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Ecology and conservation of the leopard cat *Prionailurus bengalensis* and clouded leopard *Neofelis nebulosa* in Khao Yai National Park, Thailand*

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Abstract The spatial and temporal ecology of 2 sympatric felid species, the leopard cat *Prionailurus bengalensis* and clouded leopard *Neofelis nebulosa*, was studied from October 1997 to October 1999 in Khao Yai National Park, Thailand. Felids were captured using baited box traps, were anesthetized, sexed, aged, and fitted with a radio collar. Six female and 4 male leopard cats were radio-tracked for 1－18 months. Leopard cats used larger areas during the wet season than dry season and males used larger areas than females. Most leopard cats used vegetation types in proportion to their presence. Leopard cats exhibited arrhythmic activity with increased activity during nocturnal and crepuscular periods. Dry and wet season activity was similar for all leopard cats; however, males showed greater diurnal activity than females. Travel distance for leopard cats during a 24-hour period differed by sex but not season. Murids dominated prey consumed by leopard cats. A female and male clouded leopard were radio-tracked for 17 and 7 months, respectively. Area used by the female was 39.4 km^2, whereas the male used 42.2 km^2 and both had core areas of 2.9 km^2. Clouded leopards used semi-evergreen forest greater than other vegetation types. Clouded leopard activity was arrhythmic with increased levels during crepuscular and nocturnal periods. Some conservation aspects for felids in Thailand are discussed [*Acta Zoologica Sinica* 53 (1): 1－14, 2007].

Key words Clouded leopard, *Neofelis nebulosa*, Leopard cat, *Prionailurus bengalensis*, Conservation, Ecology, Thailand

泰国 Khao Yai 国家公园豹猫和云豹的生态和保护*

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摘　要　于 1997 年 10 月到 1999 年 10 月在泰国 Khao Yai 国家公园对两种同域分布的物种（即豹猫和云豹）进行了研究。使用带诱饵的陷阱捕捉了这些动物，进行麻醉，确定了性别、年龄，并戴上了无线电项圈，对 6 只雌性豹猫和 4 只雄性豹猫进行了 1－18 个月的无线电追踪。豹猫在干旱季节的利用区域大于雨季，雄性利用的区域大于雌性。在夜间和晨昏时节，豹猫活动增加，但是并没有节律性活动。所有豹猫个体在旱季和雨季的活动都相似，但雄性个体的白天活动多于雌性。豹猫的行走距离有性别差异但是没有季节差异；其食物以鼠类为主。分别对 1 只雌性云豹和 1 只雄性云豹进行了 17 个月和 7 个月的无线电追踪，雌性个体的活动面积为 39.4 km^2，而雄性个体活动面积为 42.2 km^2，核心区都是 2.9 km^2。云豹对半绿林的使用大于其它类型的植被，在晨昏和夜

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间的活动增加，其活动无节律 [动物学报 53（1）：1－14，2007]。

关键词 云豹 豹猫 保护 生态 泰国

Literature specific to the small and medium-sized cats of Southeast Asia is replete with statements indicating that little or no information exists (Eaton, 1973; Guggisberg, 1975; Green, 1991; Kitchener, 1991; Nowell and Jackson, 1996). For small and medium-sized wild cat species thought to occur in Khao Yai National Park (KYNP), Thailand, information comes mainly from anecdotal accounts (Boorer, 1970; Grzimek, 1975; Guggisberg, 1975), descriptive accounts of captive populations (Selous and Banks, 1935; Muul and Lim, 1970), sighting reports (Davies, 1990), or more recently status reports and surveys (Rabinowitz et al., 1987; Rabinowitz, 1988; Santiapillai and Ashby, 1988; Dinerstein and Mehta, 1989; Santiapillai, 1989; Hart, 1994; Johnson and Jinping, 1996).

The leopard cat *Prionailurus bengalensis* is one of the smallest (2－5 kg) (Kanchanasakha et al., 1998; Sunquist and Sunquist, 2002) extant wild felids in Asia with a range extending from northern Pakistan through most of India and China, south through Malaysia and much of Indonesia, including Borneo. Its eastern range includes some Philippine Islands and extends north through Hainan, Taiwan, and into Korea (Corbet and Hill, 1992). It is the most common wild cat in Thailand (Lekagul and McNeely, 1977). The leopard cat is primarily a forest-dwelling animal but it occupies a variety of habitats including secondary forests, plantations, and suburban habitats (Harrison, 1974; Kanchanasakha et al., 1998; Rabinowitz, 1990; Rajaratnam①; Grassman, 2000, 2005a).

The clouded leopard *Neofelis nebulosa* is one of the most enigmatic wild cats. It is a medium-sized (11－20 kg) felid found in southeastern Asia from central Nepal (Dinerstein and Mehta, 1989) to southern China and south through peninsular Malaysia, including the islands of Sumatra and Borneo (Guggisberg, 1975; Corbet and Hill, 1992). Scientific information on wild clouded leopards is extremely limited. There has been just one other field study of this species (Grassman et al., 2005b). Other available information is anecdotal (Selous and Banks, 1935) including status reports of local surveys and interviews (Rabinowitz et al., 1987; Rabinowitz, 1988; Santiapillai and Ashby, 1988; Santiapillai, 1989; Choudhury, 1993), sighting reports (Davies, 1990; Mehta and Dhewaju, 1990), or based on captive accounts (Yamada and Durrant, 1989; Nowell and Jackson, 1996). The clouded leopard is listed by the International Union for the Conservation of Nature (IUCN) as vulnerable (IUCN, 2006) and listed under Appendix I of the Convention for the International Trade in Endangered Species (CITES), which bans international commerce.

Specific natural history information necessary for the management and conservation of wild felids include habitat requirements, spatial-use patterns, social organization, reproduction, mortality, activity, and food habits (Lekagul and McNeely, 1977; Eisenberg, 1991; Nowell and Jackson, 1996). This information can be used to increase knowledge of these poorly understood carnivores, to determine specific criteria for effective habitat management (e.g., area requirements, habitat corridors, and buffer areas), and to begin population viability analyses. A greater understanding of wild cat ecology is requisite to conveying the importance of conservation to local residents, wildlife managers, and reserve staff.

The goal of our study was to examine minimum range area requirements, habitat use, activity patterns, and prey selection for leopard cats and clouded leopards in KYNP from October 1997 to October 1999. Specific objectives were to: (1) determine felid range size and habitat use, (2) investigate movement and activity patterns, and (3) examine food habits.

1 Materials and methods

1.1 Study area

Khao Yai National Park (2 168 km^2) is located in central Thailand (Fig.1). The park is located on the Dangrek Range between 14°05′ to 14°15′ north latitude and 101°05′ to 101°50′ east longitude at the southwestern edge of the Korat Plateau in northeast Thailand. Most of the park, including the study area, is characterized by hilly terrain of ca 600－700 m asl with occasional peaks rising to 850 m asl (WCMC②).

Mean annual rainfall in the center of the study area was 227 cm. Most precipitation fell during the mid-May to October southwest monsoon, with an average of 192 cm falling during this period in the study area (Srikosamatara and Hansel, 1996). The driest months were December and January, which averaged 1.5 cm of rain monthly. Mean annual temperature was 23℃, increasing to 28℃ in April and May and decreasing to 17℃ during December and January (NPD, 1987).

Vegetation in KYNP was highly diverse with an

① Rajaratnam R, 2000. Ecology of the leopard cat *Prionailurus bengalensis* in Tabin Wildlife Reserve, Sabah, Malaysia. Ph.D. Dissertation, Universiti Kebangsaan Malaysia, Bangi, Malaysia.

② World Conservation Monitoring Centre (WCMC), 1991. Khao Yai National Park fact sheet. Biodiversity Information Management System (BIMS) Database. Forest Management and Conservation Project (FOMACOP) Headquarters, Savannakhet, Lao P.D.R.

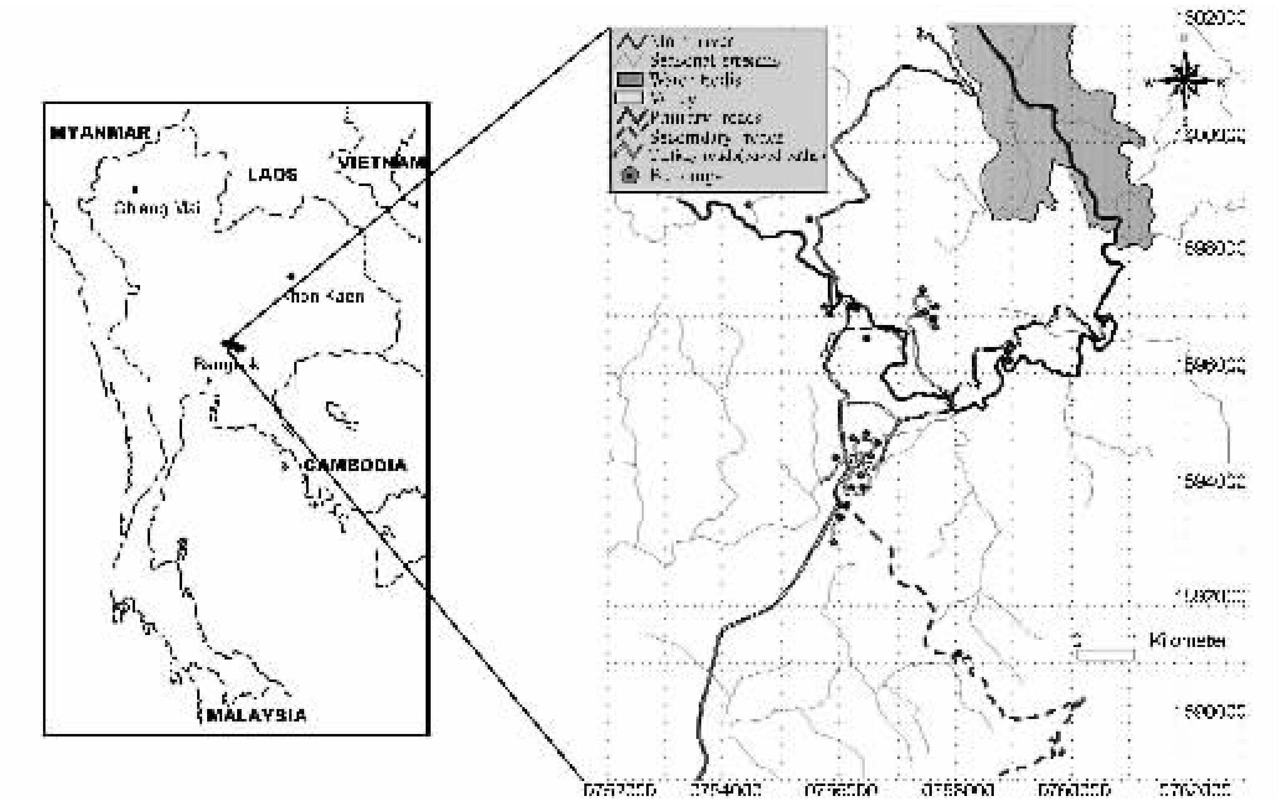

Fig.1　Study area in Khao Yai National Park, Thailand, October 1997 – October 1999

estimated 2 000 – 2 500 plant species. The park was characterized primarily by tropical evergreen rain forest that consists of a blend of moist semi-evergreen forest, dry evergreen forest, dry mixed deciduous forest, hill evergreen forest, and pockets of grassland (NPD, 1987).

The study area surrounded the park headquarters and consisted of about 125 km^2 of moist semi-evergreen tropical forest (SEF) and 17.5 km^2 of grassland and secondary forest (GSF; Fig.1). The boundary of the study area was delineated to include the ranges of all study animals, and was therefore larger than the area studied.

The SEF was characterized by canopy species as *Dipterocarpus alatus* and *Schima wallichii*. The understory species included *Lithocarpus annamensis*, *Quercus fleuryi*, and *Castanopsis acuminatissima* (WCMC①). The remaining 13% (17.5 km^2) was grassland and secondary forest from previous human disturbance.

KYNP supported a rich and diverse mammalian fauna including: Asiatic elephant *Elephas maximus*, sambar *Cervus unicolor*, muntjak *Muntiacus muntjak*, wild boar *Sus scrofa*, gaur *Bos gaurus*, mouse deer *Tragulus javanicus*, gibbon *Hylobates* spp., pig-tailed macaque *Macaca nemestrina*, tiger *Panthera tigris*, marbled cat *Pardofelis marmorata*, Asiatic black bear *Selenarctos thibetanus*, Malayan sun bear *Helarctos malayanus*, dhole *Cuon alpinus*, and binturong *Arctictis binturong* (NPD, 1987).

Tourism in the park and study area was high because of the prominence of KYNP as the first national park in Thailand and the park's proximity to Bangkok. In 1986, 500 000 tourists were recorded as visiting the park (NPD, 1987). At the time of this study, it was estimated that nearly 1 million tourists were visiting KYNP annually (K.Sathorn, KYNP Park Superintendent; pers. comm.).

1.2　Methods

Twenty steel-mesh metal box traps (150 cm × 44 cm × 44 cm) and 1 large (200 cm × 100 cm × 100 cm) wooden box trap were baited with live chickens in a separate compartment and distributed throughout the study area in locations frequented by carnivores (e.g., riparian areas and lowland trails). Traps consisted of a single door that was closed when the animal stepped on a foot treadle. Scent attractant disks (Pocatello Supply Depot, Pocatello, Idaho) were occasionally placed in and near traps to increase the attractiveness of the trap. Traps were placed in shaded areas and visited early each morning to feed and water the chickens and check for trapped animals.

Trapped cats were anesthetized using a pole syringe with 10 mg Telazol/kg body weight (A.H.Robbins Co., Richmond, Va.) or with a combination of 15 mg

① See the footnote of Page 2.

ketamine/kg body weight and 1 mg xylazine/kg body weight (Grassman et al., 2004). Radio collars equipped with activity and mortality sensors were attached to the cats and body measurements were recorded. Cats were returned to the box trap to allow recovery in a controlled, protected environment, and released after complete recovery from the sedation (ca 4 – 6 h).

A hand-held directional 3-element antenna and radio scanner-receiver (Advanced Telemetry Systems, Inc., Isanti, MN) were used for radio tracking. Receiver locations were established using topographic features, numbered utility poles along roads, or by use of a Global Positioning System (GPS) (Garmin, Inc., Olathe, KS). GPS error was determined by measuring the difference between GPS-defined UTM coordinates of specific landscapes or man-made features and actual UTM positions identified from existing maps.

Animal locations were determined by triangulating azimuths derived from the direction of the strongest signal received (Brander and Cochran, 1971). The geometric center of the polygon produced by the intersection of the lines indicated the location of the animal (Brander and Cochran, 1971). To reduce telemetry error, 3 azimuths were the minimum requirement for determining animal location, and azimuths $> 150°$ or $< 30°$ were not used.

Activity (i.e., collar movement) was indicated by a change in collar signal integrity and pulse frequency. A unique pulse frequency emitted after 8 hours of no collar movement indicated mortality. To determine activity patterns, collar signal rates were monitored at 15-min. intervals, typically during 2 – 3 h periods.

1.3 Data analysis

Range size, spatial overlap, and pattern of habitat use were determined using the minimum convex polygon (MCP; Mohr, 1947) and fixed kernel methods (Powell et al., 1997). Powell et al. (1997) contended that the fixed kernel method is the most precise animal range estimator available. Therefore, we selected this method to determine the cumulative and seasonal range for each study animal. Four previous studies on leopard cats (Rabinowitz, 1990; Izawa et al., 1991; Grassman, 2000; Grassman et al., 2005a) used MCP to estimate range use. The fixed kernel core areas were based on the probability that 50% of the range use was within this area rather than simply the innermost 50% of the telemetry locations.

MCP range areas were calculated using the point locations. Ninety-five percent of the telemetry locations were used to estimate range areas, whereas core areas were defined as the innermost 50% of the telemetry locations. Independence of locations was assumed by using 1 location for each 24-h period (Swihart and Slade, 1985). The Animal Movement extension of ArcView Geographic Information System (GIS) software (Environmental Systems Research Institute, Inc., Redlands, CA) was used for range analyses.

Two seasons were classified: dry (1 November to 30 April) and wet (1 May to 31 October). Range information was partitioned according to species, sex, and season. A paired t-test was used to compare seasonal range sizes for leopard cats with enough location points (≥ 40) in wet and dry seasons. Ranges were considered exclusive if the ranges of two animals overlapped $< 10\%$.

The study area was digitized from 1∶50 000 scale topographic maps using ArcView software. Two major vegetation classes were identified from topographic maps and ground-truthing: SEF and GSF. A Chi-square goodness-of-fit test was used to compare the observed number of telemetry locations in each vegetation type with the expected counts to determine if each vegetation type was used in the same proportion as it occurred in the animal range (i.e., no selection). If the Chi-square test showed significant vegetation type selection, a Bonferroni Z-test confidence interval was calculated to determine which vegetation type was selected (Neu et al., 1974).

Activity data were partitioned according to season, sex, and nocturnal-diurnal periods, partitioned into 12 (2 h) periods beginning at 24∶00 h. The diurnal period was defined as 08∶01 – 18∶00 h and the nocturnal period as 20∶01 – 06∶00 h. Dawn (06∶01 – 08∶00 h) and dusk (18∶01 – 20∶00 h) crepuscular periods also were distinguished.

Mean daily distance traveled was calculated by measuring the linear distance between consecutive daily locations (Rabinowitz, 1989; Bailey, 1993). Daily distance information was partitioned according to species, sex, and season.

Leopard cat diet was determined by analyzing scats found at trap locations and along trails and roads. Fecal diameters and the presence of spoor and scrapes in conjunction with feces were used to differentiate feces of leopard cats from other similar-sized species (Grassman[①]). Fecal samples were washed over wire mesh and prey remains were separated and dried. Hair samples were mounted on microscopic slides, examined for cuticular and medullar characteristics, and compared to known specimens in a reference collection at Kasetsart University, Bangkok.

2 Results

2.1 Captures

A total of 5 848 trap nights over 18 months (March 1998 to September 1999) produced 13 leopard cat and 2 clouded leopard captures. Three of the leopard cat

① Grassman LI, Jr, 1997. Ecology and behavior of four sympatric carnivore species (Mammalia: Carnivora) in Kaeng Krachan National Park, Thailand. MSc Thesis. Kasetsart University, Bangkok, Thailand.

captures were juveniles and were not radio-collared. Leopard cats were captured in different vegetation types (i.e., semi-evergreen forest, grassland, secondary-growth forest). Mean weight for leopard cats was $\bar{x}$ = 2.86 kg (n = 12, SD = 0.21). All leopard cats appeared in good health with no significant previous injuries.

A mature female clouded leopard (F59) was captured along a trail in the SEF. During initial inspection F59 appeared thin but otherwise in reasonably good condition. A previous injury to 1 eye was observed during handling, suggesting probable blindness in that eye.

A male clouded leopard (M53) was captured in a large wooden box trap in similar SEF habitat. M53 also had a significant previous injury; an upper canine completely broken about 0.5 cm external from the gum line. The remaining tooth portion was black, worn smooth, and a hole into the root of the tooth was clearly visible. Additionally, M53 had a large tumorous growth on the top and front of the nose. The weight and overall body condition of M53 otherwise appeared healthy.

2.2 Range and habitat use

The mean cross-seasonal range for leopard cats in KYNP was 4.8 km^2 (SD = 2.2) using the MCP method. The fixed kernel method produced a slightly larger range of 5.1 km^2 (SD = 2.9; Table 1). The mean MCP range for male leopard cats was 5.6 km^2 (SD = 2.0), whereas the fixed kernel range was 8.5 km^2 (SD = 3.6). Female F38 showed a pronounced shift in ranges, with pre- and post-shift ranges relatively small with larger fixed kernel ranges (Table 1). Both range analysis methods calculated smaller ranges for female leopard cats in KYNP. The mean cumulative MCP range for female leopard cats was 4.3 km^2 (SD = 2.3). The fixed kernel method showed a slightly smaller range of 4.1 km^2 (SD = 2.0). Male leopard cats M41 and M29 were tracked for 1 and 3 months, respectively, before the conclusion of the field project. Consequently, the sample size of telemetry locations and corresponding ranges for these cats were small. Using fixed kernel results, the mean male range size was considerably larger than the mean range size of females for both seasons. This pattern was similar with MCP results.

Only 5 of the leopard cats produced cross-seasonal data. Seasonal comparison of fixed kernel ranges for F32, F26, F68, F62, and M35 showed no significant (t = 0.65, df = 4, P > 0.55) difference in range size (Table 2). Most leopard cat ranges were exclusive with no overlap.

Interseasonal range comparisons between clouded leopards could not be made due to the limited number of telemetry locations. F59 and M53 were located 3 – 5 times each week for 5 and 3 months, respectively, until late October 1999. Thereafter, an attempt was made to locate each clouded leopard once each week. M53 was tracked another 3.5 months until it was found dead. The cause of death could not be determined because the animal was decomposed when found. However, the tumor or hole through the canine root may have contributed to its death. F59 was tracked another 12 months, and then could no longer be located.

Table 1 Range use (cross-season) by leopard cats in Khao Yai National Park, Thailand, March 1998 – October 1999

Cat ID	n	Minimum convex polygon (km^2)	Fixed kernel (km^2)
F62	145	7.6	6.3
F68	94	2.5	2.1
F26	110	3.8	2.6
F32	156	7.2	5
F71[1]	53	4.7	6.9
M35	173	6.5	5.9
M77[1]	69	8	11.1
M41[2]	27	4	–
M29[2]	16	3.9	–
F38a[3]	82	1.8	2
F38b[4]	54	2.7	3.9
	Mean	4.8	5.1
	SD	2.2	2.9
	Mean (Male)	5.6	8.5
	SD	2	3.6
	Mean (Female)	4.3	4.1
	SD	2.3	2

[1] F71 and M77 ranges represent wet season only.
[2] M41 and M29 ranges represent dry season only.
[3] F38a represents the pre-range shift of F38.
[4] F38b represents the post-range-shift of F38.

Fixed kernel range analysis showed both clouded leopards using large ranges (Table 3; Figs.2 and 3). The cumulative range for F59 (n = 97) was 39.5 km^2 with a small core area of 2.9 km^2. M53 used a cumulative range of 42.2 km^2 (n = 44) and a small core area of 2.9 km^2. There was considerable overlap between the 2 ranges (26.5 km^2) which constituted 67% of F59 range and 59% of M53 range. Through 5 months of tracking, 21% of the location attempts proved unsuccessful for F59 and 19% for M53. This may have affected the range and core area size.

The range of F59 included 20.5 km^2 (52%) of SEF and 19 km^2 (48%) of GSF habitat (Table 3; Fig.2). However, only 21% (n = 20) of the locations were in the GSF vegetation type. Whereas the range of F53 included a smaller proportion of GSF vegetation type (9.5 km^2, 21%) than the F59 range, M53 was found in the GSF vegetation type a greater proportion of relocations (27.3%, n = 12) than F59 (Table 3; Fig.3). M53

Table 2 Seasonal comparison of leopard cat range use in Khao Yai National Park, Thailand, March 1998 – October 1999

Cat ID	Wet season						Dry season				
		Minimum convex polygon (km^2)		Fixed kernel (km^2)				Minimum convex polygon (km^2)		Fixed kernel (km^2)	
	n	Range	Core	Range	Coren		*n*	Range	Core	Range	Core
F62	60	5.4	0.9	6.2	0.9		85	5.9	0.9	6.1	0.8
F68	54	2.5	0.5	2.8	0.3		40	0.9	0.1	1.1	0.1
F26	50	1.9	0.3	2.6	0.3		60	3.5	0.4	2.9	0.4
F32	96	6.2	0.9	5.1	0.6		60	2.9	0.6	3.3	0.4
M35	60	3.4	2	4.9	1.3		113	6.1	1.6	6.2	1.2
F713	53	4.8	1	6.9	1.1		–	–	–	–	–
M77	69	8	2.4	11.1	2.2		–	–	–	–	–
M41	–	–	–	–	–		27	4	–	–	–
M29	–	–	–	–	–		16	3.9	–	–	–
Males (*n* = 2)						Males (*n* = 3)					
$\bar{x}$	–	5.7	2.2	8	1.8	$\bar{x}$	–	4.7	–	–	–
SD	–	3.2	0.3	4.4	0.6	*SD*	–	1.3	–	–	–
Females (*n* = 5)						Females (*n* = 4)					
$\bar{x}$	–	4.2	0.7	4.7	0.6	$\bar{x}$	–	3.3	0.5	3.4	0.4
SD	–	1.9	0.3	2	0.4	*SD*	–	2.1	0.3	2.1	0.3

Table 3 Range-use and vegetation-type composition (95%, fixed kernel) for female (F59) and male (M53) clouded leopards in Khao Yai National Park Thailand, May 1999 – November 2000

Cat ID	Age	*n*	Total area (km^2)	Core area (km^2)	SEF[1] area (km^2)	GSF[2] area (km^2)	# Locations in GSF
F59	PA[3]	97	39.5	2.9	20.5	19	20
M53	PA[3]	44	42.2	2.9	32.7	9.5	12

[1] SEF: semi-evergreen forest. [2] GSF: gravel secondary-forest. [3] PA: prime adult.

used habitat types in proportion to which they occurred in its range ($\chi^2 = 1.04$, $df = 1$, $P > 0.05$). In contrast, F59 used SEF more than it was found in its range ($\chi^2 = 29.14$, $df = 1$, $P < 0.05$; Bonferroni Z-test 90% confidence intervals for SEF were $0.70 \leqslant P_2 \leqslant 0.89$, expected use of SEF was 0.520).

2.3 Activity

Cumulative activity of leopard cats (seasons and sex combined) followed an arrhythmic pattern with activity recorded during 24-h periods (Fig.4). Leopard cats were active 49% ($SD = 8.8$) of the recorded time. Mean activity level during diurnal hours (08:00 – 18:00 h) was 45% ($SD = 6.9$), whereas nocturnal activity increased slightly to 47% ($SD = 6.7$). Increased activity of 63% ($SD = 4.4$) and 63% ($SD = 9.8$) was recorded during the dawn (06:00 – 08:00 h) and dusk (18:00 – 20:00 h) periods, respectively.

There was no significant ($t = 3.14$, $df = 2$, $P = 0.09$) difference between overall wet season activity ($\bar{x} = 49.4\%$, $SD = 7.5$) and dry season activity ($\bar{x} = 50.1\%$, $SD = 7.3$). Wet season mean activity during the crepuscular, nocturnal, and diurnal periods was 60% ($SD = 8.2$), 48% ($SD = 6.3$), and 46% ($SD = 6.4$), respectively. Dry season mean activity during the crepuscular, nocturnal, and diurnal periods was 61% ($SD = 4.2$), 49% ($SD = 5.8$), and 46% ($SD = 5.9$), respectively.

Clouded leopards F59 and M53 showed similar arrhythmic activity patterns with increased nocturnal activity and crepuscular peaks (Fig.5). F59 had an overall activity level of 52% ($SD = 15$) whereas M53 showed a higher overall activity level of 58% ($SD = 25.6$). F59 activity level during diurnal, nocturnal, and crepuscular periods was 47% ($SD = 17.7$), 50% ($SD = 11.2$), and 59% ($SD = 7$), respectively. In contrast, M53 had activity levels of 43% ($SD = 12.6$),

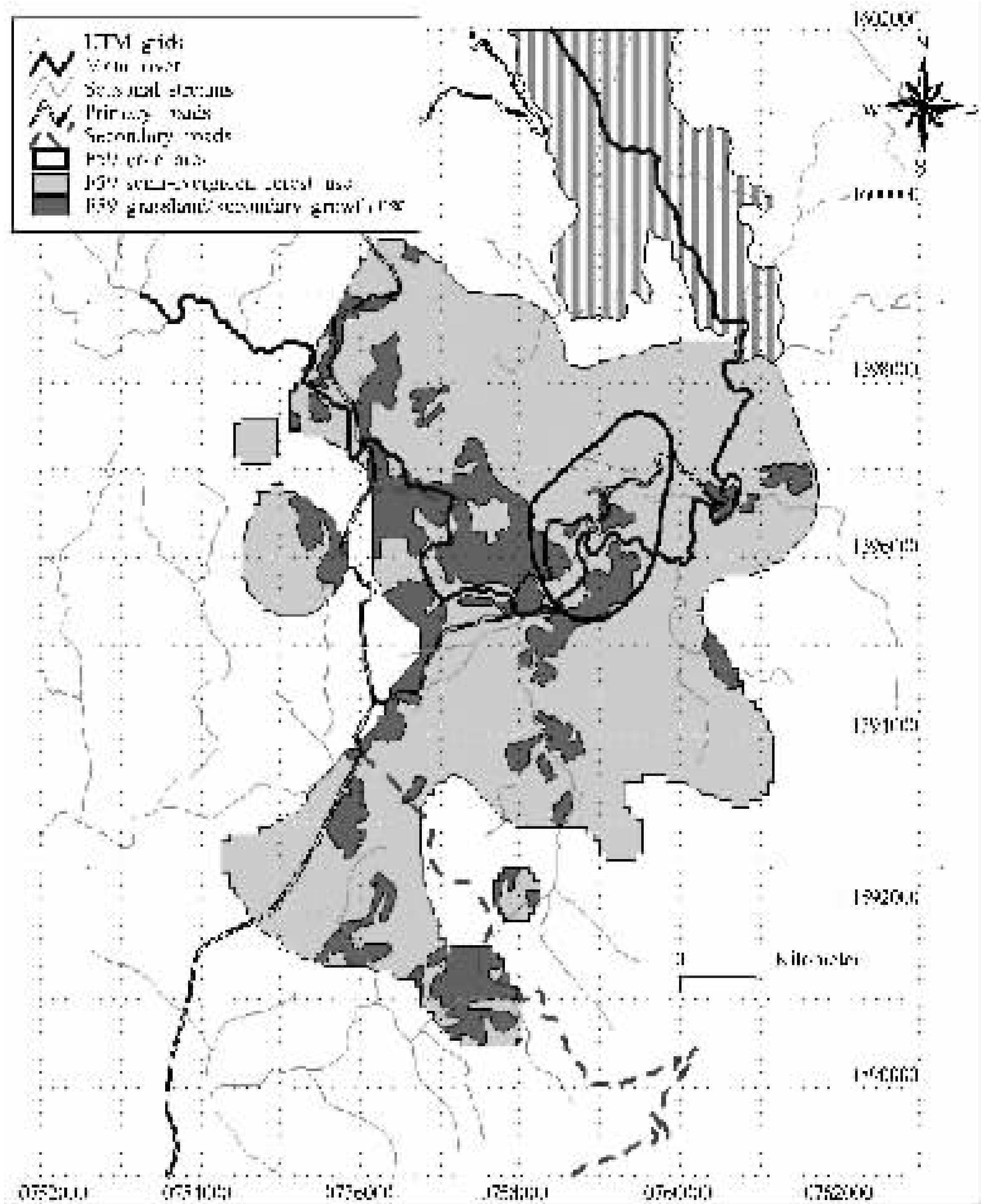

Fig.2　Female clouded leopard (F59) fixed kernel range (95%, $n = 97$), core area, and habitat composition in Khao Yai National Park, Thailand, May 1999 – November 2000

61% ($SD = 29.2$), and 90% ($SD = 2.8$) during the diurnal, nocturnal, and crepuscular periods, respectively. F59 showed greater variation ($SD = 17.7$) in activity during diurnal hours than M53 ($SD = 12.6$). For nocturnal hours the opposite pattern was observed (M53, $SD = 29.2$; F59, $SD = 11.2$).

M53 had 4 nocturnal periods where activity was high (> 85%; Fig.5). The lowest activity (25% and 28%) occurred during 04:01 – 06:00 h and 12:01 – 14:00 h, respectively. The remaining activity percentages ranged between 35% and 58%.

F59 showed similar overall patterns of activity although there were differences in high and low periods. Only 1 period (18:01 – 20:00 h) showed activity > 70%, whereas, 5 periods showed activity greater than 60%. The lowest activity level (22%) of F54 occurred from 10:01 – 12:00 h.

2.4　Daily movements

Overall mean daily movement for leopard cats was 629 m ($SD = 229$; Table 4). Wet season distance was $\bar{x} = 664$ m ($SD = 250$) whereas the dry season distance was $\bar{x} = 590$ m ($SD = 212$). Individual leopard cats displayed seasonal differences in daily movements. F62, M35, and F38b moved a greater distance ($t = 1.25$, $df = 3$, $P = 0.33$) during the dry season than the wet season (Table 4). In contrast, F68, F26, F32, and F38a moved a greater distance ($t = 2.03$, $df = 3$, $P = 0.14$) during the wet season than the dry season. No inter-seasonal comparisons could be made for F71, M77, and M41. An insufficient number of consecutive days

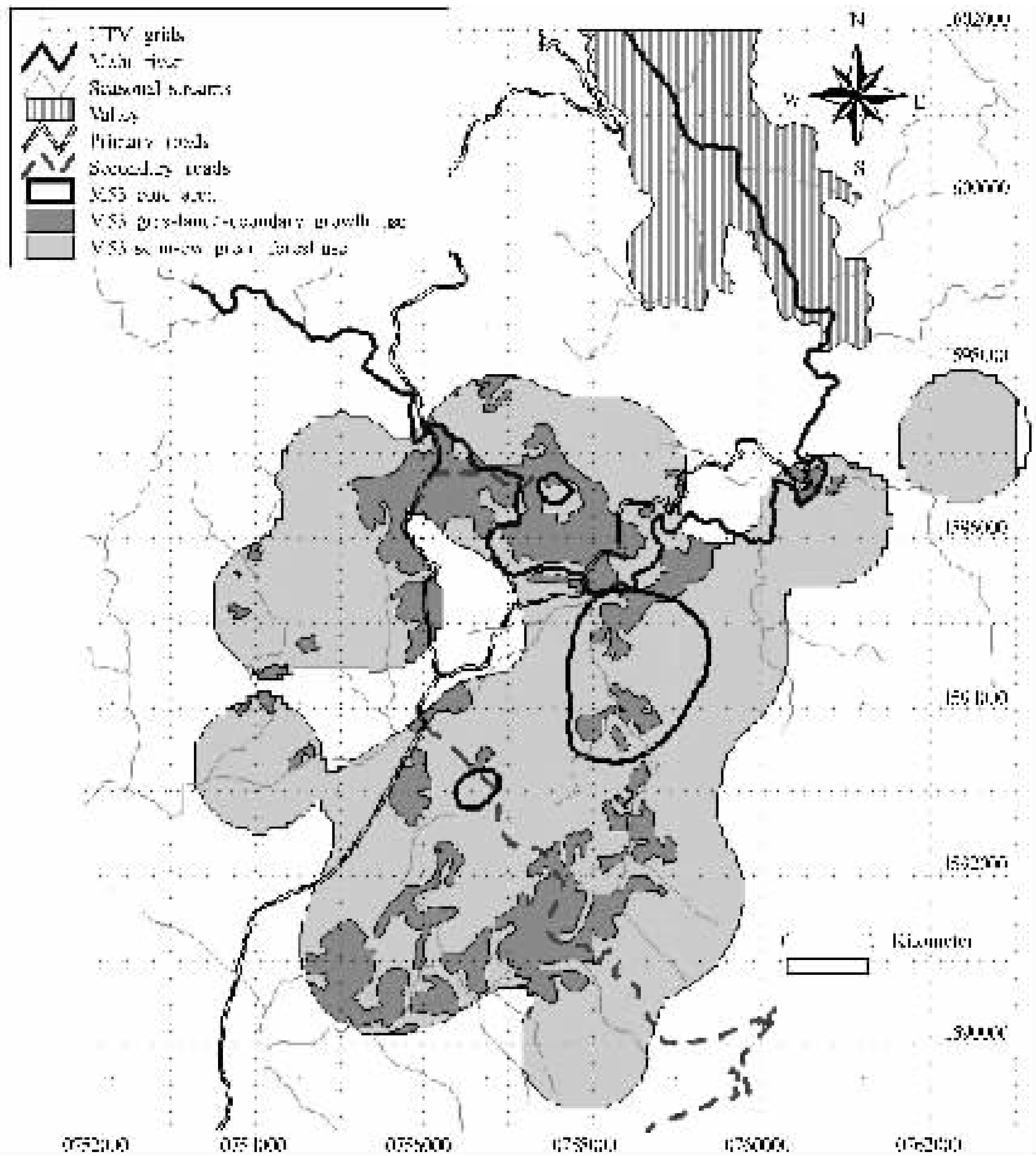

Fig.3 Male clouded leopard（M53）fixed kernel（95%，$n = 44$），core area，and range habitat composition in Khao Yai National Park，Thailand，July 1999 – January 2000

were tracked to determine daily movements for M29. Mean daily movements for males（$n = 3$；$\bar{x} = 830$ m；$SD = 289$）were greater（$t = 0.56$，$df = 1$，$P = 0.68$）than for female（$n = 7$；$\bar{x} = 568$ m；$SD = 177$）leopard cats.

Clouded leopards showed considerable variability in 24-h movement distances. F59 had a mean daily-movement distance of 976 m（$n = 39$，$SD = 751$，range 125 – 4 225 m）. Daily movement for M53 was $\bar{x}$ = 1 167 m（$n = 21$，$SD = 631$，range 275 – 2 600 m）.

2.5 Diet

Leopard cats in KYNP used at least 13 prey species（Table 5）. *Rattus* spp. and *Mus* spp. were the most common prey items found in scats at 53.1% and 28.6%，respectively. Important secondary items included several squirrel species *Tamiops* spp. and *Callioscurius* spp.，common treeshrew *Tupaia glis*，and Siamese hare *Lepus peguensis*. No scats were found that were conclusively attributed to clouded leopards.

3 Discussion

The（MCP）area of use by leopard cats in KYNP（2.54 – 7.61 km^2）was similar to the size of ranges used by leopard cats in Kaeng Krachan National Park，Thailand（KKNP；2.3 – 5.4 km^2；Grassman，2000）and Huai Kha Kang Wildlife Sanctuary，Thailand（HKK；1.5 – 7.5 km^2；Rabinowitz，1990）. Range sizes of leopard cats in KYNP were larger than for leopard cats on Tsushima Island，Japan. However，Tsushima leopard cats occupy a small island（ca 100 km^2）that has a relatively

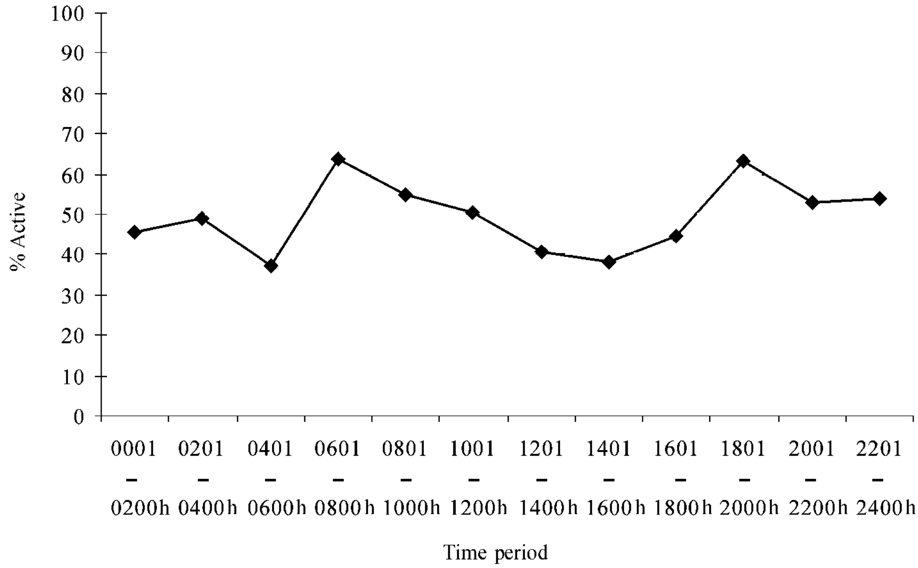

Fig.4 Cumulative activity (% active) of leopard cats ($n = 10$) in Khao Yai National Park, Thailand, March 1998 – October 1999

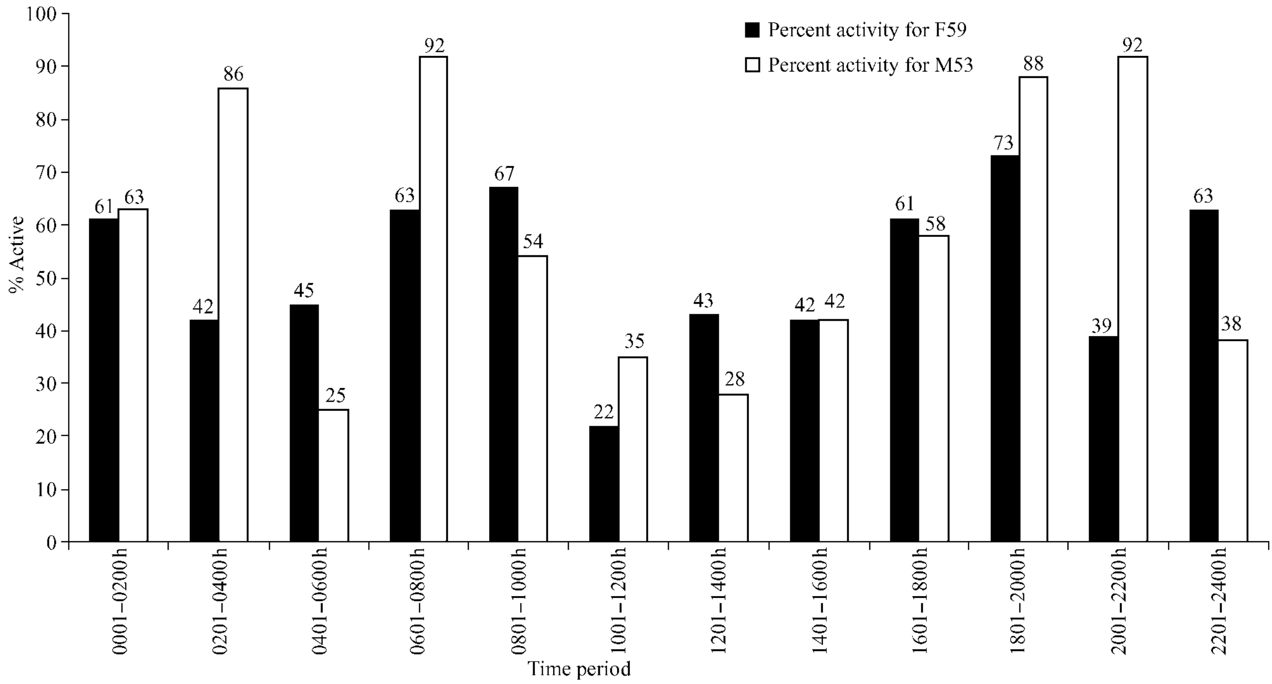

Fig.5 Comparison of overall activity levels of F59 ($n = 525$) and M53 ($n = 217$) clouded leopards in Khao Yai National Park, Thailand, May 1999 – October 1999

high population (ca 49 000 humans), and consists primarily of secondary forest (Izawa et al., 1991).

F68 and F38 appeared pregnant upon capture. This possibility was supported by the smaller ranges occupied during the few months following capture. Female cats raising young tend to occupy smaller ranges and forage over smaller areas (Knowles, 1985; Bailey, 1993; Lovallo and Anderson, 1996). F38's range doubled following a range shift that occurred 9 months after capture. F68 used 1.10 km^2 during the first 4 months of tracking and expanded to 2.75 km^2 the next 4 months.

Male and female leopard cats in KYNP had larger ranges during the wet season than during the dry season. This range pattern concurs with previous studies of leopard cats in Thailand (Rabinowitz, 1990; Grassman, 2000) although in KKNP the difference for the 1 female was slight (Grassman, 2000). In contrast, ocelots *Leopardus pardalis* in tropical regions used larger ranges during the dry season (Ludlow and Sunquist, 1987). An important seasonal difference in KKNP was the lack of many seasonal streams during the dry season. This lack of water sources possibly affects behavioral patterns of leopard cats

Table 4 Seasonal mean dustance traveled by leopard cats during a 24-h period in Khao Yai National Park, Thailand, March 1998 – October 1999

Cat ID	Season	n	Mean daily distance (m)	Range (m)	SD
F62	Wet	21	541	125 – 1 150	105.1
	Dry	39	647.5	125 – 1 450	345.4
F68	Wet	26	581	75 – 1 300	485.8
	Dry	16	412.5	75 – 775	135.5
F26	Wet	32	674	250 – 1 250	85
	Dry	12	652	125 – 1 425	145.2
F32	Wet	21	880	125 – 1 375	335.4
	Dry	34	523	125 – 950	310.2
F38a[1]	Wet	27	392	75 – 825	185
	Dry	31	331	0 – 640	135.6
F38b[2]	Wet	19	421	250 – 725	135.2
	Dry	16	438	125 – 750	275
F71	Wet	17	891.9	425 – 1 325	225.5
Female Mean			568		
M35	Wet	18	476	150 – 1 150	210.1
	Dry	41	995.8	177 – 1 250	145.1
M77	Wet	21	1 124.3	475 – 1 525	83.4
M41	Dry	8	723	50 – 1 250	245
Male mean			830		

[1] F38a represents the pre-range shift of F38.
[2] F38b represents the post-range shift of F38.

Table 5 Prey items identified in leopard cat feces (n = 49) from Khao Yai National Park, Thailand, March 1998 – October 1999

Prey items	Frequency of occurrence	
	n	%
Muridae		
Rattus spp.	26	53.1
Mus spp.	14	28.6
Tupaiidae		
Tupaia glis	7	14.3
Sciuridae		
Tamiops spp.	4	8.2
Callioscurius spp	2	4.1
Leporidae		
Lepus peguensis	3	6.1
Pteropodidae		
Rousettes leschenaulti	1	2
Cervidae		
Cervus unicolor	1	2
Insects	7	14.3
Termites	10	20.4
Birds	4	8.2
Snakes	4	8.2
Crab	1	2

and their prey. Rabinowitz (1990) speculated that seasonal changes in range patterns of leopard cats may have been influenced by changes in small mammal distributions.

We assumed that each leopard cat did not have access to all habitat areas in the study area because of intraspecific competition. Thus, habitat preferences were determined by vegetation type use within an established range. The leopard cats in KYNP, except M35 during the dry season, used both vegetation types in proportion to their occurrence in the respective ranges. Consequently, there was no significant selection for or against SEF or GSF. Thus, habitat use by leopard cats in KYNP concurs with literature that suggests these felids are habitat generalists (Boorer, 1970; Harrison, 1974; Lekagul and McNeely, 1977; Corbet and Hill, 1992; Kanchanasakha et al., 1998). Habitat use by M53 was atypical with wet and dry season ranges consisting of a much greater proportion of GSF than other leopard cat ranges. Boorer (1970) indicated that leopard cats preferred secondary forest and avoided the most dense forests. M35 occupied an area with a high proportion of GSF and used it disproportionately during the dry season. Rabinowitz (1990) cautioned that although leopard cats are ecologically flexible, extensive habitat alterations can harm local population sizes and long-term population survival.

Most of the radio-collared leopard cats had ranges that were spatially separated and thus precluded overlap although some ranges exhibited minor overlap. The range analysis method also affected the amount of overlap. Seasonal overlap varied between female leopard cats. Female leopard cats are similar to other small felids and exhibit a variety of range use patterns. Ludlow and Sunquist (1987) suggested that female felids may partially overlap ranges, have distinct core areas, or occupy small, exclusive ranges.

Leopard cats in KYNP exhibited arrhythmic activity. Most felids seem adapted to hunting during the day and night (Ewer, 1973). Leopard cat activity increased during nocturnal hours and peaked during crepuscular hours. Exceptions were leopard cats M35 and F71 that displayed greater activity during diurnal hours than nocturnal hours. Activity patterns of leopard cats in KYNP were similar to the patterns of leopard cats in other forested areas in Thailand (Rabinowitz, 1990; Grassman, 2000, 2005a). Overall activity of leopard cats in KYNP (49%) was similar to leopard cats in KKNP (47%; Grassman, 2000) and in HKK Wildlife Sanctuary (50%; Rabinowitz, 1990). These high levels of circadian activity seemed typical for solitary felids. Sunquist (1981) found tigers active 15 – 16 hours/day and Rabinowitz and Nottingham (1986) reported jaguars *Panthera onca* active about 13 hours/day.

Arrhythmic activity allows an animal to forage anytime, thereby increasing access to available prey (van Schaik and Griffiths, 1996). Similarly, Rabinowitz (1990) suggested arrhythmic activity patterns of predators increased the exploitation of a diverse prey base. Leopard cats in KYNP consumed at least of 13 prey items, including nocturnal and diurnal prey species, which indicates foraging throughout a 24-h period.

Mean activities for the 3 temporal phases (i.e., diurnal, nocturnal, crepuscular) were slightly higher during the dry season than the wet season. This contrasts with range sizes which were smaller during the dry season than the wet season. Two previous leopard cat studies found wet season activity greater than dry season activity. None of the seasonal differences between the temporal phase activity was > 1% indicating little seasonal influence on the activity of KYNP leopard cats. Rabinowitz (1990) attributed seasonal change in the activity of leopard cats in HKK Wildlife Sanctuary to changes in prey distribution. This change also corresponded with greater differences in other seasonal variables in HKK (i.e., seasonal variability in temperature, habitat types, and susceptibility to forest fires). Grassman (2000) found a similar small change in activity across seasons in KKNP which has similar habitat, topography, and climate to KYNP. The relatively uniform seasonal activity patterns observed in this study were likely related to stable seasonal prey abundance, limiting the need for temporal changes in leopard cat foraging activity.

There was no consistent seasonal pattern of daily movements among leopard cats in KYNP. Mean wet (747 m) and dry (590 m) season daily movements in KYNP were lower but similar to the overall mean daily movement of leopard cats in KKNP (830 m; Grassman, 2000) and HKK Wildlife Sanctuary (780 m; Rabinowitz, 1990). The similarity in daily movements between leopard cats in KYNP and other study areas suggests a comparable prey density. Felids that inhabit areas with low prey density have been recorded as traveling greater distances as a foraging strategy (Knowles, 1985, Litvaitis et al., 1986).

Male leopard cats in KYNP moved a greater distance than females. This disparity between felid sexes is probably related to male requirements for covering longer distances for reproductive and energy requirements. Behavior of female felids is more closely related to resources and the responsibility of raising young. This results in relatively smaller ranges and shorter distances traveled by females (Ludlow and Sunquist, 1987).

Prey use by leopard cats in KYNP was similar to leopard cat diets recorded in other studies (Rabinowitz, 1990; Tatara and Doi, 1994; Grassman, 2000; 2005a) where rodents made up a dominant proportion of prey. Most predators tend to take prey within their size range (Ewer, 1973) and tropical felids tend to take prey items up to their maximum prey size (Kitchener, 1991). The maximum prey size that a cat species can kill is related to its body size; the larger the cat, the larger the prey (Kitchener, 1991). It follows that rats and mice were the most common prey for leopard cats in KYNP followed by tree shrews and squirrels.

Both clouded leopard captures occurred within a 2-month period, following 15 months of trapping and 4 606 trap nights. Before the initial capture there were numerous clouded leopard sightings along roads and 7 camera-trap photos along trails (Austin and Tewes, 1999) suggesting clouded leopards used these travel routes in the same way as other large felids (Schaller, 1967; Sunquist, 1981; Rabinowitz and Nottingham, 1986). Because of the number of trap nights and numerous locations where traps were placed, we believe that clouded leopards were encountering traps but not entering them. At the capture location of the male clouded leopard, a different clouded leopard had been previously photographed and a live-trap had been open for 15 months.

Between May 1999 and November 1999, M53 could not be located 19% of the attempts and F59 could not be located 21% of attempts. Inability to find the clouded leopards increased when locations were attempted once each week. Thus about 20% of the attempted locations could not be established. Consequently, the range estimates in this study are conservative and ranges were probably larger. Core areas also probably would have been larger if F59 and M53 had been located for all attempts.

Range dynamics of a carnivore are dependent on a variety of factors including prey biomass and availability (Norton and Henley, 1987), metabolic requirements (Gittleman and Harvey, 1982), habitat composition (Macdonald, 1983), intra- and inter-specific carnivore densities (Knowles, 1985; Litvaitis et al., 1986), seasonal trends (Crawshaw and Quigley, 1991; Wolda, 1983), age, and sex (Bailey, 1993). Generally, the range size of an animal scales linearly with its body mass (Harestad and Bunnel, 1979; Linstedt et al., 1986; Swihart et al., 1988). Clouded leopards of this study did not fit this expected pattern, perhaps due to their previous injuries. Larger felids in Thailand such as leopards *Panthera pardus* have correspondingly larger ranges and body weights (18 km^2, 40 kg; Grassman, 1999; 27 km^2, 60 kg; Rabinowitz, 1989). Thus, based on body size, clouded leopards used areas larger than expected. However, clouded leopard home range sizes (95% MCP estimator) for 4, radio collared cats in Phu Khieo Wildife Sanctuary, Thailand averaged 23 – 45 km^2 (Grassman et al., 2005b), similar to clouded leopards in this study, indicating that larger ranges may be necessary to fulfill the ecological requirements of clouded leopards.

The study area in KYNP was relatively homogenous in terms of prey and habitat. Likely prey species (e.g., sambar, barking deer and macaques) for clouded leopards and all representative vegetation types could be found in all parts of the range. Thus, these factors would not explain the need for disproportionately large ranges. Both clouded leopards may have been behaving atypically because of significant previous injuries and were therefore covering larger areas in search of specific prey.

Tigers occured at low densities in the study area and throughout the park, with perhaps 2 – 3 individuals using the study area (Lynam et al.①). Whereas tigers and leopards partition habitat spatially, temporally, and by prey size (Seidensticker, 1976), it is unlikely that the clouded leopards altered their behavior significantly because of the few resident tigers. Rabinowitz (1989) found leopards did not show subordinate behavior patterns toward sympatric tigers when tiger density was low. Because similar low tiger densities occurred in the KYNP study area, effects on clouded leopard behavior were probably minimal.

There was considerable range overlap between clouded leopards with 66% of the female range encompassed by the male range. This example of range use is similar to that exhibited by other felids. The bobcat *Lynx rufus*, ocelot, mountain lion *Puma concolor*, jaguar, leopard, and tiger have been shown to use a social system in which 1 adult male occupies a relatively exclusive range that overlaps with that of 1, or more commonly, several females (Muckenhirn and Eisenberg, 1973; Seidensticker et al., 1973; Bailey, 1974; Schaller and Crawshaw, 1980; Sunquist, 1981; Tewes②).

Use of vegetation types by clouded leopards concurred with most sighting accounts and camera-trapping information that clouded leopards in the study area used primary evergreen forest even when other habitats were available. This cat is ecologically flexible and may use selectively logged forest (Rabinowitz et al., 1987), tall grassland and marginal scrub forest (Dinerstein and Mehta, 1989), and dipterocarp forest (Santiapillai and Ashby, 1988) when needed. Whereas the range of F59 and M53 included areas of grassland and secondary growth forest, relatively few locations occurred in these vegetation types.

The anatomical characteristics (i.e., short legs, large paws, long tail) suggest the clouded leopard is partly arboreal (Gonyea, 1976; Taylor, 1989). Clouded leopard use of SEF allowed access to vertical levels of habitat and subsequently a wider prey base. Previous reports that clouded leopards used other habitat types may be a result of limited access to primary forest. Use of vertical habitats in primary forest also could reduce competition with terrestrial carnivores.

Mean daily distances the female ($\bar{x}$ = 976 m) and male ($\bar{x}$ = 1 167 m) clouded leopards traveled matched the pattern expected for a carnivore of this size. These distances were greater than recorded for small tropical felids such as leopard cats ($\bar{x}$ = 846 m; Rabinowitz, 1990) and less than for the larger leopard ($\bar{x}$ = 1 700 m; Grassman, 1999). The high standard deviations indicated a high degree of variability in distances traveled. The method to determine daily movement measures a straight line between two consecutive locations, a method that does not incorporate meandering or additional distance traveled due to topography.

Lekagul and McNeely (1977) and Kanchanasakha et al., (1998) suggested clouded leopards are strictly nocturnal. Both clouded leopards exhibited arrhythmic activity patterns with peaks during crepuscular hours. Although some diurnal activity was recorded (43% and 47%), nocturnal activity was common. Arrhythmic activity allows foraging throughout a 24-h period, and therefore access to a greater prey base than only foraging during diurnal or nocturnal periods. Foraging during all time periods of the day would minimize and reduce competition with strictly nocturnal or diurnal carnivores. van Schaik and Griffiths (1996) found that strictly arboreal animals are either nocturnal or diurnal whereas terrestrial animals are primarily arrhythmic. Thus, the arrhythmic activity patterns of F59 and M53 support the hypothesis that clouded leopards are not strictly arboreal and may use trees primarily as resting places (Rabinowitz et al., 1987).

Despite the data provided by this project, there remains a conspicuous lack of information on tropical felids, particularly in Southeast Asia. The logistical difficulties in tropical field research are compounded by the secretive behavior of these species. Tropical felids are often difficult to observe and usually difficult to capture. This study provided baseline natural history information on 2 felids and created a reference from which other species and populations can be compared. Such information can be entered into existing databases (Round, 1989) and later included in future conservation planning and wildlife management.

Historically, Thailand has had a relatively good record of wildlife and natural resource conservation (Jintanugool et al., 1982). However, more specific natural history information on the native fauna of the country and greater region is needed. Critical information includes minimum range area requirements, habitat preferences, social organization, and prey selection. Additionally, as regional economies and subsequent

① Lynam AJ, Rabinowitz A, Brockelman WY, 2000. Effects of human landuse on faunal abundance in some Thai forest reserves. Final Report to the National Research Council of Thailand, Bangkok, Thailand.

② Tewes ME, 1986. Ecological and behavioral correlates of ocelot spatial patterns. Ph.D. Dissertation. University of Idaho, Moscow, Idaho.

tourism in developing countries of Southeast Asia increase, anthropogenic pressure on flora and fauna of protected areas also will increase. Thus, wildlife managers need to make conservation and management decisions based on sound biological information rather than speculation.

Additional studies may reveal if the results found herein are broadly representative of the species in other areas or specific to the KYNP study area. More information on all areas of the natural history of these species is needed to provide wildlife managers with the necessary tools to make informed management decisions.

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References

Austin SC, Tewes ME, 1999. Ecology of the clouded leopard in Khao Yai National Park, Thailand. Cat News 31: 17 – 18.

Bailey T, 1974. Social organization in a bobcat population. J. Wildl. Manage. 50 (1): 110 – 117.

Bailey T, 1993. The African Leopard: Ecology and Behavior of a Solitary Felid. New York: Columbia University Press, 429.

Boorer M, 1970. Wild Cats. New York: Grosset and Dunlap, Inc., 159 p.

Brander RB, Cochran WW, 1971. Radio location telemetry. In: Giles RH ed. Wildlife Management Techniques. Washington, D.C.: The Wildlife Society, 507 – 520.

Choudhury A, 1993. The clouded leopard in Assam. Oryx. 27: 51 – 53.

Corbet GB, Hill JE, 1992. The mammals of the Indomalayan region: a systematic review. Oxford, England: Oxford University Press, 496.

Crawshaw P, Jr, Quigley HB, 1991. Jaguar spacing, activity and habitat use in a seasonally flooded environment in Brazil. J. Zool. London. 223: 357 – 370.

Davies RG, 1990. Sighting of a clouded leopard *Neofelis nebulosa* in a troop of pigtail macaques in Khao Yai National Park. Nat. Hist. Bull. Siam Soc. 28: 95 – 96.

Dinerstein E, Mehta JN, 1989. The clouded leopard in Nepal. Oryx 23: 199 – 201.

Eaton RL, 1973. The smaller cats. In: Gittleman JL ed. Carnivore Behavior, Ecology, and Evolution. Ithaca, New York: Cornell University Press, 1 – 9.

Eisenberg JF, 1991. The density and biomass of tropical mammals. In: Soule ME, Wilcox BA ed. Conservation Biology. Sunderland, Massachusetts: Sinauer Assoc., Inc., 35 – 55.

Ewer RF, 1973. The Carnivores. Ithaca, New York: Cornell University Press, 494.

Gittleman JL, Harvey PH, 1982. Carnivore home-range size, metabolic needs and ecology. Behav. Ecol. Sociobiol. 10: 36 – 57.

Gonyea WJ, 1976. Adaptive differences in the body proportions of large felids. Acta Anat. 96: 81 – 96.

Grassman LI, Jr, 1999. Ecology and behavior of the Indochinese leopard in Kaeng Krachan National Park, Thailand. Nat. Hist. Bull. Siam Soc. 47: 77 – 93.

Grassman LI, Jr, 2000. Movements and diet of the leopard cat *Prionailurus bengalensis* in a seasonal evergreen forest in south-central Thailand. Acta Theriol. 45: 421 – 426.

Grassman LI, Jr, Austin SC, Tewes ME, Silvy NJ, 2004. Comparative immobilization of wild felids in Thailand. J. Wildl. Diseases 40: 575 – 578.

Grassman LI, Jr, Tewes ME, Silvy NJ, Kreetiyutanont K, 2005a. Spatial organization and diet of the leopard cat *Prionailurus bengalensis* in north-central Thailand. J. Zool. Lond. 266: 45 – 54.

Grassman LI, Jr, Tewes ME, Silvy NJ, Kreetiyutanont K, 2005b. Ecology of three sympatric felids in a mixed evergreen forest in north-central Thailand. J. Mammal. 86: 29 – 38.

Green R, 1991. Wild Cat Species of the World. Plymouth, Devon, England: Basset Publications, 131.

Grzimek B, 1975. Small felids and clouded leopards. In: Grzimek B ed. Grzimeks Animal's Life Encyclopedia, Vol. 12. New York: Van Norstrand Reinhold, 281 – 332.

Guggisberg CAW, 1975. Wild Cats of the World. New York: Taplinger Publishing Co., Inc., 328.

Harestad AS, Bunnell FL, 1979. Home range and body weight—a reevaluation. Ecology 60: 389 – 402.

Harrison J, 1974. An Introduction to Mammals of Singapore and Malaya. Singapore: Malayan Nature Society, 340.

Hart D, 1994. *Felis bengalensis*: the Status of Asian Leopard Cat Populations and Trade: Report to the Ninth Conference of the Parties to the Convention on International Trade in Endangered Species. Ft. Lauderdale. Washington, D.C.: International Wildlife Coalition, 22.

IUCN-The World Conservation Union, 2006. Red List of Threantened Animals. Gland, Switzerland: IUCN.

Izawa MT, Doi T, Ono Y, 1991. Ecological study on two species of Felidae in Japan. In: Maruyama N ed. Wildlife Conservation: Present Trends and Perspectives for the 21st Century. Yokohama, Japan: Proc. V. Int. Congr. Ecol. 141 – 143.

Jintanugool J, Eudey AA, Brockelman WY, 1982. Species conservation priorities in Thailand. In: Mittermeier RA, Konstant WR ed. Species Conservation Priorities in the Tropical Forests of Southeast Asia. Proceedings of Symposium held on 4 October 1982 in Kuala Lumpur. Gland, Switzerland: IUCN, 41 – 51.

Johnson K, Jinping Y, 1996. The leopard cat in China: ecology and management for sustainable utilization. Final report to the Cites Secretariat. Geneva, Switzerland: CITES, 853.

Kanchanasakha B, Simcharoen S, Than UT, 1998. Carnivores of Mainland Southeast Asia. Bangkok, Thailand: Siam Tong Kit Printing Co., Ltd., 236.

Kitchener A, 1991. The Natural History of the Wild Cats. Ithaca, New York: Cornell University Press, 280.

Knowles PR, 1985. Home range size and habitat selection of bobcats *Lynx rufus* in north-central Montana. Canad. Field Natural. 99: 6 – 12.

Lekagul B, McNeely JA, 1977. Mammals of Thailand. Bangkok, Thailand: Association for Conservation of Wildlife, 758.

Linstedt SL, Miller BJ, Buskirk SW, 1986. Home range, time and body size in mammals. Ecology 67: 413 – 418.

Litvaitis JA, Sherburne JA, Bissonette JA, 1986. Bobcat habitat use and home range size in relation to prey density. J. Wildl. Manage. 50: 110 – 117.

Lovallo MJ, Anderson EM, 1996. Bobcat *Lynx rufus* home range size and habitat use in northwest Wisconsin. Am. Midl. Nat. 135: 241 – 252.

Ludlow ME, Sunquist ME, 1987. Ecology and behavior of ocelots in Venezuela. Nat. Geo. Res. 3: 447 – 461.

Macdonald DW, 1983. The ecology of carnivore social behavior. Nature 301: 379 – 384.

Mehta JN, Dhewaju FG, 1990. A note on the record of clouded leopards in

Nepal. Tigerpaper 7: 21 – 22.
Mohr CO, 1947. Tanle of equivalent populations of North American small mammals. Am. Midl. Nat. 37: 223 – 249.
Muckenhirn NA, Eisenberg JF, 1973. Home ranges and predation of the Ceylon leopard. In: Eaton RL ed. The World's Cats, Vol. 1. Winston, Oregon: World Wildlife Safari, 142 – 175.
Muul I, Lim BL, 1970. Ecological and morphological observations of *Felis planiceps*. J. Mammal. 51: 806 – 808.
National Park Division, 1987. Khao Yai National Park management plan, 1987 – 1991. Bangkok, Thailand: Royal Forest Department.
Neu CW, Byers CR, Peek JM, 1974. A techinque for analysis of utilization-availability data. J. Wildl. Manage. 38: 541 – 545.
Norton PM, Henley SR, 1987. Home range and movements of male leopard in the Cedarburg Wilderness Area, Cape Province. S. Afr. J. Wildl. Res. 17: 41 – 48.
Nowell K, Jackson P, 1996. Wild Cats: Status Survey and Conservation Action Plan. Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources.
Powell RA, Zimmerman JW, Seaman DE, 1997. Ecology and Behaviour of North American Black Bears: Home Ranges, Habitat Selection and Social Organization. London, England: Chapman and Hall, 205.
Rabinowitz A, Nottingham B, 1986. Ecology and behavior of the jaguar *Panthera onca* in Belize, Central America. J. Zool. London 210: 149 – 159.
Rabinowitz A, 1988. The clouded leopard in Taiwan. Oryx 22 (1): 46 – 47.
Rabinowitz A, 1989. The density and behavior of large cats in a dry tropical forest mosaic in Huai Kha Khaeng Wildlife Sanctuary, Thailand. Nat. Hist. Bull. Siam Soc. 37: 235 – 251.
Rabinowitz A, 1990. Notes on the behavior and movements of leopard cats *Felis bengalensis* in a dry tropical forest mosaic in Thailand. Biotropica 22: 397 – 403.
Rabinowitz A, Andau P, Chai PPK, 1987. The clouded leopard in Malaysian Borneo. Oryx 21: 107 – 111.
Round PD, 1989. Monitoring the conservation status of species and habitats in Thailand. Tigerpaper 16: 20 – 27.
Santiapillai C, 1989. The status and conservation of the clouded leopard *Neofelis nebulosa diardi* in Sumatra. Tigerpaper 14: 1 – 7.
Santiapillai C, Ashby KR, 1988. The clouded leopard in Sumatra. Oryx 22: 44 – 45.
van Schaik CP, Griffiths M, 1996. Activity periods of Indonesian rain forest mammals. Biotropica 28: 105 – 112.
Schaller GB, 1967. The Deer and the Tiger: a Study of Wildlife in India. Chicago, Illinois: University of Chicago Press, 370.
Schaller GB, Crawshaw PG, 1980. Movement patterns of the jaguar. Biotropica 12: 161 – 168.
Seidensticker JM, 1976. On the ecological separation between tigers and leopards. Biotropica 8: 225 – 234.
Seidensticker JM, Hornocker MG, Wiles WV, Messick JP, 1973. Mountain lion social organization in the Idaho Primitive Area. Wildl. Monogr. 35: 1 – 60.
Selous EM, Banks E, 1935. The clouded leopard in Sarawak. J. Sarawak Mus. 4: 263 – 266.
Srikosamatara S, Hansel T, 1996. Mammals of Khao Yai National Park. Ammarind Ltd., Bangkok, Thailand.
Sunquist ME, 1981. The social organization of tigers *Panthera tigris* in Royal Chitwan National Park, Nepal. Smithsonian Contrib. Zool. 336: 1 – 98.
Sunquist M, Sunquist F, 2002. Wild Cats of the World. Chicago: The University of Chicago Press, 452.
Swihart RK, Slade NA, 1985. Testing for independence of observations in animal movements. Ecology 66: 1 176 – 1 184.
Swihart RK, Slade NA, Bergstrom FJ, 1988. Relating body size to the rate of home range use in mammals. Ecology 69: 393 – 399.
Tatara M, Doi T, 1994. Comparative analyses on food habits of Japanese marten, Siberian weasel and leopard cat in the Tsushima Islands, Japan. Ecol. Res. 9: 99 – 107.
Taylor ME, 1989. Locomotor adaptations by carnivores. In: Gittleman JL ed. Carnivore Behavior, Ecology, and Evolution, Vol. 1. Ithaca, New York: Comstock Publ., 382 – 409.
Wolda H, 1983. Spatial and temporal variation in abundance in tropical animals. In: Sutton SL, Whitmore TC, Chadwick AC ed. Tropical Rainforests: Ecology and Management. London: Blackwell Science Publishing, 93 – 105.
Yamada JK, Durrant BS, 1989. Reproductive parameters of clouded leopards *Neofelis nebulosa*. Zoo Biol. 8: 223 – 231.