Table 7. Number of dung of wild cattle found in different line transect and the total distance walked. Transect line number B to 4 are in Area 1 while the transect line number 5 to 15 are in Area 2.

Line	1988		1992		1996		1998	
	Distance (km)	Wild Cattle	Distance (km)	Wild Cattle	Distance (km)	Wild Cattle	Distance (km)	Wild Cattle
15							1.125	43
14							1.700	10
13					1.300	19	1.025	29
12					1.325	9	6.475	106
11					2.000	98	3.650	27
10					2.400	70	4.120	31
9					2.000	43	3.180	19
8					1.400	28	4.400	10
7	3.000	5	3.000	22	4.400	7	4.400	0
6	2.000	4	1.730	3	2.000	1	0.200	0
5	1.750	0	2.000	9	2.000	0	0.450	0
4	6.000	13	5.900	8	5.000	3	3.000	3
3	5.650	18	5.600	9	5.000	3	3.000	0
2	5.150	10	5.000	57	5.000	6	2.775	6
1	3.000	36	3.000	19	3.000	3	2.200	1
A	4.400	27	4.350	9	5.000	18	3.000	1
B					3.200	7	2.800	4
Total	30.95	113	30.58	136	45.025	315	47.500	290

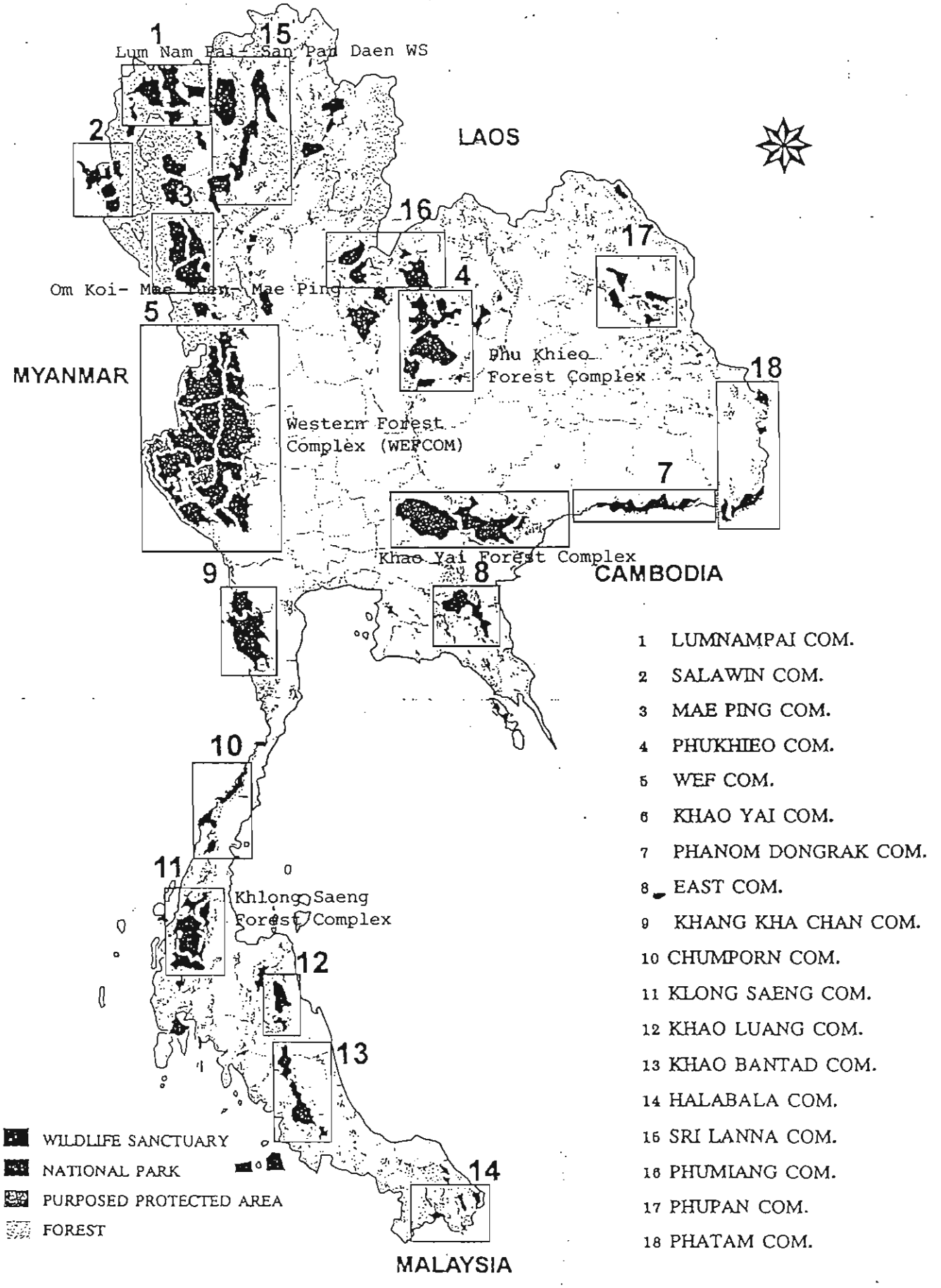

Figure 1. Map of protected areas where additional information on populations of gaur and banteng have been obtained.

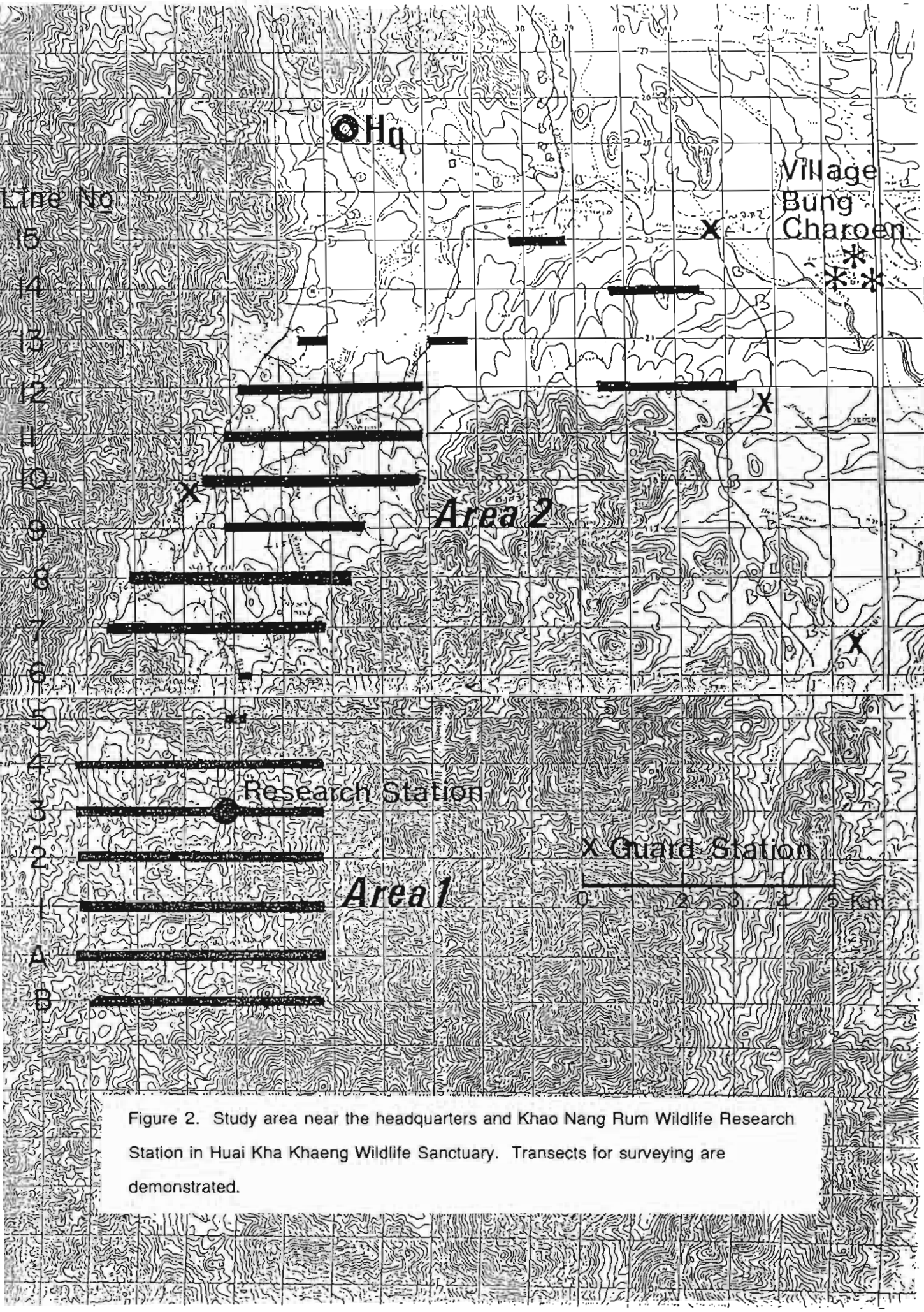

Figure 2. Study area near the headquarters and Khao Nang Rum Wildlife Research Station in Huai Kha Khaeng Wildlife Sanctuary. Transects for surveying are demonstrated.

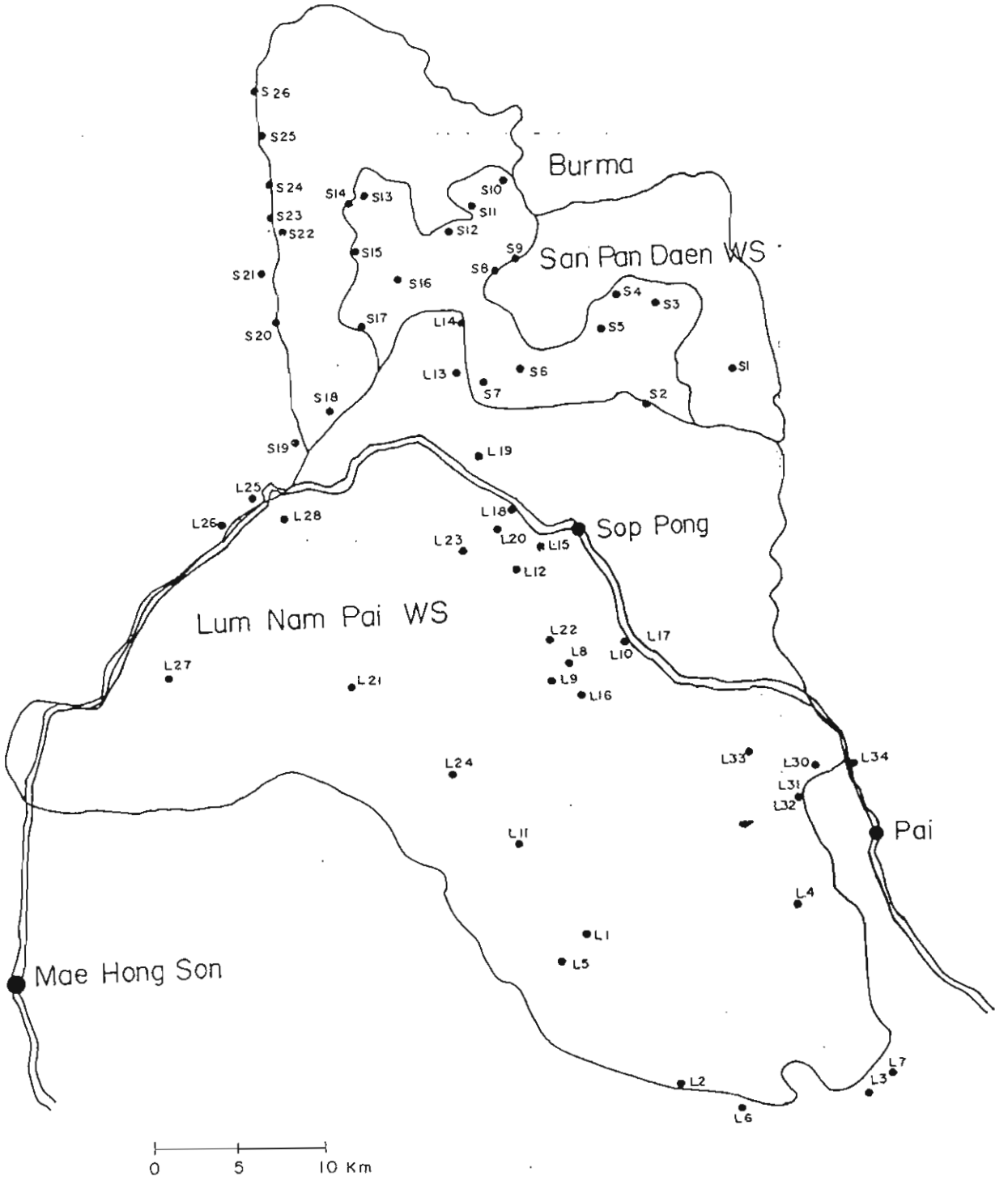

Figure 3. Villages in San Pan Daen WS and Lum Nam Pai WS where local people were interviewed. S1,S1,S3.....Sn and L1, L2, L3,...Ln are locations of villages in San Pan Daen WS and Lum Nam Pai WS, respectively.

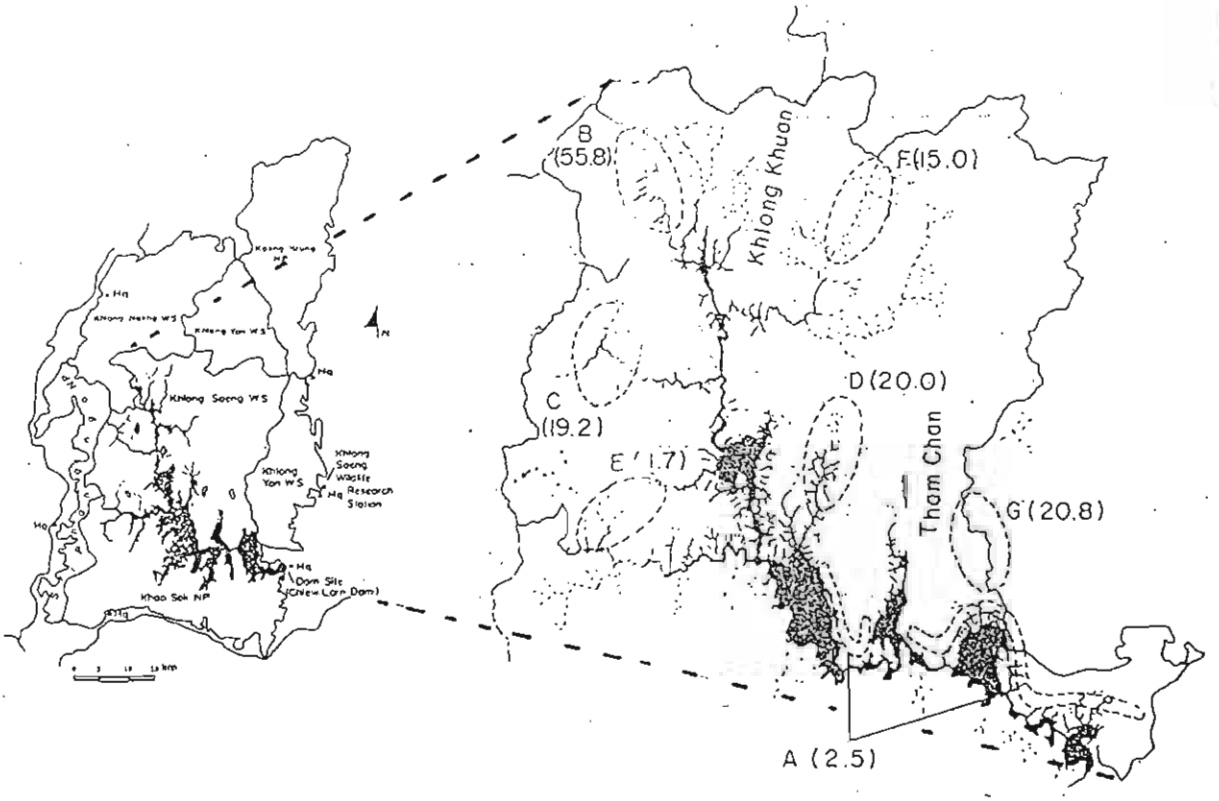

Figure 4. Seven areas in Khlong Saeng Wildlife Sanctuary that were surveyed to look at relative abundance of human signs and gaur tracks. A to G represent study sites. The numbers in brackets are per cent of 100 m-segment where gaur tracks were found. Khlong Khuan and Huai Tam Chan were areas where BHUMPAKPHAN (1997) did the study.

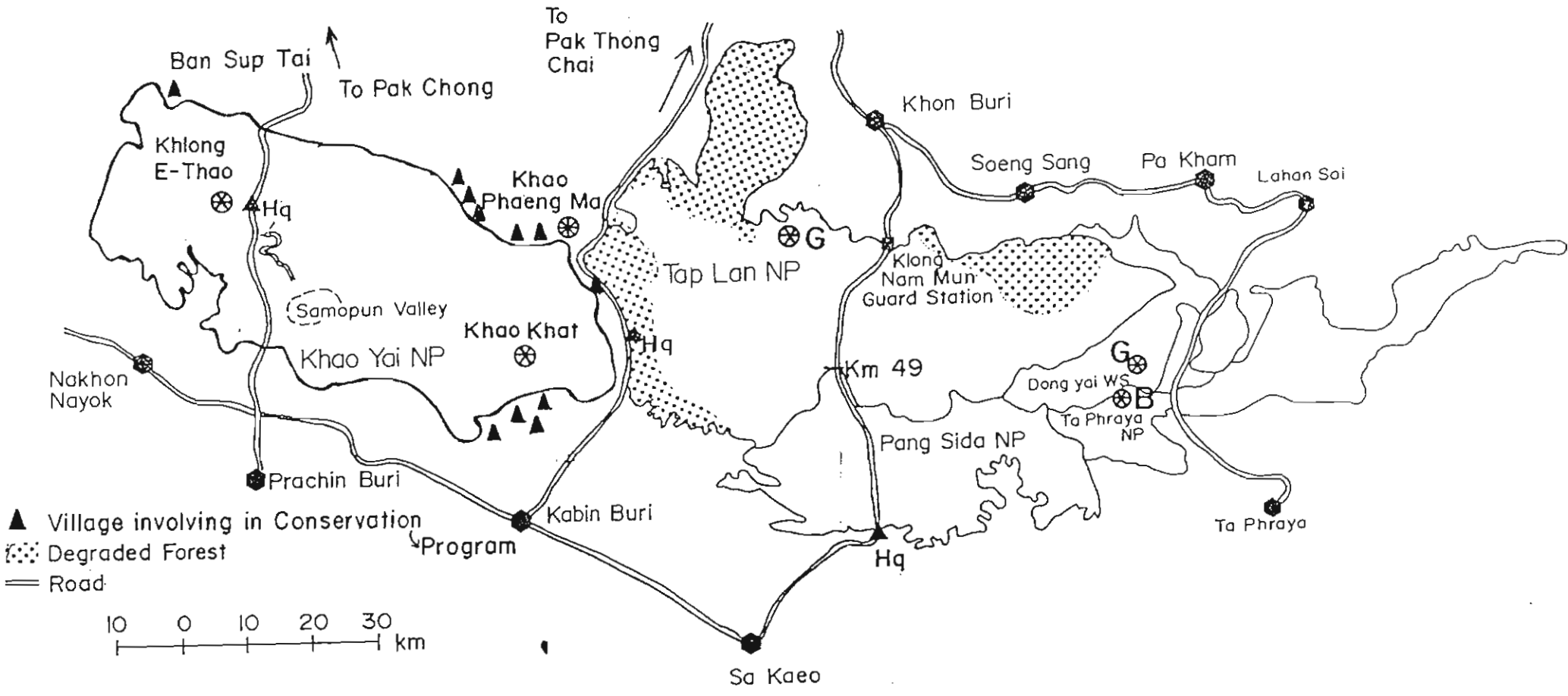

Figure 5. Protected areas in Khao Yai Forest Complex and some Important location mention in the text. Community involvement in Environmental Awareness and Development Program help the recovery of gaur population in Khao Yai NP. Viable populations were also found in Pang Sida NP and the area bordering among Pang Sida, Tap Lan NP, Dong Yai WS and Ta Phraya NP. There are few gaur left in Tap Lan NP. Banteng were found only in the area bordering between Dong Yai and Ta Phraya NP.

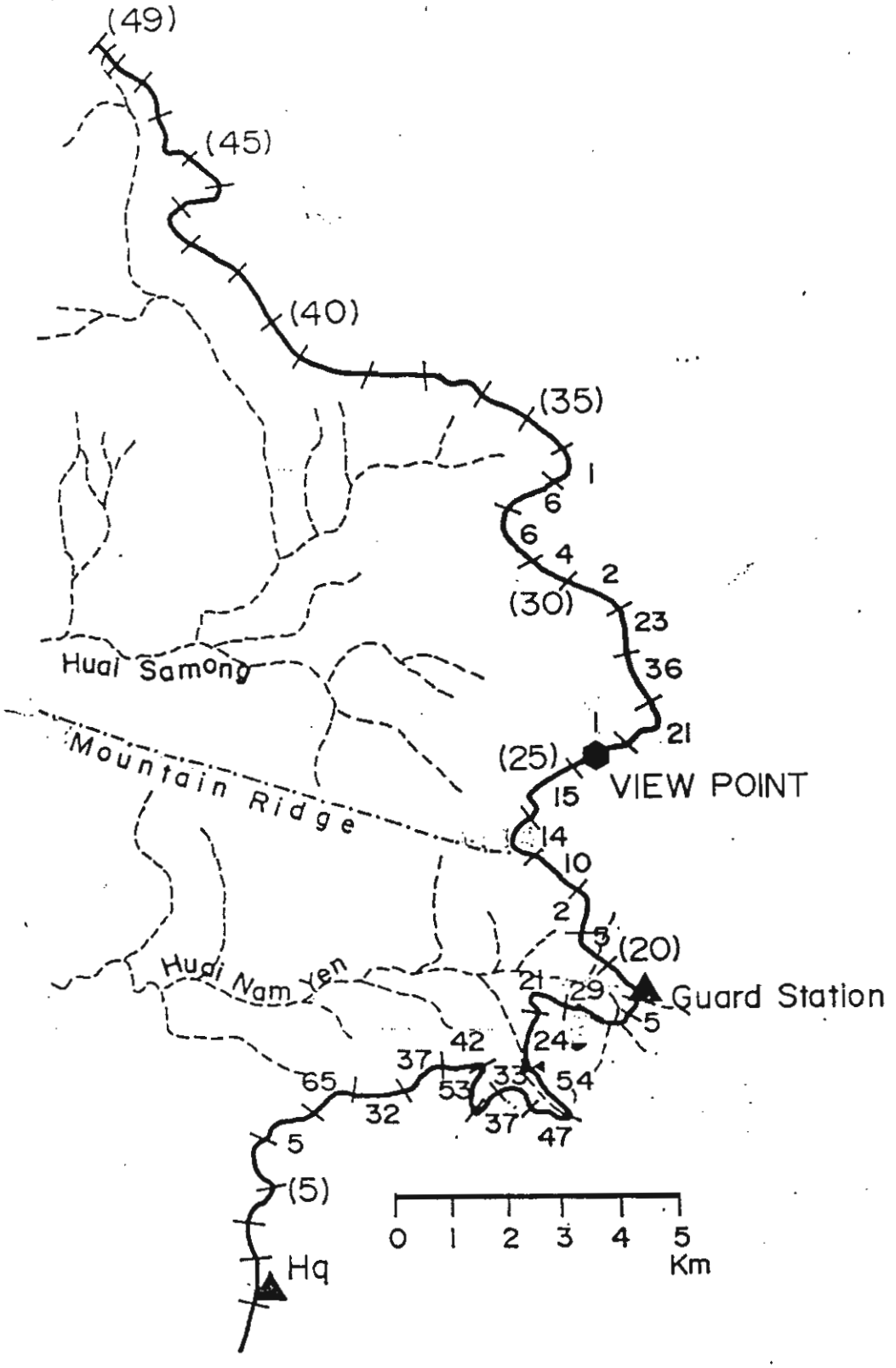

Figure 6. Distribution of dung of wild cattle in every kilometer along the road from the headquaters to km 49 in Pang Sida NP. The numbers in brackets are reference points in km. The numbers between km reference line are number of dung found.

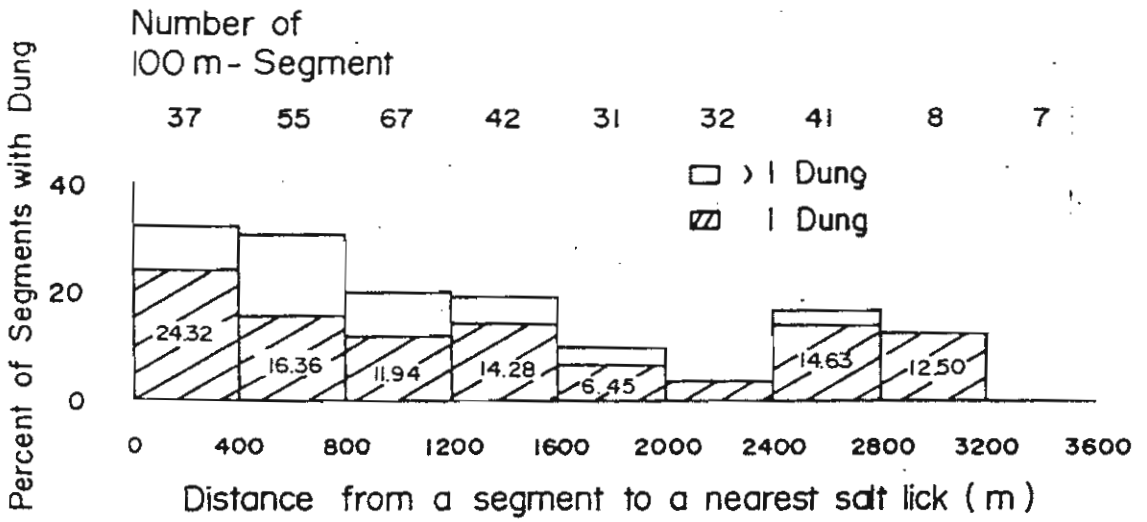

Figure 7. Per cent of transect segments with dung in relation to the distance from a segment to a nearest mineral lick.

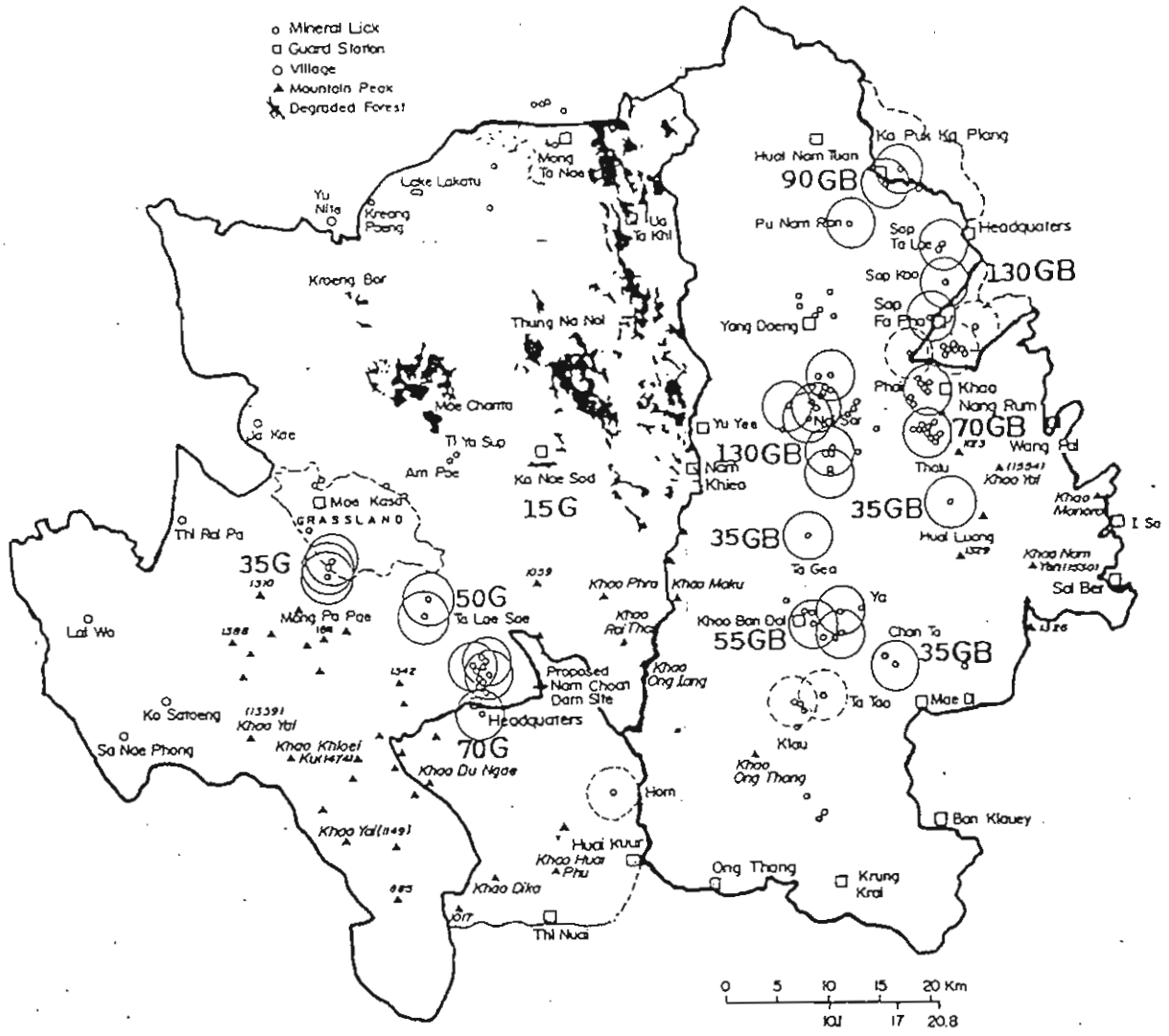

Figure 8. Distribution of populations of gaur and banteng in Thung Yai and Huai Kha Khaeng WS. The number in front of G and GB is the estimated number of gaur, and gaur and banteng combined. Area near Mong Ta Nae, Ua Ta Khi, Thung Na Noi, Ka Nae Sod and Nam Khieo in Thung Yai WS Eastern Wing were monitored by MANEERAT (1997) during Jan. 1995 and Dec. 1997.

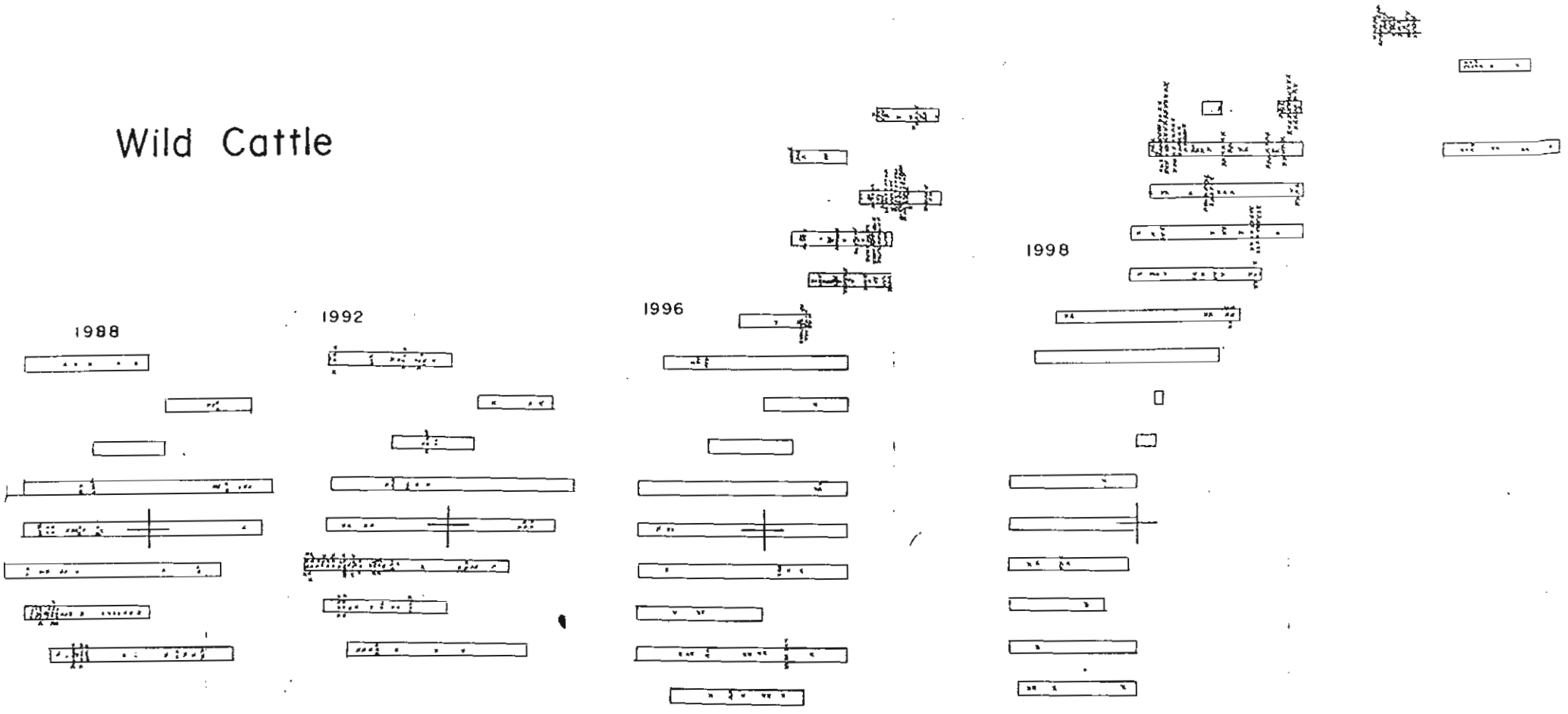

Figure 9. Distribution of wild cattle dung in a study area between Khao Nang Rum Wildlife Research Station in the northeastern side of Huai Kha Khaeng WS in 1988, 1992, 1996 and 1998. Dung are various in ages and they were possibly accumulated during the last four months before the survey. The estimate is based on the study by SRIKOSAMATARA (1993) and the study on dung deterioration rate by BHUMPAKPHAN (1997).

Relative density and distribution of large herbivores in a formerly "compression area" of a dry tropical forest, western Thailand

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ABSTARCT. After poaching activities were relaxed, relative densities of large mammals in a "compression area" are decreasing and most large mammals move to nearby area. The population of small herbivores such as barking deer fluctuate from year to year more comparing with large herbivores such as gaur, banteng and sambar deer. This is because the small herbivores are small, solitary, less mobile so that they are predated more by their natural predators like tiger and leopard. Wild pig are good colonizing species in nearby area while elephant do not colonize this nearby area as the forest is dry and little water is available so that their requirements are not fulfilled.

KEY WORDS: Asian wildlife ecology, relative density, distribution, compression area, dry tropical forest, large herbivores, Huai Kha Khaeng Wildlife Sanctuary, Thailand

INTRODUCTION

Wildlife ecology in Asia is special as it has been affected by high density of human population. In Asia, human activities affect so much on wildlife ecology even in an area that looks superficially natural. For example, destroying wildlife habitat push wildlife into a "compression area" so that their populations are high as shown in the case of elephant and other wildlife in India (Nair et al. 1977, Karanth and Sunquist 1992). Little is known about the effect of other human activities such as poaching on wildlife ecology. It is obvious that poaching will cause the wildlife population to decline and the human traffic itself will affect the distribution of animals (Griffith & van Schaik, 1993). In Asia, as conservation is getting better, there will be more and more areas where human activities such as poaching are removed. How wildlife respond to this situation is important for understanding wildlife ecology in Asia.

The purpose of this study is to examine the changes in the relative density and distribution of herbivores in an area where poaching activities used to be high. Due to a

stronger law enforcement so that there was little poaching activities, the relative densities and distributions of these herbivores were monitored to detect the pattern of changes.

STUDY SITE AND METHODS

The study site was located near Khao Nang Rum Wildlife Research Station in Huai Kha Khaeng Wildlife Sanctuary where a study on the density and biomass of large herbivores were made in 1988 (Srikosamatara 1993). The study site can be divided into 2 areas (Figure 1). Area 1 is about 25 km^2 and can be called a "compression area" as it is near a research station where a certain level of anti-poaching activities happened in 1988 while the adjacent areas in the northeastern side (Area 2) were subjected to heavy poaching pressure in 1988. Strong law enforcement started in Area 2 in 1991 (Anon., 1990; Nakhasathien & Steward-Cox, 1990). Area 2 is about 40 km^2 and is lowland and very dry during the dry season. In both areas, four major forest types are found: dry deciduous dipterocarp forest, mixed deciduous forest, dry evergreen forest and hill evergreen forest (Srikosamatara, 1993). ← Figure 1

The study was done in 1988, 1992, 1996 and 1998. Line transect methods were used to estimate the dung density (Srikosamatara, 1993). The total length of the transects walked in each line and in each area can be seen in Table 1. Dung density were calculated by program ELEPHANT developed by Dawson & Dekker (1992). Density and biomass of each species of herbivores were calculated using the same data obtained in 1988 by Srikosamatara (1993) and were summerized in Table 2. ← Table 1 ← Table 2

Other concurrent studies in the same study site were done on ecology of gaur and banteng during 1994-1996 by Prayurasiddhi (1997) and Bhumpakphan (1997) and on carnivore ecology in 1987-1988 by Rabinowitz (1989) and Rabinowitz and Walker (1991) and in 1994-1998 by Simchareon (in progress).

RESULTS

Using dung density as an indicator for population density, different species shows different pattern of density changes (Table 3). Densities of wild cattle change slightly while the densities of sambar deer increase slightly. Densities of barking deer vary a lot from year to year while the densities of wild pig and elephant are increasing.

When the study area are divided into two sub-areas. In Area 1, the densities of wild cattle are decreasing, the densities of sambar deer, barking deer vary from year to

year, and the densities of wild pig and elephant are increasing. In Area 2, the densities of all species, except barking deer, are increasing while the densities of barking deer vary a lot from year to year.

When converting the dung density to animal density and biomass for 3 species of herbivores (gaur and banteng, and sambar deer), the total biomass of these three species are more less constant (vary from 948, 938 and 835 kg km^{-2} in 1988, 1996 and 1998 (Table 4 and 5). Their biomass were decreasing in Area 1 but increasing in Area 2..

← Table 4
← Table 5

When looking at the changes in distributions through time, wild cattle moved away from Area 1 and some of them used Area 2 more and more while the distribute of sambar deer in both areas more less equally (Table 6 and Fig. 2). Elephant still used the southwestern side of Area 1 while some started to use Area 2. Wild pig were found in the edge of Area 2 while very few barking deer were found in most area.

← Table 6
← Fig. 2a
2b
2c
2d
2e

DISCUSSION

After poaching pressures were relaxed, most large herbivores move from the "compression area" to nearby areas. The changes in their densities varied from species to species. This depends on whether they are subjected to heavy predation by two large cats, tiger and leopard. Barking deer are major prey of both tiger and leopard (Rabinowitz 1989, Rabinowtz & Walker, 1991) so that their populations were heavily regulated. Other larger herbivores, e.g. wild cattle and sambar deer, are predated more when their densities are high which is similar to the situation in Royal Bardia National Park in Nepal (Stoen & Wegge, 1996). In 1995-1996, 2 gaur, one old elephant, 12 banteng and more than 20 sambar deer and many common barking deer were predated by tiger (Simcharoen, personal communication, Bhumpakphan 1997, Prayurasiddhi 1997).

As the densities of prey increase, the numbers of predator also increase but faster in this study. There was only one tiger in the study area in 1988-1989 (Rabinowitz 1989) but there were 6-8 in 1994-1996 (Simcharoen, personal communication, Bhumpakphan 1997). In 1988-1989, there were 4 leopard in the study site (Rabinowitz 1989) while there were at least 7 in 1994-1996 (Simcharoen, personal communication, Bhumpakphan 1997). The increasing in the number of leopard is not as high as the tiger as some leopard were also predated by tiger (Simcharoen, personal communication) which is also found in Royal Bardia National

Park in Nepal (Stoen & Wegge, 1996). The increasing in the number of predators may be transient as well (Karanth, 1997).

The constancy of the total biomass of three species of herbivores, gaur banteng and sambar deer, indicates the stability in multi-species assemblage of large herbivores which is similar to the study in East Africa (Prins & Douglas-Hamilton, 1990) These 3 species have great potential mobility and a capacity to form cohesive social group and contribute over 70% of the of the estimated herbivore biomass. The daily movement of gaur and banteng are about 1.0-5.7 km and 0.9-4.9 km and the gaur move about 0.6 km further than banteng on average (Prayurasiddhi, 1997). Gaur form a larger herd of up to 40 animals while the largest banteng herd is 30 (Prayurasiddhi, 1997). There is no good study of the group size of sambar deer in the study site but Varman and Sukumar (1993) reported the group size of 3.1-50 in India.

Even the density and biomass of herbivores in this area are a lot lower than in India like Nagarahole National Park (Karanth & Sunquist, 1992) but it may reflect natural density and biomass. This is because this study site is not under the strong human pressure as in Nagarahole. Other area in India like Mudumalai Sanctuary in Southern India (Varman & Sukumar, 1993) and Bandipur (Johnsingh, 1983) has lower density and biomass of large herbivores than Nagarahole but higher than this study site. The difference in the human pressure, micro-climate, natural vegetation, distribution of keystone resource like mineral lick, mammalian assemblage, and the predator-prey interaction influence the density and biomass of large mammals in an area (Fryxell & Sinclair, 1988; McNaughton, 1992) In Nagarahole, Mudumalai and Bandipur, mineral licks seem to influence very little on the distribution of large mammals, and a medium-sized deer weight about 45 kg and live in a large herd, axis deer (Axis axis Erxleben), contribute a major part of the ungulate biomass and they are the major prey of tiger (Karanth & Sunquist, 1992, 1995; Varman & Sukumar, 1993; Johnsingh, 1983, 1992). The other factor involving in prey selection is learning but the process is not well documented in tiger except in the case of man-eating tiger (Karanth, 1997). Gaur as the prey preference for tiger in Nagarahole may be exceptional as a result of learning process. In most area, prey abundance affects on the tiger food choice.

The rate of change in population density will depend on fecundity of different species but less sensitive than the adult survival rate (Gaillard, 1991). In ungulate, the multiplication rate is sensitive to adult survival rate and will increase with generation

time. Using the allomatric relationship between body size and generation time for population closed to the equilibrium level (Gaillard, 1991), the expected generation time of elephant (2700 kg), gaur (700 kg), banteng (500 kg), sambar deer (160 kg) and barking deer (20 kg) are 21.5, 14.5, 13.1, 9.4, 5.1 years. Due to predation, adult survival rate of barking deer is lower than other large mammals so that their multiplication rate is low in this study.

The movement of large herbivores from Area 1 may also due to the degradation of vegetation as the area were heavily overgrazed by the herbivores while the food in the nearby area are more plentiful. It may also due to the great traffics of human due to various research activities in Area 1 while there is less traffic in the nearby area where poaching activity used to be very high. The effect of human traffic on animal distribution have been demonstrated before by Griffith and van Schaik (1993).

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Table 1. The name, number and total distance of line transect walked in total area and each area in different year in the study site in Huai Kha Khaeng Wildlife Sanctuary. Line code can be seen in Figure 3, n represents the number of pararell line of 1 km apart.

Year	Area 1			Area 2			Total		
	Line	n	Distance (km)	Line	n	Distance (km)	Line	n	Distance (km)
1988	B-4	6	24.2	5-7	3	6.75	B-7	9	30.95
1992	A-4	5	23.85	5-7	3	6.73	A-7	8	30.58
1996	B-4	6	26.20	5-13	9	18.83	B-13	15	45.03
1998	B-4	6	16.78	5-15	11	30.72	B-15	17	47.50

Table 2. Variable to convert dung density to animal density and biomass from Srikosamatara (1993).

Species	Defecation Rate (no. day^{-1})	Age of Dung (day)	Body Weight per Unit of Animal Density (kg)
Wild Cattle	9.5	100	450
Sambar Deer	12	68	134
Elephant	16	156	2088

Table 3. Dung density (km^{-2}) of different species of large herbivores in different areas.

Year	Area 1					Area 2					Total				
	Wild Cattle	Sambar Deer	Barking Deer	Wild Pig	Elephant	Wild Cattle	Sambar Deer	Barking Deer	Wild Pig	Elephant	Wild Cattle	Sambar Deer	Barking Deer	Wild Pig	Elephant
1988	1842 (0-3804)	1469 (25-2912)	712 (68-1356)	0	220 (0-678)	555 (0-2087)	678 (0-3052)	1385 (0-7315)	273 (0-1207)	132 (0-928)	1541 (330-2752)	1359 (328-2389)	792 (0-1666)	104 (0-302)	199 (0-487)
1992	871 (0-2062)					2079 (0-5313)					1154 (227-2081)				
1996	861 (34-1688)	802 (195-1410)	160 (0-596)	0	129 (0-261)	2520 (292-4748)	3129 (809-5450)	254 (31-478)	190 (0-463)	636 (121-1151)	1336 (3-2668))	1869 (668-3070)	165 (0-388)	91 (0-230)	368 (68-668)
1998	96 (0-195)	1248 (378-2119)	770 (0-1992)	119 (0-450)	1847 (0-5883))	1683 (484-2882)	2208 (705-3712)	897 (0-2025)	459 (0-1107)	729 (27-1432)	1137 (321-1953)	1784 (758-2810)	671 (0-1441)	455 (0-1073)	1007 (0-2256)

Table 4. Density (km^{-2}) of different species of large herbivores in different areas.

Year	Area 1			Area 2			Total		
	Wild Cattle	Sambar Deer	Elephant	Wild Cattle	Sambar Deer	Elephant	Wild Cattle	Sambar Deer	Elephant
1988	1.9 (0-4.0)	1.8 (0-3.6)	0.1 (0-0.3)	0.6 (0-2.2)	0.8 (0-3.7)	0.1 (0-0.4)	1.6 (0.3-2.9)	1.7 (0.4-2.9)	0.1 (0-0.2)
1992	0.9 (0-2.2)			2.2 (0-5.6)			1.2 (0.2-2.2)		
1996	0.9 (0-1.8)	1.0 (0.2-1.7)	0.1 (0-0.1)	2.7 (0.3-5.0)	3.8 (1.0-6.7)	0.3 (0-0.5)	1.4 (0-2.8))	2.3 (0.8-3.8)	0.1 (0-0.3)
1998	0.1 (0-0.2)	1.5 (0.5-2.6)	0.7 (0-2.4))	1.8 (0.5-3.0)	2.7 (0.9-4.5)	0.3 (0-0.6)	1.2 (0.3-2.1)	2.2 (0.9-3.4)	0.4 (0-0.9)

Table 5. Biomass (kg km^{-2}) of wild cattle and sambar deerin different areas.

Year	Area 1			Area 2			Total		
	Wild Cattle	Sambar Deer	Total	Wild Cattle	Sambar Deer	Total	Wild Cattle	Sambar Deer	Total
1988	855 (0-1800)	241 (0-482)	1096 (0-2282)	270 (0-990)	107 (0-496)	377 (0-1486)	720 (135-1305)	228 (54-369)	948 (189-1694)
1992	405 (0-990)			990 (0-2520)			540 (90-990)		
1996	405 (0-810)	134 (27-228)	539 (27-1038)	1215 (135-2250)	509 (134-898)	1724 (269-3148)	630 (0-1260))	308 (107-509)	938 (107-1769)
1998	45 (0-90)	201 (67-348)	246 (67-438)	810 (225-1350)	362 (121-603)	1172 (346-1953)	540 (135-945)	295 (121-456)	835 (256-1401)

Table 6. Number of dung found in each transect in 1988, 1992, 1996 and 1998. Transect line number B to 4 are in Area 1 while the transect line number 5 to 15 are in Area 2.

Line	1988						1992		1996						1998					
	Distance	Wild cattle	Sambar Deer	Barking Deer	Wild Pig	Elephant	Distance	Wild cattle	Distance	Wild cattle	Sambar Deer	Barking Deer	Wild Pig	Elephant	Distance	Wild cattle	Sambar Deer	Barking Deer	Wild Pig	Elephant
15															1.125	43	3	7	4	0
14															1.700	10	0	9	3	0
13									1.300	19	0	1	0	0	1.025	29	3	1	20	0
12									1.325	9	0	0	0	0	6.475	106	15	2	21	0
11									2.000	98	1	1	0	5	3.650	27	46	3	5	7
10									2.400	70	1	2	5	5	4.120	31	3	1	1	3
9									2.000	43	6	1	1	14	3.160	19	33	5	0	20
8									1.400	26	14	3	5	2	4.400	10	43	1	1	5
7	3.000	5	9	2	2	2	3.000	22	4.400	7	20	1	1	19	4.400	0	5	0	0	9
6	2.000	4	0	0	4	1	1.730	3	2.000	1	14	1	0	23	0.200	0	0	0	0	0
5	1.750	0	0	11	0	0	2.000	9	2.000	0	9	1	0	2	0.450	0	0	0	0	0
4	6.000	13	7	4	0	1	5.900	8	5.000	3	10	0	0	7	3.000	3	3	0	2	1
3	5.650	18	15	6	2	0	5.600	9	5.000	3	3	0	0	3	3.000	0	12	0	0	4
2	5.150	10	9	3	0	28	5.000	57	5.000	6	8	0	1	5	2.775	6	6	1	0	2
1	3.000	36	1	6	0	0	3.000	19	3.000	3	4	1	0	1	2.200	1	3	0	0	0
A	4.400	27	1	3	0	6	4.350	9	5.000	16	1	6	0	0	3.000	1	4	1	0	5
B									3.200	7	6	0	0	7	2.800	4	3	0	0	81
Total	30.95	113	42	35	8	38	30.58	136	45.025	315	99	18	13	93	47.500	290	184	31	57	137

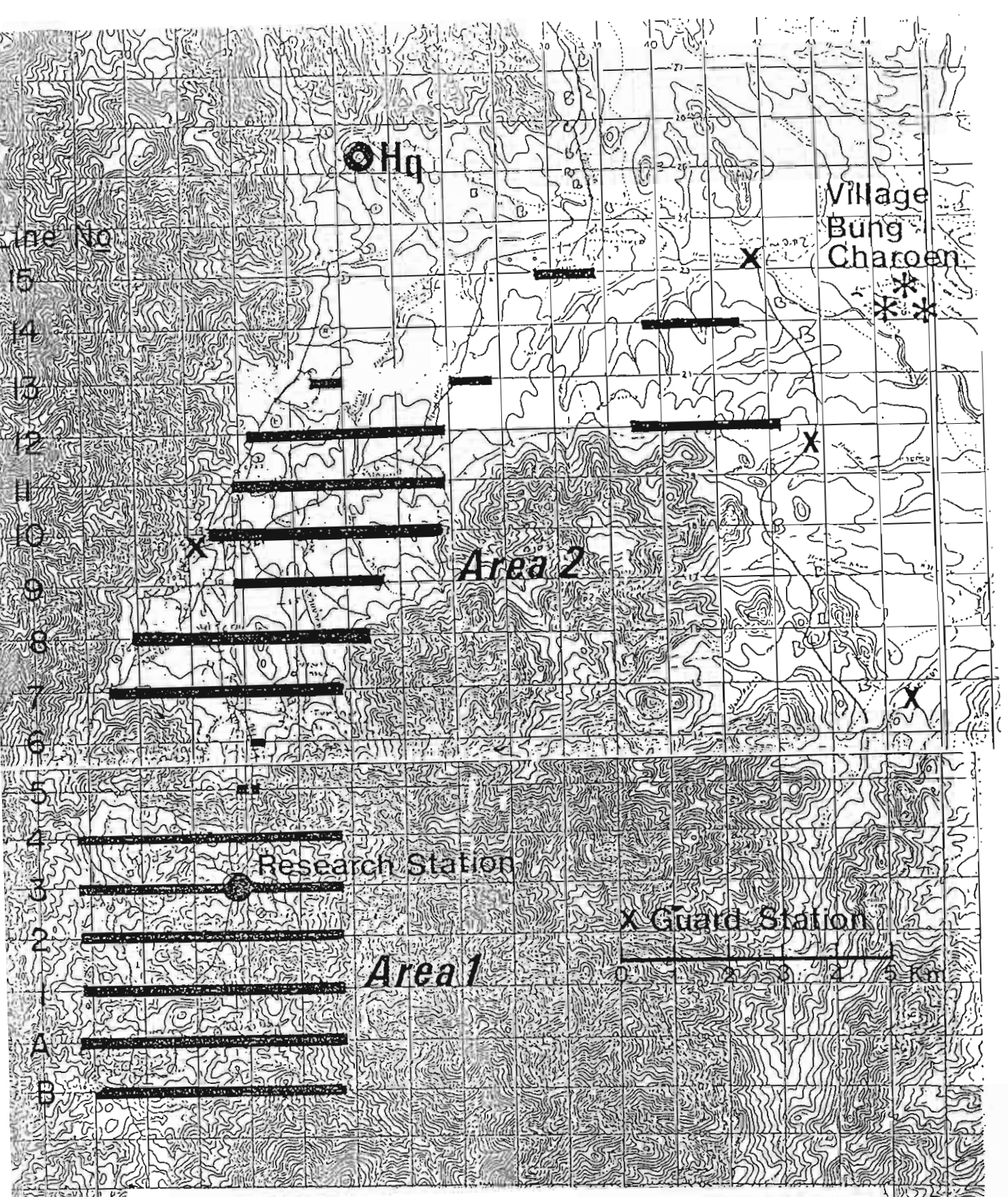

Figure 1. Study area near the headquaters and Khao Nang Rum Wildlife Research Station in Huai Kha Khaeng Widllife Sanctuary. Transects for surveying are demonstrated.

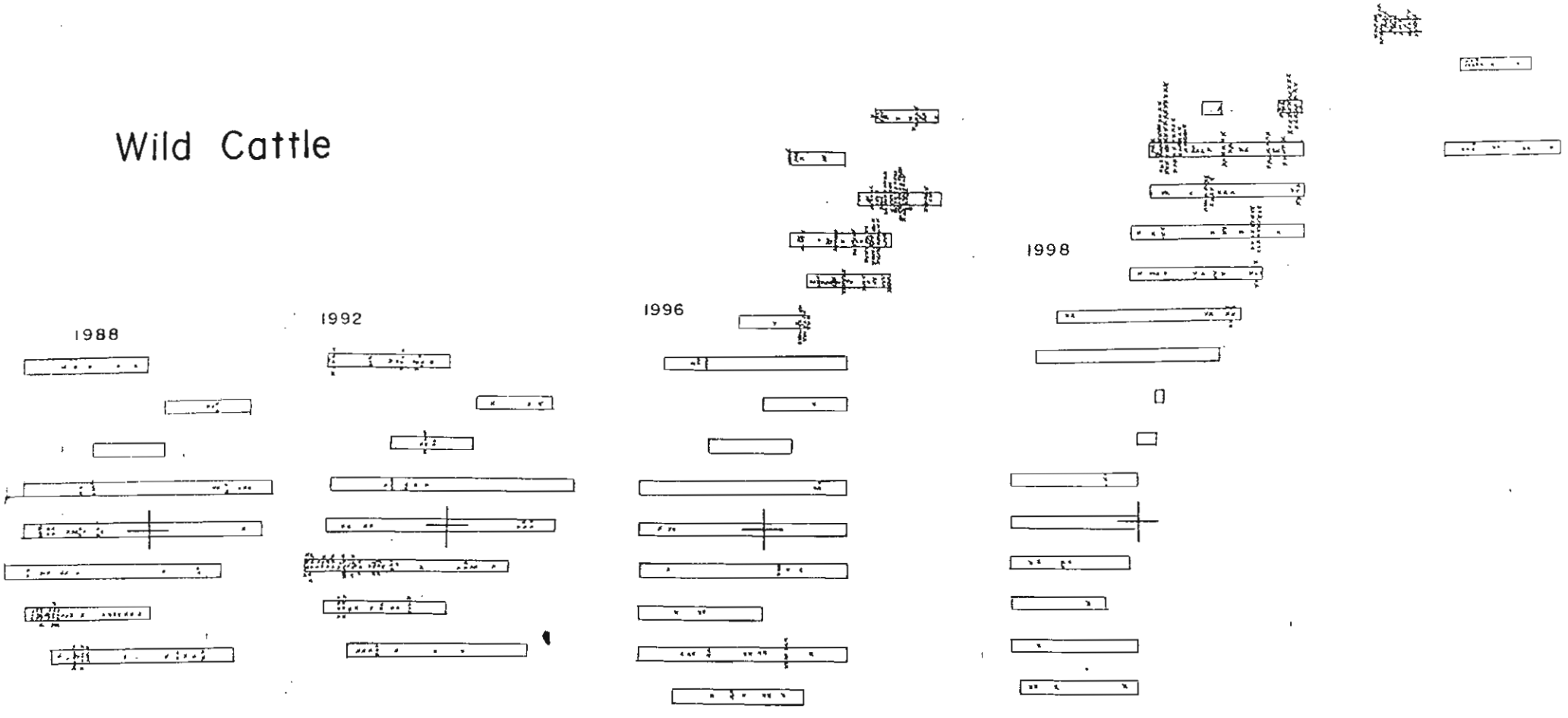

Figure 2a. Changes in the distribution of wild cattle (gaur and banteng combined) through time. Each crossing (X) represent a dung found in each location along the transect. Dung were possibly accumulated during the last four months before the survey. The big "+" sign indicate the location of Khao Nang Rum Wildlife Research Station.

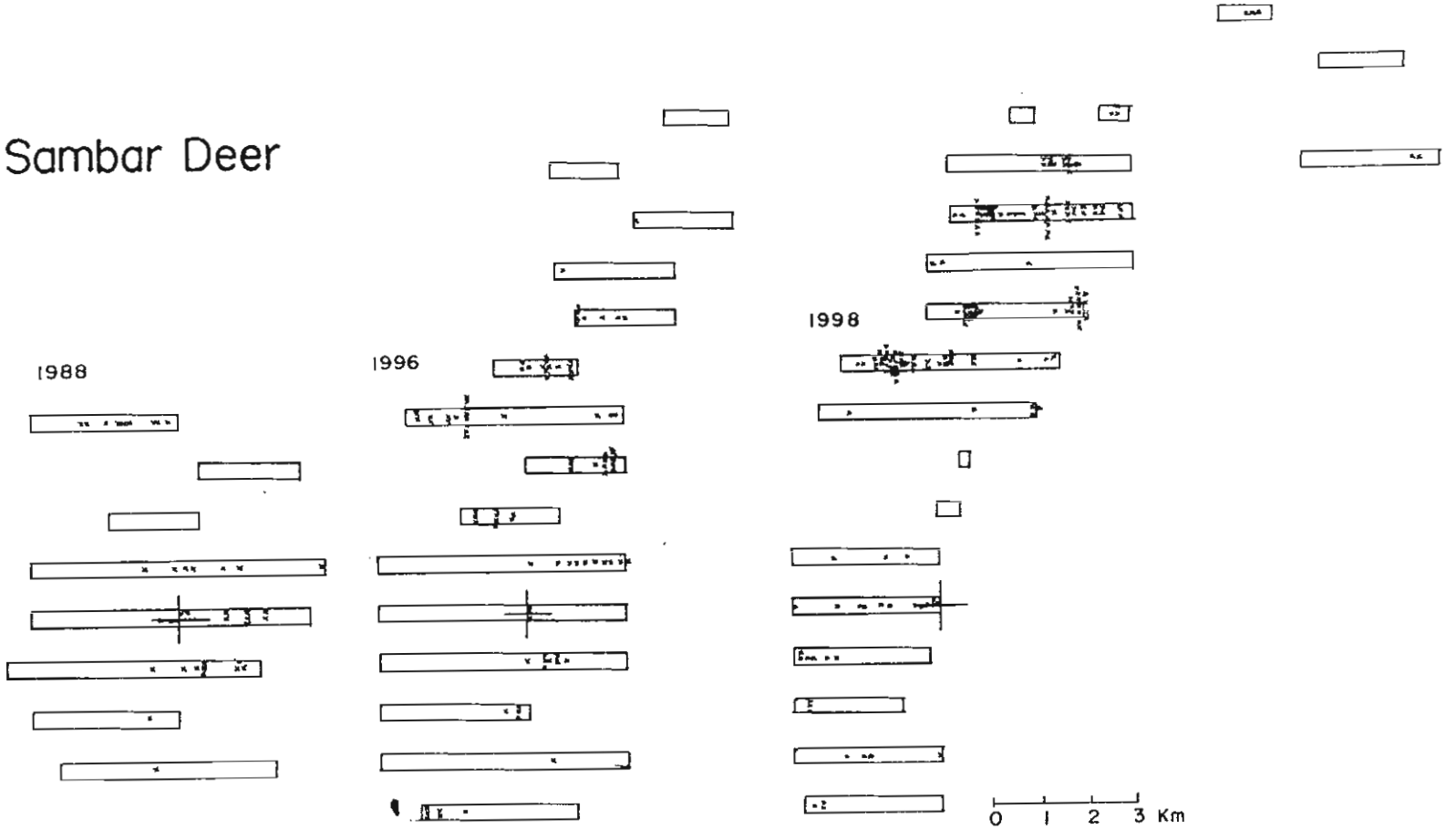

Figure 2b. Changes in the distribution of sambar deer through time. Each crossing (X) represent a dung found in each location along the transect. Dung were possibly accumulated during the last four months before the survey. The big "+" sign indicate the location of Khao Nang Rum Wildlife Research Station.

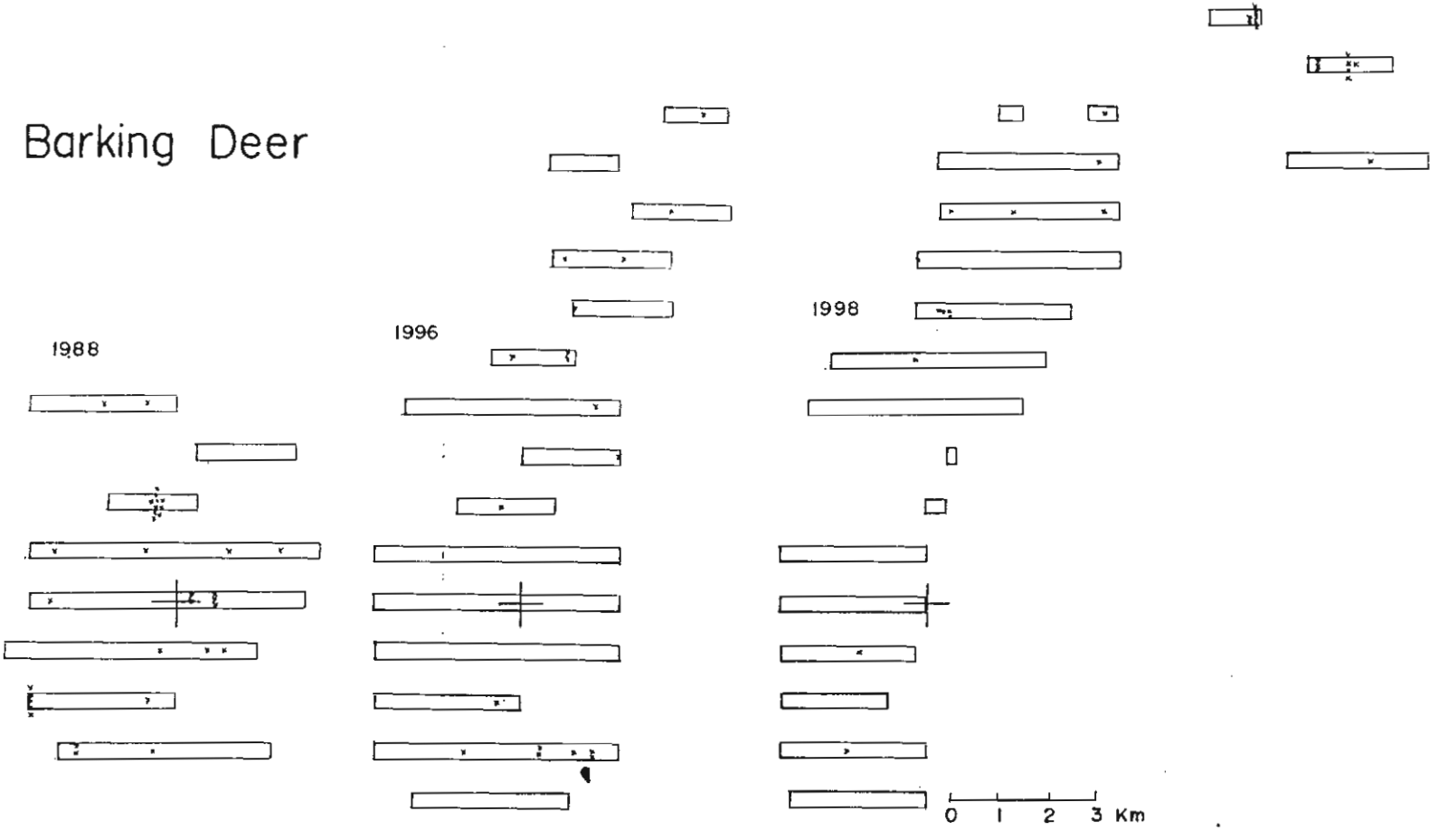

Figure 2c. Changes in the distribution of barking deer through time. Each crossing (X) represent a dung found in each location along the transect. Dung were possibly accumulated during the last four months before the survey. The big "+" sign indicate the location of Khao Nang Rum Wildlife Research Station.

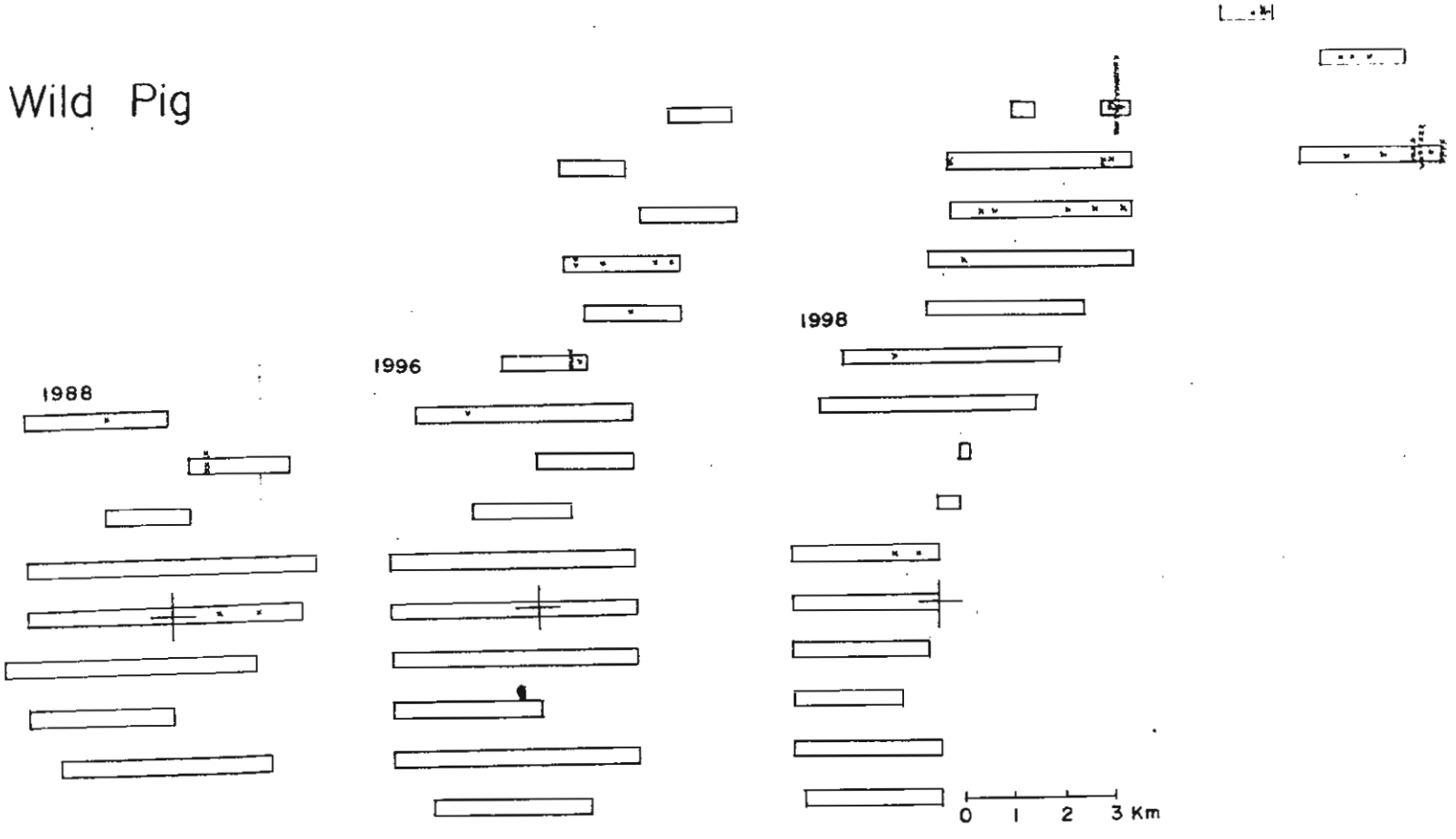

Figure 2d. Changes in the distribution of wild pig through time. Each crossing (X) represent a dung found in each location along the transect. Dung were possibly accumulated during the last four months before the survey. The big "+" sign indicate the location of Khao Nang Rum Wildlife Research Station.

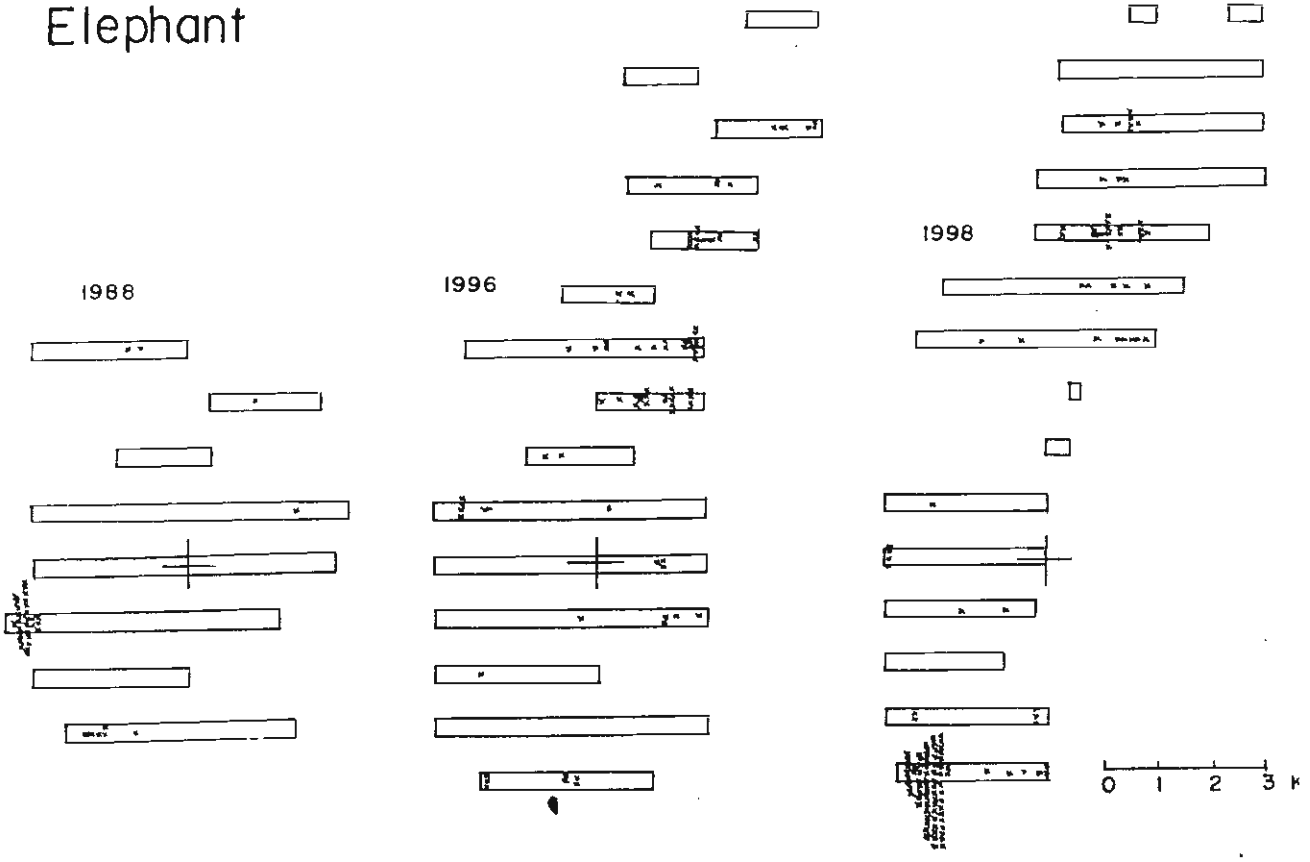

Figure 2e. Changes in the distribution of elephant through time. Each crossing (X) represent a dung found in each location along the transect. Dung were possibly accumulated during the last four months before the survey. The big "+" sign indicate the location of Khao Nang Rum Wildlife Research Station.

COMMERCIAL USE OF WILDLIFE: AN IMPORTANT FACTOR FOR THE EXTINCTION OF DEER IN THAILAND

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ABSTRACT

Although, commercial use of wildlife products has not been recognized as a major cause of wildlife depletion in Thailand, the historical record indicates the contrary. At least 4 million deer skins were commercially traded between Ayudhya and Japan during the 17th Century by the Dutch East India Company. Fewer deer skins were exported during the 18th Century but during the first half of the 19th Century, both deer skins and antlers were exported to China in large numbers. After the Bowring Treaty in 1855 until the 1940s, commercial trade of deer products continued between Bangkok and other European colonies in Asia through Chinese middleman. Some were also consumed locally as traditional medicine by Chinese immigrants, and some were collected as trophies following the western tradition. The deer skins and antlers traded were not separated according to species. This large-scale trade must have caused rapid declines of the deer populations in the lowland and intermontane areas and contributed to the extirpation of three species of deer in Thailand. The early wildlife conservation movement focused on the regulation of hunting so that regulations governing the commercial use of wildlife were not well developed. As a consequence, commercial uses of wildlife have contributed significantly to declines in populations even after 1960, when current wildlife regulations were implemented in Thailand. The above evidence helps support the argument that the introduction of markets for wildlife parts will jeopardize the effectiveness of wildlife conservation (GEIST, 1988 vs GRIGG, 1989).

INTRODUCTION

One way of gaining evidence on whether the introduction of markets for wildlife parts will jeopardize wildlife conservation (GEIST, 1988 vs GRIGG, 1989) is to look at the historical record. This paper compiles available information on commercial use of deer skins documented since early Ayudhya period in the 17th Century in Thailand (formerly "Siam" until 1949). It possibly caused or influenced the extinction of three species of deer in Thailand, although the conservation impact of such use has not been recognized. Modern efforts in wildlife conservation, including implementation of wildlife law, therefore did not adequately deal with the commercial uses of wildlife. An attempt will be made to evaluate such uses as an important factor in the decimation of certain wildlife species, especially large deer. The last individual Schombergk's deer (*Cervus schomburgki*, Byth 1863), Eld's deer (*Cervus eldi*, McClelland 1842) and hog deer (*Cervus porcinus*, Zimmermann 1780) were reported in the 1930s, 1970s and about 1977, respectively (LEKAGUL & MCNEELY, 1977; BHUMPAKPHAN, 1997).

COMMERCIAL USES OF DEER SKINS AND PRODUCTS

Table 1 summarizes available information on the commercial use of deer skins. The Japanese may have exported deer skins from Ayudhya since the 15th and 16th Centuries, as 58 Chinese junks sailed between Japan and Ayudhya during those times (ISHII & YOSHIKAWA, 1987). The Dutch East India Company was stationed in Ayudhya during 1608–1694 (SMITH, 1977). In the 17th Century, about 4 million deer skins were exported to Japan and most of them shipped by the Dutch East India Company (Table 1). In 1615, the Dutch East India Company hired a Chinese junk to carry 9,857 deer hides and other items from Ayudhya to Pattani before sending them to Japan (SMITH, 1977), while an English merchant also bought 8,260 deer skins for sale (RUANGSILP, 1984). In 1621, it was estimated that 300,000 deer skins could have been exported annually from Ayudhya to Japan (VAN NEUJEMRODE, 1871, cited in SMITH, 1977), although SMITH (1977) suspected that this number was an overestimate. It is unfortunate that there are no reliable records of the export of deer skins by the Japanese who lived in Ayudhya. One record suggested that 120,000 deer skins were exported by Japanese in 1613 (ISHII & YOSHIKAWA, 1987). As the Dutch East India Company stopped their business in Siam at the end of 17th Century, fewer deer skins were sent to Japan in 18th Century, the total amount being only about 28,540 (Table 1). Deer skins were used to make armor and tabi (two-toed socks), to

cover boxes, trunks and other items (SMITH, 1977), to make shields (BRUMMELHUIS, 1987), and to make cloth, gloves, gun bags, and lens cleaners (ISHII & YOSHIKAWA, 1987). Three grades of deer skins were recognized (SMITH, 1977) but with no species separation.

During the 18th century, Siam was at war with Burma most of the time so that the situation was not favorable for trade. There is scant information about the trade during this period (NUNN, 1922). Ayudhya as a commercial center was destroyed. Commercial uses of wildlife resources apparently ceased for about 100 years. This allowed wildlife populations, free from hunting, to recover.

When Thonburi became a capital, animal skins including deer skins were traded with the Dutch East India Company in Java in exchange for 6,000 guns in 1777 (RUANGSILP, 1979). When Bangkok became the capital in the 1780s, Thailand began to trade more with China, Singapore and Java, and many animal products were also exported. Although trade in hides was not well documented, the number of boats trading with China during the reigns of Rama I and II was very high. An annual fleet of 140 and 60-80 boats were recorded trading with China in 1822 and 1835 (TERWIEL, 1983). During 1833, 100,000 deer skins were exported. Deer skins were processed for use as mattresses and pillows (ROBERTS, 1837).

When Thailand signed the Bowring Treaty in 1855 and opened up the country to Western influence, commercial uses of wild animals continued. Early in 1857 it was noted that there was a remarkable influx of traders (TERWIEL, 1983). In 1856, there were 141 vessels, other than Chinese junks, trading with Bangkok, in 1857 there were 204, and in the following years this number gradually rose to some three to four hundred vessels (TERWIEL, 1983). In 1868, deer horns and tendons were still items for tax farming by Chinese appointed by the King (RUANGSILP, 1984; Bangkok Calendar, annually, 1868, p. 60). Many Chinese merchants also developed connections with Western traders and increasing became the compradors for western trading houses (HAMILTON & WATERS, 1997). During this period there were no good records on deer skins in trade, but the trade in animal horns, antlers and skins still continued. In 1871, very few deer skins were exported as deer populations were possibly declining (RUANGSILP, 1984; Siam Repository, V. 4, p. 187).

Since the mid 19th Century, deer products possibly were exported to European colonies where there were many Chinese, such as Penang, Singapore and Hong Kong,

and some may have been consumed by Chinese immigrants as traditional medicine in Thailand. In 1939, the British Empire took 40.65 percent of Thailand's total foreign trade, that of Hong Kong representing 4.86 per cent, Penang 14.54 percent, and Singapore 14.44 percent (THOMPSON, 1941). The Chinese have been the most prominent economic minority in Thailand for hundreds of years (HAMILTON & WATERS, 1997). There were an estimated 230,000, 300,000 and 792,000 Chinese in Siam in 1825, 1850 and 1910, respectively (SKINNER, 1957; WYATT, 1984). In a social sense, there were at least two Siams in 1910 (WYATT, 1984). There were also 451,500 Chinese immigrants during 1882–1917 and 655,800 in 1921–1950 (PHONGPAICHIT & BAKER, 1996). In 1932, Chinese comprised about 12.2% of the whole population of Thailand (WYATT, 1984). ZIMMERMAN (1931) and LANDON (1941) reported that old-fashioned Chinese medicine was common in Thailand in the 1930s and that tiger paws, snake skins, skeletons of strange-looking sea animals, and other unusual materials could be seen in these shops. During 1933–1937, GUEHLER, (1939) estimated that at least 75,000 deer skins were traded, so that at least 15,000 deer skins were traded annually. In one dry season, 3,000 skins of sambar deer and 10,000 skins of barking deer were handled at Kaeng Khoi, Saraburi Province, at the headwaters of the Pasak River, during the 30s and 40s. A total of 108,540 kg of deer horns was also exported during 1933–1937 (GUEHLER, 1939). THOMPSON (1941) mentioned that in the 1930s an alarming slaughter of barking deer took place in Peninsular Thailand by Chinese dealers. Bangkok was then believed to be the cheapest animal market in the world. Deer were also taken alive and sold in the plains by the highlanders in northern Thailand in 1912 (GRAHAM, 1912).

HUNTING METHODS AND SOURCES OF DEER PRODUCTS

In 17th Century, deer were hunted during the rainy season in the central plain (O' KANE, 1972). Shah Sulaiman from Persia described a hunting crew of 100 people (O' KANE, 1972). Nets were set up near a group of deer and from the other direction riders and men on foot closed while shouting and making as much noise as possible. In the short time between dawn and noon, about 30 deer (possibly hog deer which they called "little short-foot") were caught (O' KANE, 1972). In early 19th Century very few guns were available in Thailand. For example, in 1844-1846, only 50 flint-lock guns were registered in Ayudhya (TERWIEL, 1989). Hunting methods in early 19th Century were probably similar to those used in the 17th Century. In the early 20th

Century, according to GRAHAM (1912), beasts of prey were trapped and shot in self defense and deer were hunted, especially when rising waters cut them off in the plains from their jungle retreats and rendered them comparatively easy prey to the hunters. LEKAGUL & MCNEELY (1977) also wrote that this method was used in the central plain of the Chao Phraya River in early 20th Century. They described that in the rainy season, when the plains were flooded, the deer had to seek refuge on small patches of raised ground above water. On such "island refuges," many species could be found, including Schomburgk's deer, hog deer and Eld'deer. The hunters would form a big party consisting of a number of men riding on water buffalos or in boats and surround an "island", and kill everything they could. The animals that escaped into the water would be chased down by men in canoes and clubbed or speared. Pictures of this hunting scene and another hunting tactic that the hunter put Schomburgk's deer antlers and hide himself in the grass so that the buck came to inspect and were killed by spears were demonstrated very nicely by LEKAGUL (1962). During the 1870s to the 1930s, large scale logging was conducted in northern Thailand (DE ' ATH, 1992; ANON, 1891a,b), large numbers of deer were possibly shot with high-quality rifles by Europeans and their Chinese counterparts who worked for the logging companies (CAMPBELL, 1935).

During the 17th Century, most deer skins were taken in central Thailand from places such as Poucelouk (Phitsanulok; GERVAISE, 1688) and Capheyn (Kamphaengphet; GERVAISE, 1688) and some in southern Thailand from Parathou (near Ban Dohn), Rion (Bion or Ban Dohn near Surat Thani) and Pattani, and eastern Thailand near Cambodia from Banae (possibly Ban Na, Nakhon Nayok) according to van Vliet in 1692 (VAN RAVENSWAAY, 1910). Some skins were given as tribute from nearby kingdoms, especially Lan Na (Chiang Mai), Lan Sang (Laos) and Lawaek (Cambodia).

There is no good information about the sources of deer skins and products in the 19 th century. As the economy of Thailand in this period could be described as export-oriented and expansive (TERWIEL, 1989), deer products would have been obtained not only in nearby central Thailand but from nearby kingdoms such as Chiang Mai, Laos and Cambodia. Wildlife products in Central Thailand were taken along the river and by ground transport as far as Kamphangphet, Pichit, Nakhon Sawan and Phetcahbun in the north, Kabinburi and Aranyaprathet in the east, Thung Yai or Trat and Chantaburi in the southeast, Phetchaburi and Ratchaburi in the southwest, and Sangklaburi, Si Sawat and Kanchanaburi in the west and northwest. Hides and leather ropes were reported to be

sent from Ratchaburi, Kanchanaburi and Suphan Buri for the royal cremation of King Rama I in 1810.

After the Bowring Treaty in the mid 19th Century, more deer products were obtained not only from central Thailand as a result of large-scale canal construction, but possibly also from northern Thailand as more areas were accessed by logging companies. The 1920s and 1930s was a great period of railway construction, and central Thailand became connected to the north, northeast, east and southern Thailand. Kaeng Khoi, Saraburi was a trading center for deer skins and products from north and northeast Thailand in the 1930s and 1940s (GUEHLER, 1939). THOMPSON (1941) mentioned several hunting locations in Southern Thailand in the 30s.

DISCUSSION

The existing reports on commercial uses of deer skins appear to be just "the tip of the iceberg" when we consider the whole picture. Even with the small amount of information available, there is still no doubt that the volume of trade was very high indeed. It is highly likely that this astonishingly high commercial exploitation contributed to the rapid decline of deer populations in Thailand.

Undoubtedly, the extirpation of these deer was not solely the result of commercial uses of deer-skin. Since 1855, the large-scale conversion of wild lands to rice fields accelerated rapidly. The first stages of habitat conversion occurred in the lowlands of the Chao Phraya River, and along the main rivers in inter-mountain areas throughout Thailand (TAKAYA, 1987). These lowland areas are the main habitat for these deer. Schombergk's deer prefer swampy areas, hog deer prefer low-lying grassland, while Eld 's deer prefer open dry deciduous forest (LEKAGUL & MCNEELY, 1977; DHUNGEL & O' GARA, 1991). Introduction of railways also opened new areas for exploitation hitherto left undisturbed, introducing migrant populations from other parts of the country (TAKAYA, 1987; THOMPSON, 1941).

The data indicate that wildlife resources in Thailand have been over-exploited for at least the past 200 years. Not only Schomburgk's deer but also Eld's deer and hog deer might have been hunted out since the 1930s or 1940s.

The influence on the commercial use of deer skins and products on the decline of deer populations in Thailand has become obvious. The trade in deer skins and products

was monopolized by the royal court until 1855, when the trade were released to commoners who traded wildlife products through Chinese merchants. In the early 1900 s, there was concern about the disappearance of deer, and some suggestions were made to solve this problem. For example, AMBROSE (1904) suggested that efforts be made to preserve deer in the interior far away from the Chao Phraya basin and its tributaries. Other suggestions were to prevent wildlife over-utilization by regulating it like sport hunting, and establishing a hunting season (ANON., 1928; LEKAGUL, 1959; SAMABHUDDHI, 1963), or by permitting only subsistence use (ANON, 1928). As commercial use of wildlife has a different character and scale, it requires a different type of regulation. Rules and regulations on sport hunting and subsistence use did not have enough effect to allow wildlife populations to recover.

ROBINSON & REDFORD (1991) recognized five categories of wildlife use: subsistence use, local market uses, wildlife farming and ranching, sport hunting, and commercial uses. Subsistence use where people hunt wildlife for their own consumption. Local market uses happen when wildlife is exploited for sale in local markets and the capital investment is low. Sport hunting or hunting for recreation dominates the Western approach to wildlife management. Commercial uses are large in scale involve external markets and require a higher investment than local market uses. The King of Siam was the chief merchant of the country until King Rama III's time (NUNN, 1922). When the trade was extended to the common people, the commercial development of Siam was in the hands of Chinese immigrants (ZIMMERMAN, 1931; ANDREWS, 1935; LANDON, 1941; CUSHMAN, 1989; HAMILTON AND WATERS, 1997).

The first wildlife law in Thailand, the Wild Animal Reservation and Protection Act of 1960, did not have enough rules and regulations controlling commercial use of wildlife, but followed the examples of laws used in Europe and America (LEKAGUL, 1959) which largely governed sport hunting. As a result, the commercial use of wildlife kept increasing into the 1970s (RYHINER & MANNIX, 1958; WINSTON & WINSTON, 1959; TREFFLICH & ANTHONY, 1967; LENG-EE, 1974; DOMALAIN, 1977a,b). Wildlife law in Thailand not only failed to regulate commercial uses of wildlife at the national level, but also did nothing to control illegal international wildlife trade. In 1991, the commercial export of wildlife from Thailand became so high that members of the Conventional on International Trade in Endangered Species of Wild Fauna and Flora (CITES) voted sanctions to ban all trade in wildlife products with Thailand for a year. The wildlife law was updated in 1992.

Commercial use of wildlife and deer hunting by rounding up herds were significant factors contributing to the decline of wildlife populations in Thailand at least since the 17 th Century. These factors were just realized by the Western countries in the 1960s when international conservation authorities set up the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973 (KING, 1974). The long history of commercial use of deer skins and other wildlife products in Thailand demonstrates the importance of socio-economic, cultural, and political factors which are different from those affecting wildlife conservation in Western countries, especially in the U.S. and Europe. In Germany, where hunting rights were given to the farmers for the first time since the revolution of 1848, all game were nearly decimated so that new rules were set up to stop total destruction (SCHWENK, 1991).

Schomburgk's deer is one of the clearest examples of extinction out of 46 species of deer which have become extinct in the world in modern times. Pere David's deer (*Elaphurus davidianus*, Milne-Edwards, 1866) in Northeast China became extinct in the wild, but thriving populations still exist in captivity. At present there are four endangered and seven vulnerable species of deer in the world (IUCN, 1996). The extirpation of three species of deer in Thailand is quite remarkable. Many species of deer are abundant in spite of high hunting pressure. For example, deer populations distributed throughout Europe and North America total about 40 million (GILL, 1990). Since 1900, all species of deer in Europe and North America, with the probable exception of the North American caribou, have increased in numbers even though about 6.5 million deer are harvested per year (GILL, 1990).

The commercial use of deer skins may also cause the extirpation of Formosan sika deer (*Cervus nippon taiouanus*, Blyth 1860). During the 25 years of 1635-1659, a total of 1,621,228 deer skins or about 65,000 skins per year were known to be imported to Japan from Formosa by the Dutch East India Company (HOLLMANN). Even after the Dutch were driven from Formosa, about 50,000 deer skins were taxed annually by the Chinese General during 1661-1683 (PATEL & LIN, 1989) and they were also hunted during the Japanese occupations during 1895 and 1945 (HSU & AGORAMOORTHY, 1997). Althoough the skins could have been any of the three species of deer in Taiwan, Formosan Reeve's muntjac (*Muntiacus reevesi micrurus* Sclater 1875), Formosan sambar deer (*Cervus unicolor swinhoei* Sclater 1862), or the Formosan sika deer, the sika deer are most easily hunted as they live in more open habitat than sambar deer. Since the late 1960s, Formosan sika deer have been

extirpated from Taiwan due to intensive hunting and expansion of agriculture (McCULLOUGH, 1974).

Other examples of commercial uses of deer skins on a large scale can be found in South America. Between 1860 and 1879 over 2 million Pampas deer (*Ozotoceros bezoarticus*) skins were exported from Argentina (JACKSON & LANGGUTH, 1987; cited by REDFORD & ROBINSON, 1991). In 1996, the Pampas deer (*O. bezoarticus celer*) in Argentina was classified as internationally endangered (IUCN, 1996).

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Table 1. Numbers of deer skins (pieces), or pairs of deer horns (*) exported from Thailand.

Year(A.D.)	Volume of trade (deer skins or horns)	Country or City imported	Reference
1613	120,000	Japan	ISHII & YOSHIKAWA (1987)
1615	18,117	Japan	SMITH (1977); RUANGSILP (1984)
1617	9,000	Japan	ANDERSON (1890); NUNN (1922)
1621	<300,000	Japan	SMITH (1977)
1622	32,930	Japan	NEGOTIE JOURNAL NFJ 829
1624	47,730	Japan	NEGOTIE JOURNAL NFJ 829
1625	62,874	Japan	NEGOTIE JOURNAL NFJ 830
1627	97,875	Japan	NEGOTIE JOURNAL NFJ 831
1633-63	1,970,124	Japan	SMITH (1977)
1664-94	1,453,000	Japan	SMITH (1977)
1712	>11,260	Japan	ISHII & YOSHIKAWA (1987)
1745	2,094	Japan	NAGAZUMI
1747	5,230	Japan	NAGAZUMI
1751	656	Japan	NAGAZUMI
1756	9,300	Japan	NAGAZUMI
1833	100,000	China	ROBERTS (1837)
1850	30,000*	China	NUNN (1922)
1892	13,424	Penang, Singapore and Hong Kong	NUNN (1922)
1901	15,952	Penang, Singapore and Hong Kong	NUNN (1922)
1919-20	215,658	Penang, Singapore and Hong Kong	NUNN (1922)
1933-1937	>75,000	Penang, Singapore and Hong Kong	GUEHLER (1939); THOMPSON (1941)

Note: Information extracted from Negotie Journal were kindly done by Dr. Yoko Nagazumi. Negotie Journal is a daily record of transactions of the Dutch factory in Hirado and Nagasaki. Hog deer, Eld's deer and Schombergk's deer were described in 1780, 1842, and 1863, respectively and were extirpated from Thailand in 1977, 1970s, and 1930s, respectively. Ayudhya periods were between 1351-1767, Thonburi period were between 1767-1782, Bangkok period began 1782. The Bowring Treaty was on 1855.