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Home range size and daytime habitat selection of leopards in Huai Kha Khaeng Wildlife Sanctuary, Thailand

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ABSTRACT

Leopards (*Panthera pardus*) are endangered in South East Asia yet little is known about which resources need to be secured for their long-term conservation or what numbers of this species this region can support. This study uses radio telemetry to investigate seasonal variation in habitat selection and home range size of Leopards in Huai Kha Khaeng Wildlife Sanctuary, Thailand. Over a five year period, 3690 locations were recorded from nine individuals. The mean ± standard error of fixed kernel home range size for six adult females was 26 ± 8.2 km^2, for two adult males was 45.7 ± 14.8 and for two sub-adult females was 29 km^2 ± 5.5. Adult female wet and dry season home range sizes did not differ significantly. One adult male showed an increase in home range size from dry to wet seasons. Estimated density was 7 adult females/100 km^2, which suggests 195 adult female leopards living in Huai Kha Khaeng alone, thus highlighting the larger Western Forest Complex's potential contribution to leopard conservation. Compositional analysis of second and third order habitat selection suggested mixed deciduous and dry evergreen forest types, flat slope and areas close to stream channels are important landscape features for leopards. These results can help formulate a much needed conservation strategy for leopards in the region.
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1. Introduction

The leopard (*Panthera pardus*) is a widespread but endangered large felid. Habitat destruction, poaching and prey depletion have created a discontinuous patchwork of leopard populations throughout Asia, Africa, the Middle East and south eastern Europe (Bailey, 1993; Uphyrkina et al., 2001). Persecution of leopards has led to listing of the species on Appendix 1 of the Convention of International Trade of Endangered Species of Wild Fauna and Flora.

In Thailand, leopards are particularly threatened with habitat loss and prey depletion (Rabinowitz, 1989; Grassman, 1999), and there are few contiguous areas left where large cats such as the leopard have a chance of long-term survival (Trisurat, 2006). Without research-based conservation planning in the region, remaining leopard populations face an uncertain future (Rabinowitz, 1989; Weber and Rabinowitz, 1996).

An essential component of conservation planning is identifying important resources that relate to population persistence (Alldredge and Ratti, 1992; Marker and Dickman, 2005). The "importance" of a resource can be measured by its perceived contribution to an animal's survival or reproduction (Garshelis, 2000). However, for short-term conservation planning it is necessary to identify key resources during the considerable time needed to investigate habitat-specific

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demographic parameters for long-lived animals with low reproduction rates such as the leopard (Nielson et al., 2006). Importance can potentially be inferred by 'habitat selection" which refers to a behavioral response resulting in disproportionate use of habitat types that may affect the animal's fitness (Block and Brennan, 1999). Habitat selection may vary due to seasonal variation in resource availability, so studies should take this into account to identify resources important at only certain times of year (Schooley, 1994).

Although habitat selection for leopards is covered by some studies (Bailey, 1993; Marker and Dickman, 2005), information is lacking for Asia. A camera trap study in Kaeng Krachen National Park in Thailand found that leopard habitat use increased with distance from human habitation (Ngoprasert et al., 2007). However, no study in Thailand has conclusively identified, either seasonally or otherwise, leopard selection of other geographical features likely to influence their distribution, such as forest type, topography or water courses.

In addition, management will benefit from improved understanding of leopard home range, which can be considered a more-or-less restricted area where an animal moves during its normal activities (Harris et al., 1990). Information on leopard home range size will allow managers to assess population status and model responses to different threat scenarios. Information regarding leopards' spatial requirements and habitat needs can then be used with existing satellite coverages to guide management of the species on a landscape-level, as has been done for tigers (*Panthera tigris*) (Sanderson et al., 2006).

Considering the leopard's elusive nature and naturally low densities, radio telemetry is probably the best available means to investigate both habitat selection and home range size (Bailey, 1993). This technique has been used extensively in the leopard's African range (Norton and Lawson, 1985; Bailey, 1993; Jenny, 1996; Mizutani and Jewell, 1998; Marker and Dickman, 2005). In Asia it has been used in Nepal (Seidensticker, 1976; Sunquist, 1983; Odden and Wegge, 2005), India (Karanth and Sunquist, 1995, 2000) and Thailand (Rabinowitz, 1989; Grassman, 1999). Rabinowitz (1989) collected telemetry data on two leopards in Huai Kha Khaeng Wildlife Sanctuary, and Grassman (1999) collected data on three leopards in Kaeng Krachen National Park. Both studies suggested there may be slight increases in male leopard home range size during the wet season, possibly in response to wider dispersion of prey (Rabinowitz, 1989; Grassman, 1999).

We conducted a radio telemetry study in Huai Kha Khaeng Wildlife Sanctuary (HKK), Thailand to investigate seasonal variation in (1) home range size and (2) selection of vegetation, slope and stream habitat types. We chose to focus on second and third order habitat selection, which reflects an animal's choice of a home range within the landscape and habitat patches within a home range, respectively (Johnson, 1980). We also included analysis of combined season habitat selection to determine if this pooled data source would have failed to identify temporally important resources, as has been noted for other studies (Schooley, 1994). To give an indication of population status for the area, we estimated density of adult female leopards.

Rabinowitz's (1989) previous study of leopards in HKK established the trapping and monitoring methodology outlined in this paper. Our investigation builds substantially on this earlier work by taking advantage of the largest sample size of its kind in Asia, a longer study time and the development of more advanced analysis techniques. This study does not identify causal factors that drive spatial dynamics or density. Instead it focuses on providing baseline data on population status and identifies important landscape features for leopards that can be used for conservation planning on a national or regional scale.

2. Materials and methods

2.1. Study area

The study site consisted of a valley and surrounding hills in Huai Kha Khaeng Wildlife Sanctuary around Khao Nang Rum Wildlife Research Station and Sub Pha Pa Guard Post (Fig. 1). Average annual rainfall for the area, as recorded at Khao Nang Rum, was 1447 mm. The rainfall pattern delineates wet (May–October) and dry (November–April) seasons (Walker and Rabinowitz, 1992). Elevation varies from 121 m at the valley bottom up to the highest surrounding hill at 1350 m. HKK is a well protected sanctuary with human activities largely limited to research, tourism and an annual mushroom harvest. HKK also experiences annual fires originating in adjacent agricultural land. These fires are generally of low intensity and affect a small proportion of the sanctuary.

Forest types include mixed deciduous, dry deciduous dipterocarp, dry evergreen and hill evergreen (Rabinowitz, 1989). In addition to leopard, HKK's large mammal assemblage includes tiger (*Panthera tigris*), Asiatic black bear (*Ursus thibetanus*), Malayan sun bear (*Helarctos malayanus*), banteng (*Bos javanicus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), Malaysian tapir (*Tapirus indicus*) and elephant (*Elephas maximas*) (Rabinowitz and Walker, 1991; Srikosamatara, 1993). The 2780 km^2 HKK Wildlife Sanctuary is part of the larger 18,727 km^2 Western Forest Complex (WEFCOM), and is made up of 17 protected areas. This whole area is one of the largest intact contiguous forests left in South East Asia (Trisurat, 2006).

2.2. Leopard capture

Wooden box traps (2 m long, 0.8 m wide, 1 m high) were baited with live or dead chickens and placed along jeep tracks and animal paths. Placement was based on presence of secondary sign such as tracks and scrapes, which indicated regular leopard travel routes (Rabinowitz, 1989). All traps were checked on a daily basis. Captured leopards were immobilized using Ketamine (5 mg/kg) and Xylazine (2 mg/kg), delivered by a jab stick. The Xylazine was later antagonized with Yohimbine (0.05 mg/kg). Leopards were fitted with a VHF radio collar (Telonic Inc., Mesa, Arizona and Advanced Telemetry Systems, Minnesota, USA) and released at the site of capture. Leopards were observed until they regained full consciousness and walked away.

2.3. Home range estimation

Each day, an attempt was made to locate all radio-collared leopards using standard telemetry procedures (Mech, 1983).

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