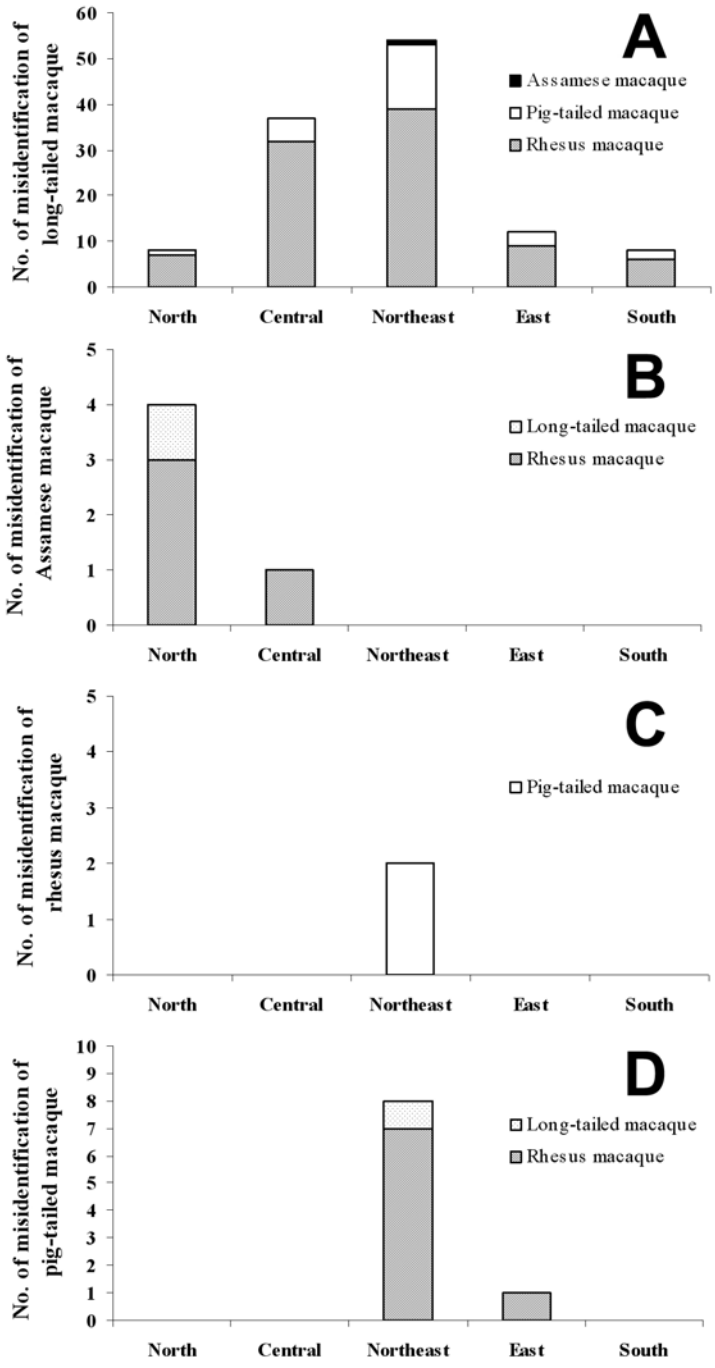

FIGURE 2. The numbers of questionnaires with misidentification of (**A**) long-tailed macaque, (**B**) Assamese macaques, (**C**) rhesus macaques, and (D) pig-tailed macaques as other macaque species.

3. Translocation of long-tailed macaques

Translocations have influenced the distribution of long-tailed macaques in Thailand. Monkeys at Wat Pa Sila Wiwek (16° 32´ N), which was regarded as the northernmost population of pure long-tailed macaques, were reported to have been translocated from Don Chao Poo Forest Park (15° 36´ N), approximately 100 km away, several years ago. They were translocated by the chief monk of Wat Pa Sila Wiwek in an effort to attract visitors to the temple. Therefore, in terms of their natural habitat, a population at location no. 8 (Wat Haad Moon Bang Kra Beau, 16° 30´ N) should be the northernmost population of long-tailed macaques in Thailand at present.

The population at location no. 44 (Nong Yai Water Reservoir, 10° 32´ N) was translocated from location no. 36 (Wat Thammikaram Worawiharn, 11° 48´ N). Location no. 36 was a recreation park on a hill, surrounded by human settlements, the sea, and a temple. Since there is limited habitat and heavy provisions by many tourists, the population at location no. 36 has become locally overcrowded. Thus, some of the monkeys were trapped and translocated by the local government. Subsequently, a native troop of conspecifics at the Nong Yai Water Reservoir faced competition for resources from the translocated troop.

4. A release of heterospecific pet macaque(s) into a troop of long-tailed macaques and hybridization.

Another potential threat to long-tailed macaques in Thailand is the release of pet macaques. Although keeping macaques as pets is illegal in Thailand, many pet

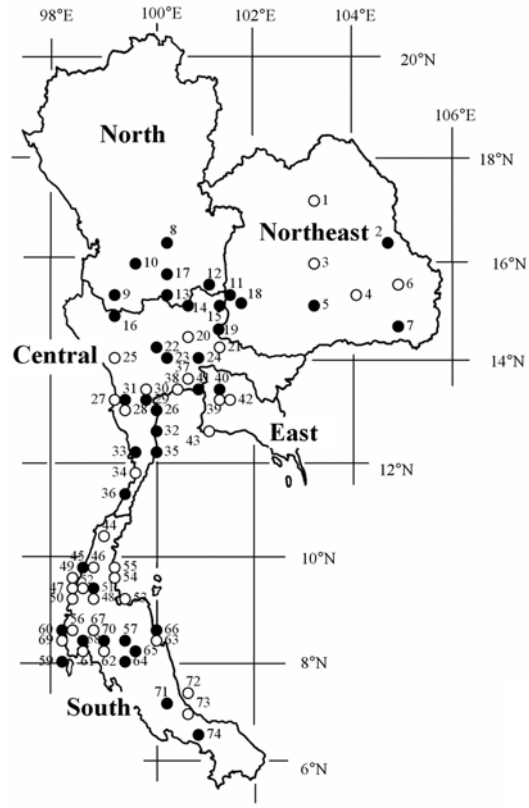

FIGURE 3. The distribution of long-tailed macaques based on the information from our field survey during December 2002 to December 2007. Dark circles indicate a temple habitat; open circles indicate other habitat types. The details of each location recorded are shown in Table 2.

macaques, especially infants, can be found. Upon reaching sexual maturity and becoming aggressive, the pet is often released. Thai people rearing pet macaques usually release them into the vicinity of wild or semi-wild macaque troops. Because long-tailed macaques can easily be seen, the pet owners released their pet macaques into those troops. We found released female pig-tailed macaques in location nos. 10 (Wat Tasang Tai), 20 (San Prakan), and 38 (Khao Sam Muk). A released female stump-tailed macaque was also found in location no. 20.

TABLE 2. Names and geographical coordinates obtained using the Global Positioning System (GPS) for long-tailed macaques found in Thailand. Wat, Ban, Khao and Koh stand for temple, village, mountain or hill and island, respectively, in Thai.

Region		Name of Location	GPS (N, E)	Number counted	Duration of observation	Estimated number of troops
Northeast	1	Kumpawaphi City Park	17° 06´, 103° 01´	130	29 August 03	2
(7 locations)	2	Wat Pa Sila Wiwek	16° 32´, 104° 43´	46	11 July 04	1
				30	11 October 04	1
	3	Kosumphi Forest Park	16° 15´, 103° 04´	287	27-30 March 03	3
	4	Don Chao Poo Forest Park	15° 36´, 104° 50´	378 (600)*	11 October 04	3
	5	Wat Kupra Kona	15° 33´, 103° 49´	87	11 July 04	3
	6	Muangling Ban Whan	15° 22´, 104° 10´	119	12 October 04	>1
	7	Wat Ban Muangkhaen Potharam	15° 21´, 104° 13´	88	12 October 04	2
North	8	Wat Haad Moon Bang Kra Beau	16° 30´, 100° 16´	60	20 January 07	1
				>100	23-26 April 07	2
(8 locations)	9	Wat Khao Nor	15° 57´, 99° 52´	N/A (>200)*	18-21 September 02	4
				932	5 September 03	4
	10	Wat Tasang Tai	15° 56´, 99° 57´	345	23 July 04	3
	11	Wat Paa Khao Pha	15° 47´, 101° 13´	24	16 May 03	1
	12	Wat Tham Thepbandan	15° 44´, 101° 02´	117	16 May 03	2
				177	1-4 March 04	2
	13	Wat Kriang Krai Klang	15° 44´, 100° 11´	>200	15 May 03	2
	14	Wat Khao Thong	15° 12´, 100° 24´	100*	20 January 07	1
	15	Wat Khao Wong	15° 10´, 100° 24´	73	20 January 07	1
Central	16	Wat Khao Patthawee	15° 28´, 99° 45´	234 (>1,000)*	July 04	2
(21 locations)	17	Wat Phikun-ngam	15° 16´, 100° 03´	47	22 July 04	1
	18	Wat Khao Sompod	15° 09´, 101° 16´	258 (>1000)*	4 November 07	>3
	19	Wat Khao Pra Ngam	14° 53´, 100° 37´	84 (200)*	5 November 07	2
	20	San Prakan	14° 48´, 100° 36´	850-1,100	24-25 November 07	5**
	21	Route to Jed Kod-Pongkonsao	14° 33´, 101° 05´	30	16 July 06	1
	22	Wat Kai	14° 30´, 100° 31´	82	6 September 03	2
				81	7 August 04	1
	23	Wat Hansang	14° 30´, 100° 31´	N/A	3 June 04	N/A
	24	Wat Praputthachai	14° 28´, 100° 56´	156 (>200)*	17 May 03	>1
	25	Mahidol University of Kanchanaburi Campus	14° 07´, 99° 09´	75	19 June 04	1
				N/A	27-29 September 05	1
	26	Wat Thammasala	13° 48´, 100° 06´	49	23 August 03	2
				64	20-22 February 04	1
	27	Khao Ngu Rock Garden	13° 34´, 99° 46´	>1,000	22-25 September 02 10 December 02 7 April 03	5

TABLE 2. Continues.

Region	Name of Location	GPS (N, E)	Number counted	Duration of observation	Estimated number of troops
	28 Bangtaboon Witthaya School	13° 15´, 99° 57´	36	2 January 03	1
	29 Wat Tham Khao Yoi	13° 14´, 99° 49´	45	23 July 05	1
	30 Pranakhonkhiri or Khao Wang	13° 06´, 99° 56´	N/A	22 July 05	>1
	31 Wat Khao Luang	13° 07´, 99° 55´	N/A (>500)*	15 April 05 22 July 05	5
	32 Wat Khao Thamon	13° 02´, 99° 57´	800* >500*	23 August 03 24-27 February 04	4 4
	33 Wat Khao Krachiw or Wat Banpatawad	12° 57´, 99° 54´	50	24 August 03	1
	34 Sam Roi Yot National Park	12° 07´, 99° 57´	111	16 July 05	2
	35 Wat Khao Takieb	12° 30´, 99° 59´	600* 600*	25 August 03 25-27 April 06	>1 >1
	36 Wat Thammikaram Worawiharn or Wat Khao Chong Krachok	11° 48´, 99° 48´	N/A 343	26-29 April 03 16 July 05	3
East	37 Khao Ang Luea Nai Wildlife Reserve Center	13° 24´, 101° 52´	N/A	20 December 02	1
(7 locations)	38 Khao Sam Muk	13° 18´, 10° 54´	200*	18 March 05	2
	39 Khao Khieow Open Zoo	13° 12´, 101° 03´	>100	15 April 05 20 November 05 29 July–1August 06 8 December 07	2
	40 Wat Khao Cha-ang-on	13° 12´, 101° 39´	24	17 March 05	1
	41 Wat Khao Cha-ang-on Nok	13° 06´, 101° 34´	25	17 March 05	1
	42 Small hill close to Sudthangruk Restaurant	13° 04´, 100° 52´	27	18 March 05	1
	43 Lan Hinkhong or Khao Plutaluang Monastery	12° 42´, 100° 58´	50*	18 March 05	1
South	44 Nong Yai Water Reservoir	10° 32´, 99° 12´	800*	25 March 05	>1
(31 locations)	45 Wat Paknam Pracharangsarith	9° 57´, 98° 35´	16 20	24 March 05 7-9 May 06	1 1
	46 Suan Somdet Prasrinakharin Chumphon	9° 56´, 99° 02´	9 (200)*	25 March 05 2-4 May 06	1 2
	47 Ban Koh Lhao	9° 54´, 98° 34´	100*	24 March 05	1
	48 Ngao Mangrove Research Center	9° 52´, 98° 36´	N/A 32	22 July 05 8-9 May 06	1 1
	49 Koh Piak Nam Yai and Koh Thao	9° 35´, 98° 28´	70 65	23-24 March 05 1-6 December 07	4 5
	50 Water Reservoir	9° 32´, 98° 42´	N/A	22 July 05	N/A

TABLE 2. Continues.

Region	Name of Location	GPS (N, E)	Number counted	Duration of observation	Estimated number of troops
	51 Wat Tham Silatieb	9° 31´, 99° 11´	29	18 July 05	1
	52 Eastern Marine Research Center	9° 22´, 98° 24´	N/A	22 July 05	N/A
	53 Pak Nam Laempho	9° 22´, 99° 15´	13	17 July 05	N/A
	54 Ban Pak Nam 1	9° 05´, 99° 13´	13	18 July 05	1
			N/A	29 April -1May 06	3
	55 Decha Tukhan Monastery	9° 04´, 99° 50´	300*	19 July 05	2*
	56 Koh Klang	8° 52´, 98° 21´	20*	21 July 05	1
	57 Wat Nasarn	8° 48´, 99° 22´	N/A	20 July 05	>1
	58 Wat Ban Rhiang	8° 35´, 98° 40´	N/A	21 July 05	1
	59 Wat Tham Tapan	8° 27´, 98° 31´	N/A	21 July 05	1
	60 Wat Suwankhuha	8° 25´, 98° 28´	137	10-13 May 03	2
			N/A	24 October 05	N/A
	61 Srinakharinthara Princess Garden	8° 25´, 98° 31´	20**	10 May 03	1
	62 Ban Chong Mai Kaew	8° 24´, 98° 44´	N/A	21 July 05	1
	63 Moo 4, Ban Kong Khong	8° 23´, 100° 11´	1,000*	19 July 05	>1
	64 Wat Chai Khao	8° 21´, 99° 47´	32	20 July 05	1
	65 Wat Khuhasantayaram or Wat Tham Khao Daeng	8° 14´, 99° 52´	46	30 April 03	1
				13-14 January 07	
	66 Wat Khao Kaew Wichian	8° 12´, 100° 05´	280	19 July 05	3
	67 Ban Kho-en	8° 09´, 98° 20´	N/A	24 January 05	1
	68 Monkey Bay	N/A	11*	23 October 05	1
	69 Khao Chumthong Monastery	8° 08´, 99° 52´	N/A	1 May 03	N/A
	70 Wat Thamsue	8° 07´, 98° 55´	6*	9 May 03	N/A
	71 Wat Khuha Sawan	7° 37´, 100° 5´	N/A	5 May 03	N/A
	72 Khao Chaison	7° 30´, 100° 10´	N/A	10 October 05	N/A
	73 Khao Noi/Khao Tangkuan	7° 12´, 100° 35´	>300	1-5 May 03	3
	74 Wat Khuha Phimuk	6° 31´, 101° 13´	55	5-10 May 03	2

* Number of monkeys that we could observe on the day of survey, while other individuals fled or foraged in other areas. The number in parentheses is the estimated population size.

** Reported by Watanabe et al. (2007)

N/A = population size or troop size not available. For some troops we could not see monkeys, but we confirmed the species by scrutinizing photos taken by the local people. For some troops we did not have enough time to count all individuals.

The monkeys in location no. 1 (Kumpawaphi City Park, 17° 06´ N) showed the mixed morphological characteristics of long-tailed, rhesus, and pig-tailed macaques. Based on reports from the local residents, the pig-tailed macaques in this population were released in the recent past. However, the presence of the other two species in the past is only anecdotal. Searching from a gazette printed by the local governor in an occasion of the opening ceremony of the city hall in the year 2000, it was stated that the macaque monkeys (without specifying the species) lived in the area for hundreds of years. Museum records suggest that this area is on the edge of the

range of rhesus and long-tailed macaques (Fooden 1995; 2000). During our survey, the relative tail length of monkeys in this troop varied between 60 – 100%. The pelage colour pattern in some monkeys was a bipartite pattern of rhesus macaques. Some monkeys had crests at the crown like long-tailed macaques, posteriorly directed crown hairs like rhesus macaques, or a dark brown crown patch like pig-tailed macaques.

We also observed a free-ranging troop of macaques at the Khao Khiao Open Zoo (no. 39) with morphological characters of long-tailed macaques, rhesus macaques or mixed morphological characters between these two species (Fig. 4A-C). From a survey in November 2005, one of the two troops exhibited mixed morphological characters (Troop A) whereas another showed morphological characteristics of long-tailed macaque (Troop B) about 2-3 km apart. In our interview, the veterinarian at the zoo (B. Siriaroonrat, personal communication, 2005) said that there were troops of native long-tailed macaques on that hill before the zoo was established in 1974. It is possible that pet or captive rhesus macaques were released into the troop. In December 2007, we visited the zoo again and found one adult male pig-tailed macaque in Troop A. He approached a female long-tailed macaque (identified by morphological characters) and successfully mated (Fig. 4D). The zoo's veterinarian (B. Siriaroonrat, personal communication, 2007) reported that there was a troop of wild pig-tailed macaques on another side of the hill, and they often came to the zoo area during dry season (November–April). However, no monkeys in this troop showed any morphological indications of introgression from pig-tailed macaque.

5. Special characteristics found in some populations: Diversity in Thai long-tailed macaques

A considerable number of long-tailed macaques at Kosumphi Forest Park (no.3) showed a yellow pelage, and they were called *yellow monkeys* (Hamada et al., 2005a). Yellow long-tailed macaques were also observed at location nos. 12 (Wat Tham Thepbandan), 22 (Wat Kai), and 23 (Wat Hansang), one individual in each location.

The sex skin swelling of female long-tailed macaques varied and depended on the geographical regions. The prominent sex skin swellings (level 4) at the base of the tail were observed only in the Sundaic region. Most Indochinese long-tailed macaques showed a less developed swelling (level 1-2). Populations at six locations (nos. 3, 4, 9, 26, 27 and 39), distributed in the northern (or Indochinese) region, pubertal female monkeys exhibited a swelling of sex skin which strongly resembles the male scrotum. This swelling develops bilaterally into a globular structure and is located in the inguinal region.

In location no. 65, long-tailed macaques inhabiting a hill near Wat Tham Khao Daeng were sympatric with stump-tailed macaques. Both populations of the two species depended on the same provisioned food resource. Banana, papaya, watermelon, mango, rambutan, pineapple and coconut were provisioned by villagers and pilgrims at the temple nearly every day. We previously reported our observation in May 2003 that long-tailed macaques avoided and always kept their distance from stump-tailed macaques (Malaivijitnond and Hamada, 2005). However, in February 2007 we found that these two species of macaques came closer to each other during

FIGURE 4. The morphological characters of long-tailed macaque (**A**), rhesus macaque (**B**) and mixed characters between these two species (**C**) at the Khao Khiao Open Zoo (location no. 39, see also Table2). (**D**) A free-ranging male pig-tailed macaque approached a free-ranging female long-tailed macaque living in the Khao Khiao Open Zoo area (location no. 39, see also Table2). The pair successfully mated.

grooming and playing. However, no hybrids were identified.

Monkeys at location nos. 45 and 49 exhibited a stone tool use. The habitats are islands in the Andaman Sea. Monkeys were observed using stones to crack oysters, other marine invertebrates (Malaivijitnond et al., 2007c), and nuts. Interestingly, these two populations of monkeys belong to the *M. f. aurea* subspecies. We also found another example of tool use in city monkeys at location no. 20, San Prakan, Lop Buri Province which belongs to *M. f. fascicularis* subspecies. The monkeys inserted human hair or coconut shell fiber between their

teeth, in a manner comparative to tooth flossing (Watanabe et al., 2007).

6. Conflict and mutualism between long-tailed macaques and humans

In many locations, the local people or local organizations hold a feeding party for monkeys once a year, with different names, such as a Monkey Buffet at San Prakan (no. 20) in November, a Boon Pa Khaow Ling (Boon Pa Khaow Ling=bringing food for monkeys, northeastern Thai dialect) at Kosumphi Forest Park (no.3) in April, a Monkey Palaeng (Palaeng=party, north-eastern Thai dialect) at Don Chao Poo Forest Park (no. 4) in April, a Monkey Buffet at Muangling Ban Whan (no.6) in March, and a Monkey Buffet at Khao Wang (no. 30) in January. The feeding party for monkeys at Lop Buri has become an internationally renowned event (Fig. 5A). The main group of monkeys attending the party lives at the Prang Sam Yot shrine. The people believed that Lop Buri's monkeys are the descendants of Hanuman, the Monkey King of the mythic Hindu figure Rama, and respected and tolerated them. As in Figure 5B, people drove the cars slowly and allowed monkeys to cross the road. In addition to the positive attitude towards the monkeys, there were some negative attitudes towards the monkeys: the monkeys were chased off when they ventured inside buildings.

Interview reports indicate that monkeys at location nos. 9, 16, 20, 27, 30 and 63 damage crops and houses during the dry season when the natural foods are scarce and thus they are viewed as pests. Residents living around these populations protected their houses with metal fencing and television antennae with steel guards that block the macaques from climbing them (Fig. 5C). At location no. 30, the local governor managed the contraceptive operation for population control of long-tailed macaques during October 2005 to September 2006. However, veterinarians in Thailand are not well experienced in monkey care and management, and the methods used were based on experience with stray dogs, which are not appropriate models for long-tailed macaques. Veterinarians castrated male monkeys and implanted contraceptive drugs of steroid hormones in female monkeys. After being castrated, the adult male monkeys lost their social rank, were chased out of the troop, and lived peripheral to the troop. Subsequently, this caused more problems to the people living nearby. As for the implantation of a contraceptive drug in female monkeys, the dosage was based on human dosage with no previous reports to support whether the dosage is effective to suppress the folliculogenesis and ovulation in long-tailed macaques. In January 2007, after the project of population control was done, the author (SM) was appointed to be a committee member of the Monkey Buffet and was also consulted about this problem. Thus, she suggested an alternative way of contraception such as doing vasectomy to male monkeys instead of doing orchidectomy.

At Khao Noi/Khao Tangkuan (no.73) people were divided in their attitudes towards the monkeys. Those that established the foundation for monkeys' food and fed them once a day had a positive attitude and those that lived near the site and were disturbed by monkeys had a negative attitude. The monkeys were increasingly blamed for attacking humans, damaging crops, and raiding houses for food.

FIGURE 5. (**A**) A Monkey Buffet Festival at San Prakan, Lop Buri Province. (**B**) The people believed that Lop Buri's monkeys are descendants of Hanuman, the Monkey King of the mythic Hindu figure Rama, so people respected and tolerated them. People drove the cars slowly and allowed monkeys to across the road. (**C**) The human houses near monkey population at location no. 30 (see also Table 2) were protected with metal fencing (blue arrows) and the television antennae with steel guards (dark arrow).

DISCUSSION

Long-tailed macaques (*M. f. fascicularis* and *M. f. aurea*) adapt well to disturbed habitats and some people refer to them as a typical "weed species" (Richard *et al.*, 1989). Although these two subspecies are classified as low risk/near threatened on the IUCN Red List 2007 (IUCN, 2007), the local populations in Thailand are under different threats. These include isolation from each other, genetic pollution (hybridization and translocation), over-population and conflict with humans. From our questionnaire and field survey, we found that the present distribution of long-tailed macaques is similar to that surveyed 30 years ago (Fooden, 1995). However, the habitats of the 74 populations have been greatly changed from natural forests to temples or recreation parks. Thirty-nine of 74 locations were temples. Roughly 90% of Thai people are Buddhists, a religion that teaches great respect for the well-being of all living things. Living in the temples, the monkeys are provisioned by the monks and pilgrims, and are safe from hunting and predators (Aggimarangsee and Brockelman, 2005). For these reasons, the population of long-tailed macaques has increased 5-10 folds compared with 15 years ago (Aggimarangsee, 1992). They are now locally overcrowded and during the dry season or the period outside the pilgrimage they raid crops or human houses. They are both respected by and in conflict with humans. Therefore, the conservation and management plan for Thai long-tailed macaques will require a unique solution and should be based on up-to-date information on their status.

From the questionnaire survey, the largest number of negative replies (no monkey observed) is in the northeastern region. Most Kamnans in the northeastern region have lived long in respective sub-districts to observe the history of environmental change and the loss of wildlife. They described that local macaque populations went extinct or were exterminated about 30 years ago because of the rapid and extensive deforestation for agricultural development. As the climate in the northeastern region is seasonal and dry, the forest could not recover well (WorldClimate.com). On the other hand, most of the replies from the southern region were positive. The southern areas are mountainous and include islands, which may have prevented local residents from turning these lands into human settlements or agricultural areas.

In general, local Thai residents do not always precisely identify the species of macaque monkeys. This is one of the reasons why the pet macaques were released into the heterospecific wild or semi-wild macaque troops. Our field survey indicated that in the northeastern and central regions, long-tailed macaque tended to be misidentified as rhesus macaque. These regions lie in the midst of the postulated hybrid zone between long-tailed and rhesus macaques, at the latitude range of 15-20° N (Fooden, 1995; Hamada et al., 2006). Fooden (1964) and Hamada et al., (2006) proposed a hybridization hypothesis between rhesus and long-tailed macaques at the boundary areas based on the tail-length variation and body size. Thus, it is possible that the observed rhesus and long-tailed macaque characteristics at Kumpawaphi City Park (17° 06´ N) were the result of a long

history of interbreeding. Malaivijitnond et al. (2008) also supported a hybridization hypothesis between Thai long-tailed and Thai rhesus macaques in terms of the human ABO-blood group analysis. However, exact nature and processes of hybridization have not been elucidated, and thus, the study of their genetics using nuclear and mitochondrial DNA markers is necessary. Furthermore, Thai long-tailed and Thai rhesus macaques are not always precisely distinguished by their morphology. The morphological characters of Thai rhesus macaques, e.g. tail length and body mass, are different from those of typical (Indian and Chinese) conspecifics. The relative tail length of Thai rhesus macaques was much longer (52.30–66.20%) than the average values from China (35.30%) and India (42.50%), whereas the body size was much smaller (Hamada et al., 2005b; 2006). The bipartite pelage colour pattern of Thai rhesus macaque is not different enough for the local people to notice (Hamada et al., 2006). In addition, the northern long-tailed macaques have the shorter tails (<120%) and lighter and yellowish pelage close to that of rhesus macaques (Hamada et al., 2006; 2008). Based on their geographical location, the characteristics of rhesus macaques observed at Khao Khiao Open Zoo should be brought by the pet released, because the Zoo is located on a hill at 13° 12´ N, which is far from the "postulated hybrid zone", 15-20° N. On the other hand, two other macaque species that are sympatric with long-tailed macaques in the southern region, that is, stump-tailed and pig-tailed macaques showed extensively different morphological characters (Fooden 1975; 1990; 1995), thus the misidentification by the southern people is only 17.78% of the questionnaires surveyed. Moreover, the southern people are very familiar with pig-tailed macaques because they are used for coconut-picking. Among the five species of macaques in Thailand, stump-tailed macaques have distinct morphological characters and only their newborn infants have a whitish pelage colour (Malaivijitnond and Hamada, 2005). They are therefore the only macaque species not misidentified by local Thai people.

Currently, there are neither concrete management plans nor primatologist participation to overcome the problem of local overcrowding and conflict with humans. The local overcrowding of long-tailed macaques is a delicate matter, and to solve the problem we need public participation. In many macaque localities the local governors made short-term plans such as catching and translocating monkeys or performing contraceptive operations, without considering the consequences. The translocation may destroy the natural genetic diversity and impair the genetic integrity of the species itself (through outbreeding depression) (Frankham et al., 2002; Allendorf and Luikart, 2007). This makes it difficult to understand the evolutionary history of macaques. Inexperience in contraceptive operation, such as castration of male monkeys, can cause more problems. A castrated male monkey could lose their androgen production, aggressiveness, and social rank.

Another threat of genetic pollution is the release of heterospecific pet macaques, which was reported to have occurred in several local troops. Such releases could result in interspecific hybridization, as found in the Wat Tham Pa Mak Ho of a juvenile hybrid between a released male pig-tailed

macaque and a native female rhesus macaque (Malavijitnond et al., 2007a). As the hybrid offspring are fertile (Bernstein and Gordon, 1980), the influences of hybridization are transmitted to the following generation.

The World Conservation Union (IUCN) has listed the long-tailed macaque as one of the "100 Worst Alien Invasive Species". In fact, they are present as an alien invasive species only in a restricted area, in this case on Mauritius Island. They were introduced to Mauritius in the early 1600's and in the absence of mammal competitors or predators, they thrived (Kawamoto et al., 2008). They currently cause considerable damage to agriculture and are believed to have contributed to the extinction of forest birds (Sussman and Tattersall, 1986). It is important to note, however, that long-tailed macaques are not a biodiversity threat in their native range, as sympatric species have adapted to their presence through evolutionary time. As a result, some troops of long-tailed macaques are worth conserving.

Thai long-tailed macaques have many unique characters, e.g., yellow pelage colour, scrotum-like features, stone tool use, and tooth-flossing behaviour, which have never been reported in other long-tailed macaques. Local people can benefit from these unique characters. For example, the yellow pelage colour of monkeys in Kosumphi Forest Park is used to advertise for Monkey Buffet Festival. Most people there have a positive attitude toward monkeys and they established a plan for conservation. However, other unique characters of scrotum-like features, shell-cracking and tooth-flossing behaviour which were recently discovered have not received attention from any authorities for conservation.

In Thailand, there are pros and cons to having a troop of long-tailed macaques living close to humans. Many people benefit from the monkeys, such as banana venders, hotel owners and shop keepers, but there are also people who live near monkey populations and do not gain any economic benefits but do suffer damages. Management and conservation plans will require cooperation from various groups, including conservationists, governmental agencies, and NGO's. Educational programs are needed to raise awareness in the public, government, and conservation sectors. Education will need to focus on population management and controlling human interaction with long-tailed macaques. Particular emphasis will need to be placed on lobbying the Thai government for initiating macaque management programs that will decrease macaque over-population and alleviate human-macaque conflict, while also protecting and maintaining a healthy long-tailed macaque population. Specific strategies initially should include 1) controlling provision to and translocation of monkeys, 2) developing well-managed contraception programs, 3) curbing pet release and 4) seeking government-level protection for populations with unique characteristics.

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APPENDIX 1

The questionnaire sent to the heads of sub-districts as translated from Thai to English.

1. First name.....Family name.....
   Head of sub-district..... Address.....
   Telephone no..... Fax no.....Cell phone no.....
2. Have you ever seen the monkeys in your area or vicinity? (please mark one)

   ☐ Ever ☐ Never ☐ Other .....
3. What species of monkeys did you see? (Please refer to the attached brochure)
4. When was the last time that you saw monkeys? (Approximate date, month, year)
5. How many groups of monkey did you see?
6. How many times did you see those monkeys?
7. If you could see monkeys more than one time, was the number of monkeys that you saw for the last time increased or decreased compared to the first time?
8. How many monkeys were in each group?
9. In one group of monkeys, how many species of monkeys did you see?
10. Please give us the name of the location where you saw monkeys.
11. Please give us detailed information about the location where you saw monkeys, e.g., close to the village, in the temple, close to the agricultural area or in the forest.
12. How well have monkeys been habituated to humans? (Please mark at least one)

    ☐ When monkeys found humans, they fled away and we could not see them

    ☐ When monkeys found humans, they escaped or climbed up trees, but we could see them.

    ☐ Monkeys came to get food from humans' hands when they were provisioned
13. Where did monkeys forage for foods?
14. If we want to get more information or to perform survey, whom should we contact and how should we contact them?
15. Are there any researchers/persons who studied those monkeys? If yes, please give us the information, e.g., names of researchers and when they performed their study?
16. Have you ever seen monkeys with a name printed in the brochure that showed a different morphology from the picture in the brochure? Please tell us the details, such as body size, pelage colour, hair characters, group or solitary monkeys, colour of baby.
17. Have you ever seen other monkeys in your area or vicinity that do not appear on the brochure? If yes, what is the morphological character of those monkeys?