HABITAT USE AND HOME RANGE ANALYSIS OF SIAMESE FIREBACK *LOPHURA DIARDI* AND SILVER PHEASANT *L. NYCTHEMERA* IN SUB-MONTANE FOREST, KHAO YAI NATIONAL PARK, THAILAND

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
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Habitat Use and Home Range Analysis of Siamese Fireback *Lophura diardi* and Silver Pheasant *L.nycthemera* in Sub-montane Forest, Khao Yai National Park, Thailand

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A Thesis Submitted in Partial Fulfillment of the Requirements for
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Abstract

One of the observed consequences of global climate change on wildlife is that lowland species are likely to shift to higher elevations, but the specific habitat and behavioral reasons for such shifts have been poorly documented. The aim of this study was to investigate habitat use in Siamese Fireback (*Lophura diardi*), a lowland species, which has recently expanded its range into sub-montane habitat where it now occurs in sympatry with the resident species Silver Pheasant (*L. nycthemera*) in Khao Yai National Park, northeastern Thailand, as a possible consequence of climate change. The results, on radio-collared birds, show that Siamese Fireback population groups tended to use topographically flat areas, similar to the topography found in the lowlands, with the exception of nest site locations, which were found on steeper slopes. The birds also selected areas with greater under-story cover during the mating season and moved to areas with higher ground vegetation density while rearing young chicks. The results also indicate differences in topography use between two pheasant species, with Siamese Fireback in areas of gentle topography while Silver Pheasant were found mainly on steeper slopes. As a possible consequence of non homogeneous topography on sub-montane habitat, Siamese Fireback found at higher elevation show larger home range sizes than has been reported for similar lowland *Lophura* species. Nevertheless, it remains largely unclear is which specific aspects of either the sub-montane habitats and/or the lowland habitats are being altered by climate change.

Keywords : Global Climate Change / Siamese Fireback / Silver Pheasant / Sympatry / Khao Yai National Park / Radio-collars / Thailand

หัวข้อวิทยานิพนธ์	การวิเคราะห์การใช้พื้นที่และอาณาเขตถิ่นที่อยู่อาศัยของไก่ฟ้าพญาลอ (*Lophura diardi*) และไก่ฟ้าหลังขาว (*L. nycthemera*) ในพื้นที่ป่ากึ่งดิบเขา ณ อุทยานแห่งชาติเขาใหญ่, ประเทศไทย
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คณะ	ทรัพยากรชีวภาพและเทคโนโลยี
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บทคัดย่อ

จากการศึกษาผลกระทบจากสภาวะโลกร้อนต่อสัตว์ป่าได้มีรายงานว่า ชนิดพันธุ์ที่เดิมอยู่ในพื้นที่ระดับต่ำจะเกิดการย้ายขึ้นไปอยู่ในพื้นที่ระดับสูง แต่การใช้พื้นที่และพฤติกรรมของสัตว์หลังจากมีการย้ายถิ่นที่อยู่อาศัยนี้ยังมีการศึกษาน้อยมาก การศึกษาในครั้งนี้จึงมีเป้าหมายที่จะตรวจสอบถึงการใช้พื้นที่ของไก่ฟ้าพญาลอ (*Lophura diardi*) ซึ่งเดิมเป็นชนิดพันธุ์ที่อาศัยในพื้นที่ระดับต่ำ แต่ปัจจุบันพบว่ามีการขยายอาณาเขตการหากินขึ้นมาอยู่บนพื้นที่ของป่ากึ่งดิบเขาระดับสูง และเกิดการอาศัยอยู่ร่วมกันกับไก่ฟ้าหลังขาว (*L. nycthemera*) ที่เดิมอาศัยอยู่ในพื้นที่ดังกล่าวอยู่แล้ว จากการได้รับผลกระทบของสภาวะโลกร้อน ณ อุทยานแห่งชาติเขาใหญ่ ภาคตะวันออกเฉียงเหนือของประเทศไทย จากผลการศึกษาโดยใช้วิทยุติดตามตัวพบว่าโดยส่วนมากไก่ฟ้าพญาลอจะใช้พื้นที่บริเวณที่ราบ ซึ่งลักษณะดังกล่าวนี้พบได้ง่ายในพื้นที่ระดับต่ำ ยกเว้นบริเวณที่ไก่ฟ้าพญาลอเลือกทำรังซึ่งจะพบในบริเวณที่มีความชันสูง ไก่ฟ้าชนิดนี้ยังเลือกพื้นที่ที่มีการปกคลุมของพืชชั้นล่างสูงในช่วงฤดูผสมพันธุ์ และจะเลือกใช้บริเวณพื้นที่ที่มีความหนาแน่นของพืชชั้นล่างสูงในขณะที่เลี้ยงลูก ผลการศึกษายังชี้เฉพาะถึงความแตกต่างของลักษณะภูมิประเทศที่ไก่ฟ้าสองชนิดเลือกใช้ โดยแม้ไก่ฟ้าพญาลอจะย้ายขึ้นมาใช้ในพื้นที่ระดับสูง แต่ไก่ฟ้าชนิดนี้ยังเลือกใช้บริเวณที่ราบ ต่างจากไก่ฟ้าหลังขาวที่จะพบตามพื้นที่ชันมากกว่า นอกจากนี้พบว่าอาณาเขตการหากินของไก่ฟ้าพญาลอในพื้นที่ระดับสูงนี้มีขนาดใหญ่กว่าที่เคยมีรายงานไว้ในไก่ฟ้าที่อาศัยอยู่ในพื้นที่ระดับต่ำด้วยกัน อย่างไรก็ตามยังไม่เป็นที่แน่ชัดว่าถิ่นที่อยู่อาศัยระดับสูงและ/หรือถิ่นที่อยู่อาศัยระดับต่ำได้ถูกเปลี่ยนแปลงจากการเกิดภาวะโลกร้อน

คำสำคัญ : สภาวะโลกร้อน / ไก่ฟ้าพญาลอ / ไก่ฟ้าหลังขาว / Sympatry / อุทยานแห่งชาติเขาใหญ่ / วิทยุส่งสัญญาณติดตามตัว / ประเทศไทย

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CHAPTER 1 INTRODUCTION

1.1 Background

Pheasants, subfamily Phasianinae, order Galliformes, include 52 species, of which more than 30 are listed in the red data book for threatened birds of Asia (BirdLife International 2009). Habitat disturbance and hunting pressure are the main cause to their declining populations (McGowan and Garson, 1995; Keane et al., 2005). Conservation actions have been variously proposed to help mitigate the threats to their survival (McGowan and Garson, 1995; McGowan et al., 1999) although, baseline information on their biology and ecology of most of the species is still lacking. Evaluation of their status of distribution and abundance is a prior need for implementing their conservation action plan. Alarmingly, a recent status assessment (McGowan et al., 1998) shows a decline in 56% of galliformes species when compared with data available from 1970.

In Thailand, pheasants consist of 10 species of which 6 are in the Red data book for threatened birds of Asia (BirdLife International, 2009). As for other country their major threat is the disturbance of their suitable habitat mainly in lowland species as lowland forest has almost all been converted to agriculture land while montane forest is disturbed by clearing for shifting agriculture (Round, 1988). The conservation action in Thailand has supported pheasant populations by limit them within several protected areas. At the current stage basic information on their biology and ecology, including distribution and abundance, are need to design and implement suitable management. A likely recent impact that has been reported is global climate change which may be affecting the pheasant community through enabling range shift of lowland species into sub-montane habitat (Round and Gale, 2008). At the moment still little is known on the effect of this community change.

Thesis project

Siamese Fireback (*Lophura diardi*) (Figure 1.1) is classified as a near threatened species (BirdLife International, 2009) with an overall population estimate of 10,000 individuals distributed from eastern Myanmar through northeastern and southeastern Thailand and

Laos, Cambodia, and central and southern Vietnam (Madge and McGowan, 2002). In Thailand their population is estimated at 5,000 individuals (Madge and McGowan, 2002; BirdLife International 2009), mainly found in lowland forest up to 800 m in elevation (Lekagul and Round, 1991; Robson, 2002). Habitat loss is a major threat in Thailand (Round, 1988). In this study Siamese Fireback is found sympatrically with Silver Pheasant (*L. nycthemera jonesi*), which range in north, northeastern and southeastern Thailand, southwestern China, eastern Myanmar, southern Vietnam, southwestern Cambodia, northern Laos and Island of Hainan (Johnsgard, 1999; Madge and McGowan, 2002). It is a highly variable species with 15 subspecies, which 2 occur in Thailand; *L. n. jonesi* (Figure 1.2) and *L. n. lewisi* (Lekagul and Round, 1991; Johnsgard, 1999; Robson, 2008). In Thailand, *L. n. jonesi* occur in evergreen forests from 700 to 2,000 m (Lekagul and Round, 1991). Due to their different use in elevation, the two species has only been reported sympatrically in the past 20 years when an increase in detection of Siamese Fireback was reported in the sub-montane forest area around the Mo Singto Long Term Biodiversity Plot at Khao Yai National Park (Round and Gale, 2008). Global climatic change was suggested as the cause of range shift for Siamese Fireback which lowland habitat condition has changed enabling this lowland species to move at higher elevation in order to find suitable habitat, however, the affect of this occurring sympatric still uninvestigated.

Figure 1.1 Siamese Fireback (*Lophura diardi*) male (left) and female (right).

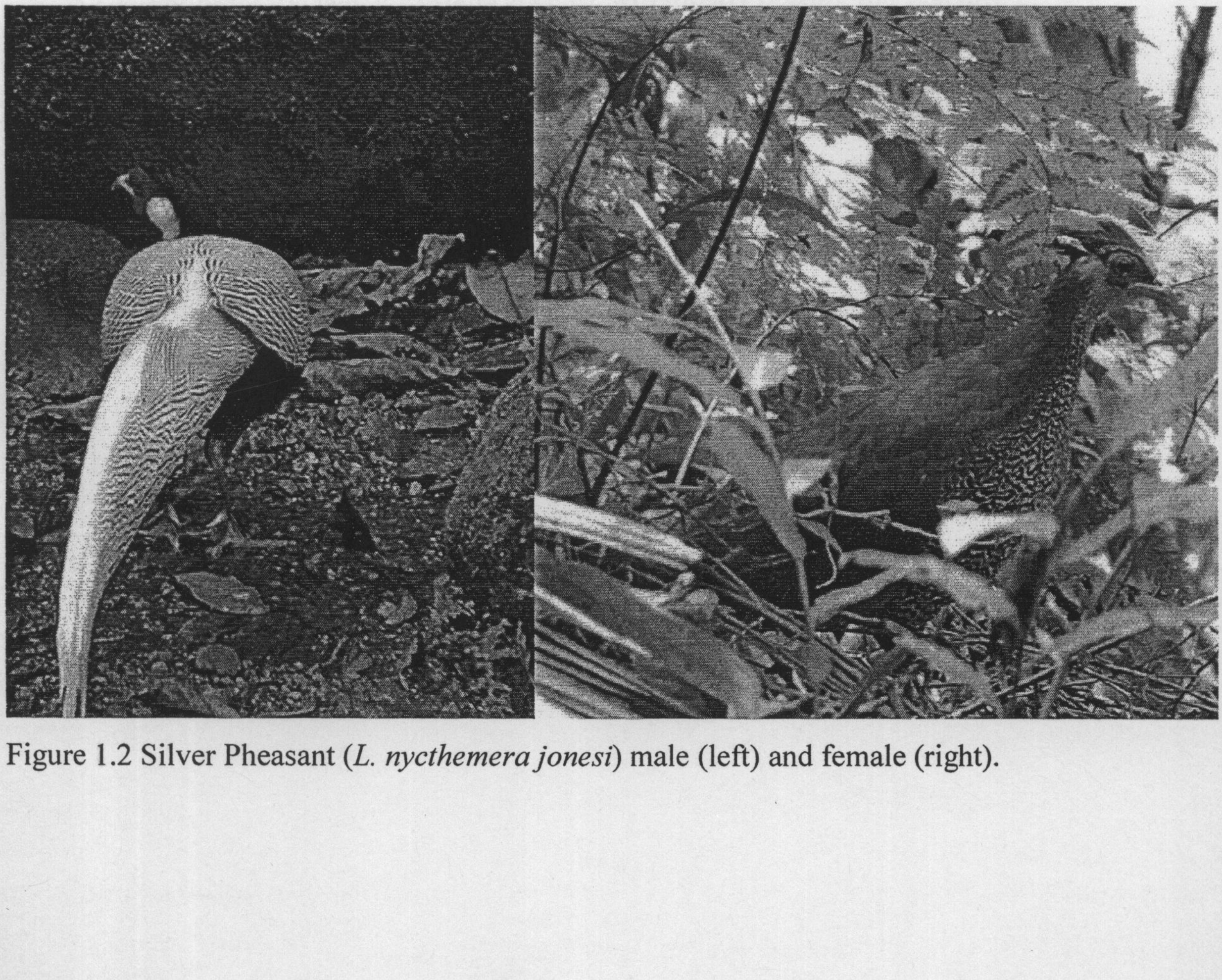

Figure 1.2 Silver Pheasant (*L. nycthemera jonesi*) male (left) and female (right).

1.2 Objectives

The objective of this study is focused on the shift to higher elevation of the lowland Siamese Fireback leading to sympatry with another *Lophura* species on sub-montane forest of Khao Yai National Park, Thailand.

In this project I will investigate two major aspects:

1. Define the use of topography between the two *Lophura* species in order to define potential species overlaps.
2. Investigate the micro-habitat structure used by the lowland Siamese Fireback once moved to sub-montane habitat.

For this I will hypothesize:

H1. Topography is influencing habitat use by different pheasant species.

P1.1 Silver Pheasant, a montane species, will mostly occupy slopes.

P1.2 Siamese Fireback, a lowland species, will mostly occupy flat patches.

H2. Forest structure influence patterns of habitat use by Siamese Fireback.

P2.1 Lowland forest species will mostly occupy topographically flat areas with understorey habitat characteristics similar to that of lowland forest habitat (e.g. Deignan, 1945; Vy *et al.*, 1998).

CHAPTER 2 LITERATURE REVIEW

2.1 Order Galliformes

Galliformes, containing turkeys, grouse, quail, and pheasants, is composed by 284 species spread worldwide (Keane et al., 2005), of which 107 are in the IUCN Red List of Threatened Species (BirdLife International, 2009). They show a wide diversity of mating systems: monogamy, polygyny, polygynandry, and courtship in some species entails elaborate visual displays in males (Johnsgard, 1999). In the end, some species are solitary while spending some time in the part of year for mated pairs such as Great Argus *Argusianus asgus* (Davison, 1981). Parental care is mostly carried out by females. Brooding is usually absent but in the rare case where it occure is conducted primarily by the females. Males may guard nests, brooding females and/or chicks (Johnsgard, 1999).

Foraging behavior is either arboreal or terrestrial, mostly move mainly by walking and infrequent fly, mainly when alarmed from any disturbance (Lima, 1993). Galliformes forage on a variety of plant and animals, especially insects (Johnsgard, 1999). Plant material includes: fruits, seeds, leaves, shoots, flowers, tubers and roots. As consequence they may play important ecosystem roles as seed dispersers or seed predators (Corlett, 1998).

Pheasants, subfamily Phasianinae, a group of birds in the order Galliformes comprising 52 species of which more than 30 are in the Red data book for threatened birds of Asia (BirdLife International, 2009). Pheasants are limited in their distribution to Asia, with the exception of Congo peafowl (*Afropavo congensis*) in central Africa (Johnsgard, 1999; Madge and McGowan, 2002). They are terrestrial bird, mostly omnivorous consuming fruits, leaves and a variety of arthropods. Pheasants show variably mating system depending on their habitat, their nests are mostly on the ground blinded with bushes, buttress, or small trees. The pheasant chicks are precocial and can forage with their mothers straight after hatching (Johnsgard, 1999).

2.2 Home range

Animal movements, consequence of habitat characteristic and food resource, lead to the definition of their ranges. Both forest composition and food resources can affect home ranges size. As a general definition home ranges can be defined as the area covered by animals during their daily activity. This is also the area that can provide shelter or barrier against the predators (Lima, 1993). In the end, this area should provide enough resources for their requirement (Manly et al., 2004). Animals will establish and maintain a home range when the benefits this maintenance exceed the cost, and that this area will be changed when the cost will start to exceed the benefits as consequence of a lowering in the overall quality (Boitani and Fuller, 2000). Size of home ranges variation can then be related to seasonal changes in food quality and/or changes in the dispersion of resources in the area (Boitani and Fuller, 2000). This is observed in Hazel Grouse (South Korea) where home range composition differs in relation to habitat availability. Coniferous plantations were occupied more than mixed forest as it provides a barrier against predators (Rhim, 2006). Home ranges might show overlaps between groups, or single individuals, if the area happen to be of high quality for what it concern food resource (Ratcliffe and Crowe, 2001). The Helmeted guinea fowl *Numida meleagris* at South Africa have an overlap of home range among population in areas where the quality is high, whereas the Helmeted guineafowl population inhabiting low quality area have larger home range with overall less overlap (Ratcliffe and Crowe, 2001).

2.3 Habitat use

The habitat use can be a random proportion of habitat available in the area or the result of an active selection in the area over the others of a given type in habitat available (Manly et al., 2004; Boitani and Fuller, 2000). Animals tend to select the area for their activities (foraging, building nest, courtship, etc.) in order to maximize their reproduction and overall survival (Boitani and Fuller, 2000).

Most of studies on habitat use deal with food or habitat characteristic. One of the habitat characteristics selected is the highly dense ground vegetation, which may provide shelter against predators (Lima, 1993). Habitat use in two species of pheasants, Copper pheasant *Symaticus soemmerringii* and Tibetan Eared pheasant *Crossoptilon harmani* were mostly composed by dense shrub (Lu and Zheng, 2002; Yasuhiro and Noritomo, 2003). Copper pheasant in central Japan show a difference among vegetation types between the encountered place and the available habitat. The frequency of broad-leaved trees in encountered places was higher than the proportion broad-leaved trees in the available habitat. Similar result was found for shrub density. In this area, broad-leave trees produce nut and berries, main foods for pheasants, while moderate density of shrubs provide shelter and high gradients provide barrier against predators (Yasuhiro and Noritomo, 2003). For Tibetan eared pheasant, which forage and roost in highly dense shrub, high frequency in the use of narrower stream belts over other habitats was observed. This habitat provides soft soils as the foraging method of this bird consist in digging up plant roots. The eared pheasants disappear from areas with less than 40% vegetation cover and less than 1.2 m vegetation height and also night-roosting sites selected areas with cliffs and dense cover. Moreover, the populations inhabited closely the monastery area that they have more daily time foraging around monastery. Because they have food supply from people at monastery, clearly that food resource influence to their habitat uses (Lu and Zheng, 2002).

2.4 The overlap among genus *Lophura*

Observations conducted in Khao Yai National Park, northeastern Thailand, during the past twenty years have reported an expansion of Siamese Fireback *Lophura diadi* that are now being found at higher elevations, around 800 m, where previously only Silver Pheasant *Lophura nycthemera* was found (Round and Gale, 2008). The likely explanation for this altitudinal expansion (Round and Gale, 2008) is climate change observed during the past 100 years, whereby the global average temperature has increased about 0.6°C (Houghton et al., 2001). Round and Gale (2008) also speculated that these increased temperatures, and consequent changes in evapotranspiration, had led to drier micro-habitats upslope, resulting in an increase in the numbers of Siamese Fireback relative to populations of resident Silver Pheasant. This was based primarily on observations elsewhere that suggest that tropical forest birds were particularly sensitive to micro-climatic gradients (Karr and Freemark, 1983). In cloud forest of Costa Rica, Pounds et al. (1999) observed rapid changes in species composition.The colonization of montane habitats by non-montane species was the consequence of drier habitat created by a decrease in frequency of mist.

Although on a large scale the genus *Lophura* appears overlap in a few locations it is always ecologically separated by elevation or habitat. In Sumatra were *L. ignita* is a lowland species replaced at higher elevations by *L. hoogerwerfi*, in the north of the island, or *L. inornata*, in the southern part (BirdLife International, 2001). In West Malaysia *L. ignita* inhabits wet riverine forest while *L. erythrophthalma* prefers drier slopes (Davison, 1981). As for other *Lophura* species, Silver Pheasant and Siamese Fireback appear overlap in over much of their southeastern Asia range (Dickinson, 2003). In Laos, they are naturally segregated by different elevations with Silver Pheasant usually predominating at 500 m or above while Siamese Fireback are found in the lowlands (Thewlis *et al.*, 1998). A similar segregation pattern has been so far observed in Thailand, these two species are largely segregated by elevation. Silver Pheasant are montane and sub-montane in distribution, occurring at elevations of 700 m and above, while Siamese Fireback is a characteristic lowland species, inhabiting forest in plains and foothills to a maximum elevation of 800 m (Lekagul and Round, 1991; Robson, 2008). Except in Khao Yai National Park where Silver Pheasant and Siamese Fireback are found sympatry (Round and Gale, 2008). In Vietnam, where the situation is more complicated and possible encounters between two *Lophura* species might have occurred, hybridization was observed, resulting in *L. imperialis* (Hennache et al., 2003), once considered a critically endangered species (McGowan and Garson, 1995).

2.5 Elevational range shifts

Recent studies have demonstrated that changes in the distribution and ecology of many threatened taxa are significantly influenced by aspects of global climate change (Walther et al., 2002; Hansen et al., 2006; Kannan and James, 2009). Few data exist, but some species respond to such changes by exhibiting significant shifts (expansion or contraction) in their biogeographic or elevational range (e.g. Parmesan, 2006; Colwell et al., 2008), modification of behavioural traits (Nussey et al., 2005; Bradshaw and Holzapfel, 2006), or even changes to their morphology and physiology (Hughes, 2000; Walther et al., 2002; Bradshaw and Holzapfel, 2006). Increases in global temperatures can also influence the extent and quality (structural characteristics) of habitats, thereby influencing patterns of habitat selection by threatened taxa, and inducing mismatches between the timing of breeding seasons and the availability of suitable food resources necessary to optimize reproductive success (e.g. Nussey et al., 2005).

Range expansion is considered as being one of the earliest signs or responses by threatened taxa to climate change-induced habitat alteration (Karr and Freemark, 1983). This phenomenon should be most obvious to detect amongst species distributed across an elevational gradient (Hughes, 2000). Species normally restricted to lowland habitats may shift their range to occupy habitats at higher elevations, leading to possible detrimental effects for the resident montane species, e.g. reduction in their population sizes (Shoo et al., 2005). In addition, lowland species 'moving up' an elevational gradient must adapt to different topographies, and to different features of the broader habitat type or micro-habitat (Sekercioglu et al., 2007). Unfortunately, it remains to be seen whether such responses are a typical response amongst the majority of threatened species across elevational gradients since quantitative data are sorely lacking. This makes it exceedingly difficult to properly frame the broad agenda for conservation/habitat management strategies for these environments.

CHAPTER 3 METHODS

3.1 Study area

This study was conducted at the area about 1 km^2 where including Mo Singto Long-term Biodiversity Research Plot, Khao Yai National Park (Brockelman et al., 2002), Thailand (2,168 km^2; 101°22' E, 14°26' N; ~ 130 km NE of Bangkok). In a hilly terrain 730 - 890 m elevation (Figure 3.2), and is dominated by seasonally wet evergreen forest (Kerby et al., 2000; Kitamura et al., 2004) (Figure 3.1). Average annual precipitation is 2,696 mm (range 2,976 to 2,297 mm) with a dry season from November to April and a wet season from May to October. Average daily temperatures vary between 18.7°C and 28.3°C, and mean humidity ranges from 64.6 percent during the dry season to 77.1 percent during the wet season (Savini et al., 2008).

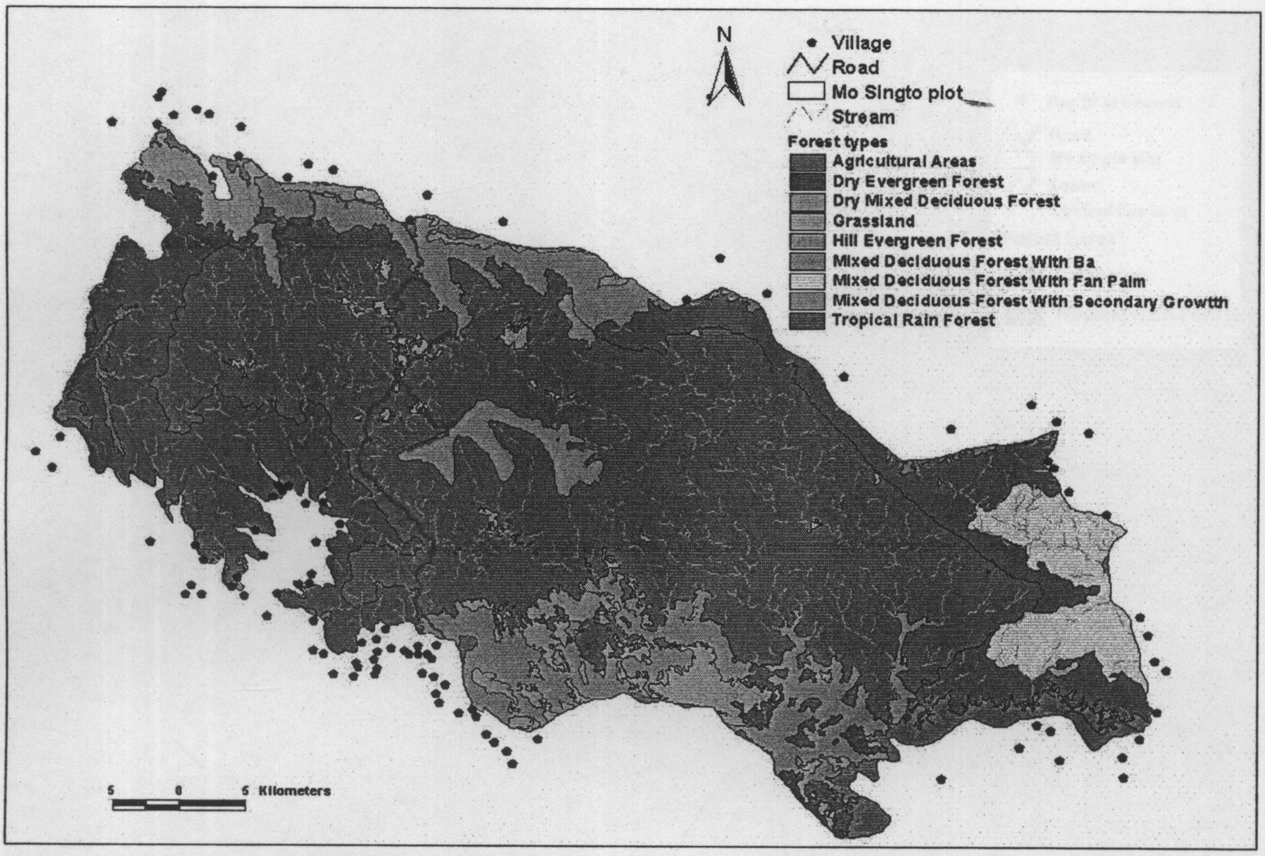

Figure 3.1 The area of Khao Yai National Park is dominated by seasonally wet evergreen forest.

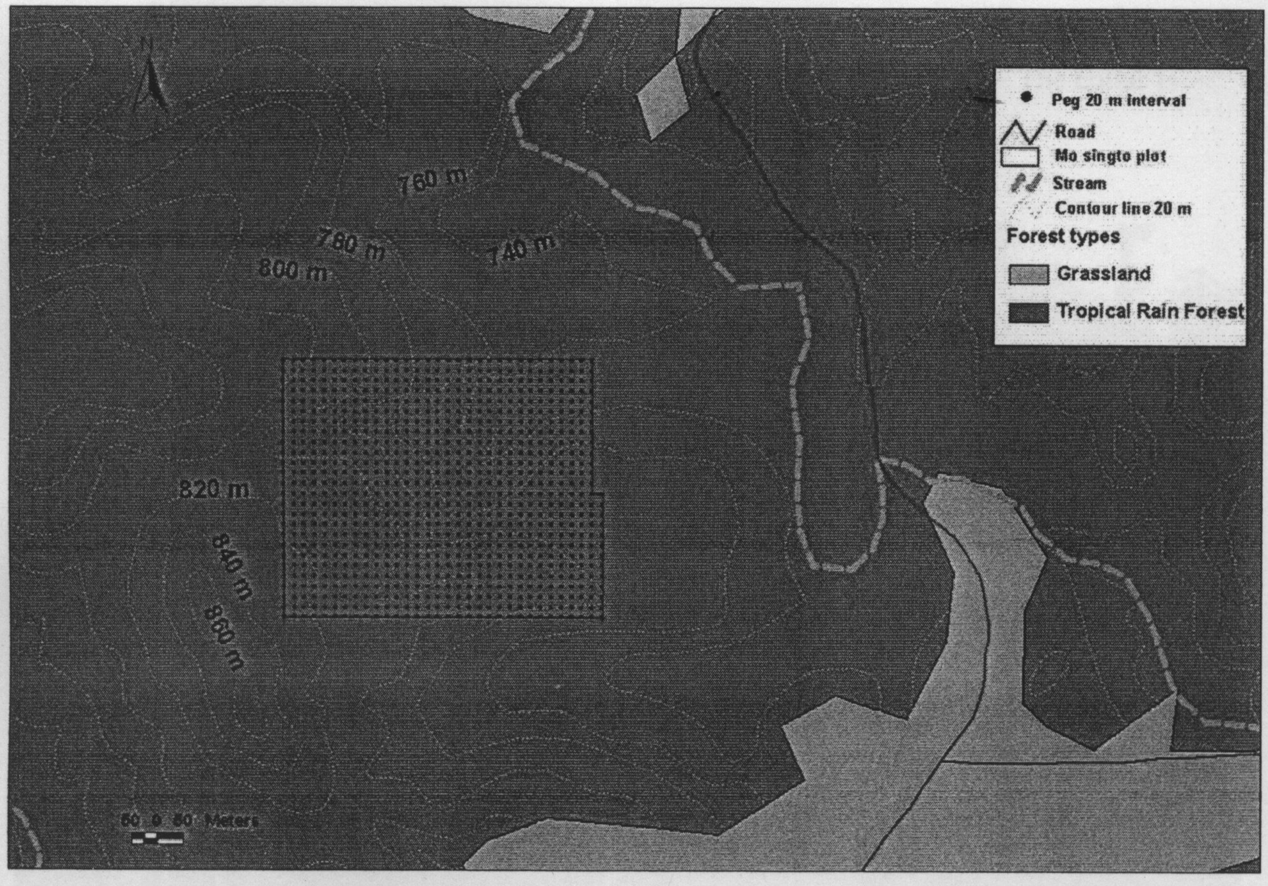

Figure 3.2 The area of Mo Singto Long-term Biodiversity Research Plot (30 ha in size) in a hilly terrain 730 - 890 m elevation, the plot is outlined by the box.

3.2 Animal capture and marking

All data were collected between February 2007 and September 2008. Individual pheasants were caught using mist-nests (Keyes and Grue, 1982) and modified traditional leg-snare traps made from bamboo and soft polyester string (Figure 3.3). Mist nets (3x12 m with 15 cm mesh) were set at ground level across pheasant pathways surrounded by leg-snare traps. All pheasants caught were ringed with size 11A (11.0 mm. of internal diameter) Thai Royal Forest Department (RFD) metal rings, and color-ringed with two-color combinations on the left leg and one color-ring and the metal ring on the right leg (Figure 3.4), so that they could be individually identified in the field. The pheasants were also fitted with a 15 g radio-collar model RI-2B made by Holohil Systems Ltd with a life span of 24 months. The

RI-2B is designed as a necklace-mounted transmitter. The transmitter rests on the bird's breast while the antenna loops around the neck and emerges behind the head. The collar is made of flexible elastic attached to the transmitter in two points.

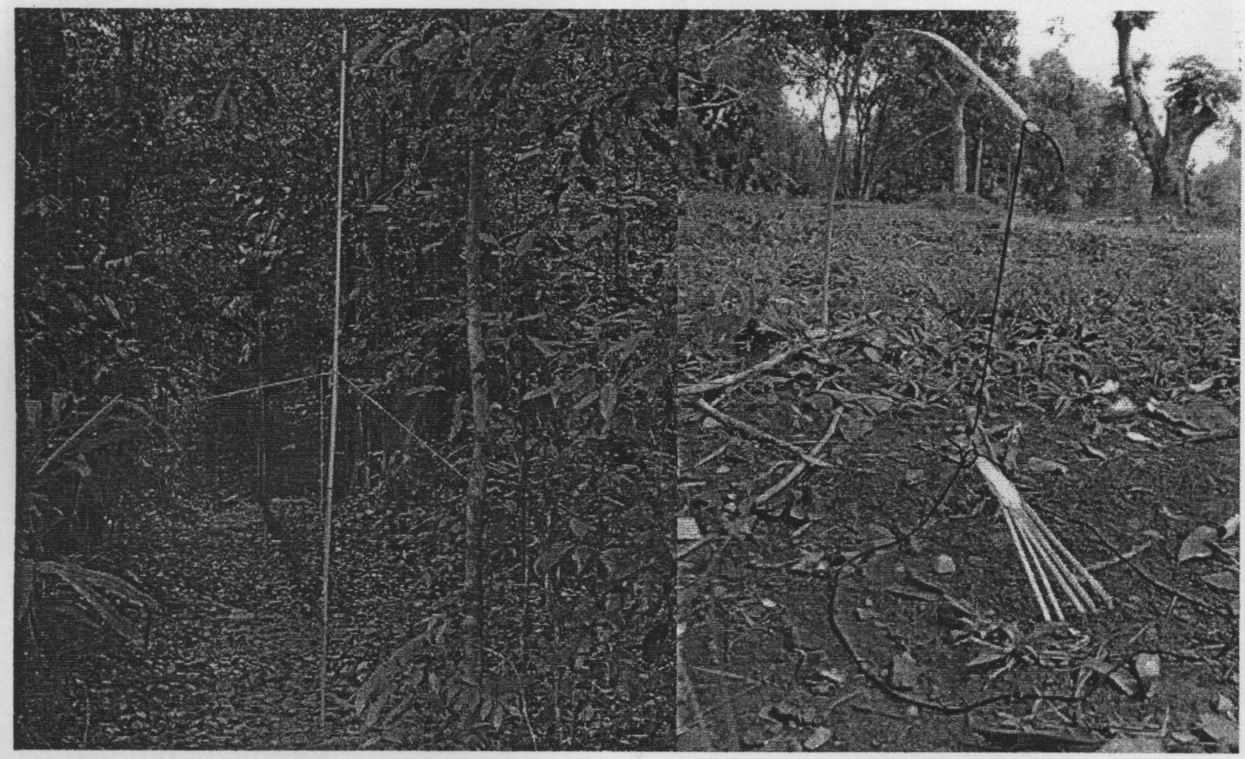

Figure 3.3 Pheasant capture used 12 meters with 3 shelves mist-net (left) and noose trap (right).

Figure 3.4 All pheasants caught were ringed with size 11A (11.0 mm. of internal diameter) Thai Royal Forest Department (RFD) metal rings and color-ringed.

3.3 Animal locations

Each individual pheasant was located by homing several times per day, with at least a two-hour interval between radio fixes for each individual. This time gap was considered sufficient to eliminate any potential disturbance generated from the previous observation (Savini and Sukumal, 2009). Once detected, individuals were followed for 15 min after which the individual and any associated group members were left alone to reduce excessive disturbance, before another collared individual was located. During each 15 min period and for each individual, we recorded their behavior and its proximity to members of the group. We also recorded its location, elevation, and slope at the point each individual was located. Triangulation was used to estimate a birds' position if the individual pheasant could not be seen due to dense ground vegetation.

3.4 Reproductive data

Data for each female caught were divided into four periods according to the chronology of the reproductive cycle: (1) in the group (mating period), (2) incubating, (3) alone with chicks, i.e., the initial period after hatching when females travel alone with their brood (between one and three months) and, (4) back in her group together with her chicks and the other group members (adult males, adult females and their brood), up to ten individuals.

3.5 Habitat measurements

Features of the habitat were recorded using 5-m radius circular plots (Martin et al., 1997). We established plots by centering them on the sites where individual pheasants were first located after homing. In addition, we also established control plots centered on randomly selected locations within 30 ha of Mo Singto Long-term Biodiversity Research Plot (for details on the plot see Brockelman et al., 2002). The plot contains hilly terrain between 730-890 m in elevation, and is covered primarily by seasonally wet evergreen forest. In each plot, habitat features were recorded following Martin et al. (1997). For each plot we counted all understory stems with DBH $\leq$ 10 cm and trees with DBH >10 cm which were then categorized into three classes based on their height: 0.5-3 m, >3-5 m and >5 m. We also estimated the percentage vegetation cover of each height category for each plot.

3.6 Home range size analysis

Home range size was estimated for each of the reproductive cycle periods using 95% minimum convex polygons (MCP) as well as kernel home ranges based on 50% and 95% probability of use which is less prone to the effects of outliers (Boitani and Fuller, 2000). The analyses were conducted in Arcview GIS version 3.2a with the Animal Movement Extension (Hooge and Eichenlaub, 2000).

3.7 Patterns of habitat use analysis

All statistical analyses were conducted using SPSS version 15.0 (Kinnear and Gray, 2000; Garson, 2009) and R version 2.7 software (Crawley, 2007). Data were examined for normality using Kolmogorov-Smirnov tests. To investigate potential differences in their use of topography and elevation, locational data were compared among groups of Siamese Firebacks and between the two pheasant species using non-parametric procedures (Kruskal-Wallis *H*-test and Mann-Whitney *U*-test respectively).

We used non-parametric Kruskal-Wallis tests to compare habitat variables between sites selected by females during four periods of the reproductive cycle and randomly selected areas. Non-parametric Kruskal-Wallis tests were also used to compare topography (slope) between sites selected by females during four periods of the reproductive cycle and randomly selected areas. We used forward stepwise multinomial logistic regression with the presence/absence of females during three reproductive periods (1, 3, and 4, see above) as the dependent variable to identify which habitat features significantly influenced habitat use. Since stepwise regression procedures involve multiple testing, increasing the risk of type 1 errors (Mac Nally, 2000; Whittingham et al., 2006), we set our significance level α <0.01. The order of entry of independent variables into any stepwise regression model and the total number of variables can all effect the final model selection (Whittingham et al., 2006). For the forward selection procedure, we began with a constant-only model and added habitat variables one at a time based upon their relative correlations with the dependent variable, until the step at which all habitat variables not included in the model had a significance of > 0.1. Goodness of fit was determined using the likelihood ratio test of the overall model (the model chi-square test). Final model selection was determined using Akaike Information Criterion (AIC) whereby the step with the lowest AIC value was judged to be the 'final model'. We then compared the habitat variables identified as having a significant influence on habitat use by females between the three periods and the randomly chosen areas using Kruskal-Wallis *H*-tests.

For the nesting/incubation period (Period 2), we used a forward stepwise binary logistic regression to identify which features of the habitat influenced nest site selection. The presence/absence of females in each reproductive phase was entered as the dependent variable. We used the same criteria for forward selection procedure as the multinomial stepwise regression model (see above). Similarly, goodness of fit was determined using the model chi-square test and final model selection was determined using AIC. We compared topography (degree of slope) between nest site selected by females and those of randomly selected areas using Mann-Whitney *U*-tests.

CHAPTER 4 RESULTS

4.1 Year cycle of female Siamese Firebacks

Two Siamese Fireback females were fitted with radio collars and observed for 19 months between February 2007 to September 2008 (Female 1) and for eight months between February and September 2008 (Female 2). The female year cycle consists of: (1) associating in a group of other adults during the mating period (mean period± SD: 30.3 ± 18.9 days), (2) incubation (mean period± SD: 23.5 ± 0.71 days), (3) alone with chicks (mean period± SD: 69 ± 41.0 days) and (4) associating again in a group of adults along with her chicks (mean period± SD: 227 ± 77.8 days).

4.2 Home range size patterns

We compared home range size between the two observed female Siamese Firebacks during each period of the year cycle. The 95% MCP analysis indicated a difference in the home range size during the different phases of the year cycle (Figure 4.1a). Home range size decreased when females left the group after the mating season and started to range alone with their young chicks, but increased again when females rejoined the group with their grown chicks (Table 4.1). Both females showed the same pattern in home range size variation between the different years phases (Figure 4.2b). A similar pattern was observed using a 95% kernel for the overall home range and a 50% kernel for the core area (Table 4.1).

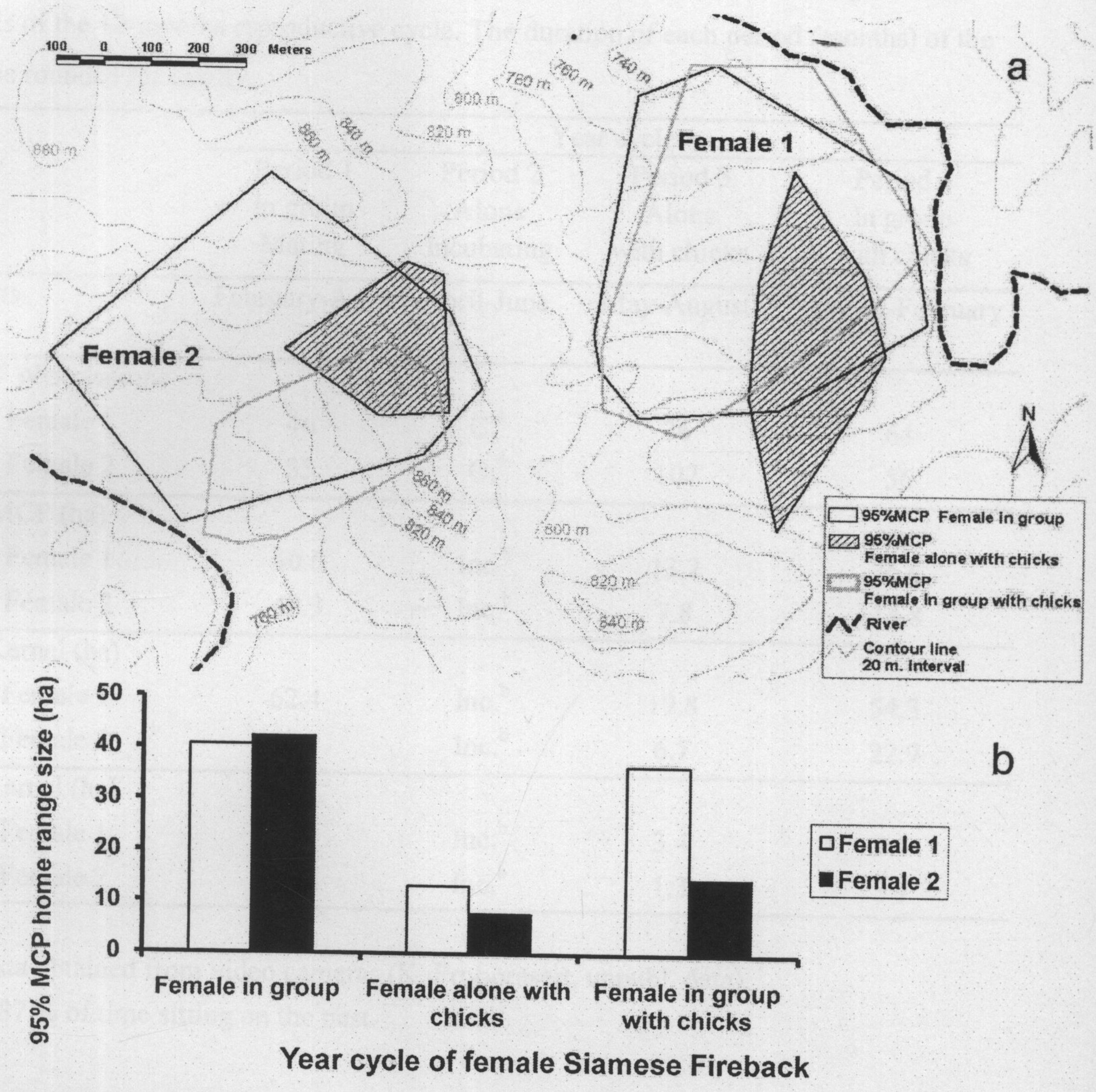

Figure 4.1 a) Ranging size during different periods of the year cycle of Siamese fireback, Female 1 and Female 2, estimated using 95% minimum convex polygon (MCP) b) 95 % MCP home range size compared in different phases of the year cycle between the two female Siamese firebacks.

Table 4.1 Home range sizes of two female Siamese Fireback pheasants during different periods of the 12-months reproductive cycle. The duration of each period (months) of the cycle is rounded for clarity.

	Year cycle			
	Period 1 In group Mating	Period 2 Alone Incubating	Period 3 Alone with chicks	Period 4 In group with chicks
Months	February-April	April-June	May-August	August-February
No. of observations				
Female 1	46	C.[a]	36	64
Female 2	33	C.[a]	107	56
95% MCP (ha)				
Female 1	40.6	Inc.[b]	13.2	36.6
Female 2	42.3	Inc.[b]	7.8	14.8
95% Kernel (ha)				
Female 1	62.4	Inc.[b]	19.8	54.3
Female 2	50.9	Inc.[b]	6.7	22.9
50% Kernel (ha)				
Female 1	8.9	Inc.[b]	3.4	9.5
Female 2	3.4	Inc.[b]	1.3	3.7

[a] C.=Data obtained from video cameras (K. Probprasert, unpubl. data).
[b] Inc.= 87 % of time sitting on the nest.

4.3 Habitat characteristic between sites selected by females and randomly selected areas

The forest habitat selected by female Siamese Fireback during all periods of the reproductive cycle was dominated by tall trees (height > 5 m; mean ± SD 8 ± 3.1 trees), dense understory trees (height > 3-5 m; 13 ± 6.9 stems) and dense understory saplings (height 0.5-3 m; 299 ± 170.6 stems). Randomly selected areas were dominated by trees (taller > 5 m; 7 ± 4.1 trees), dense understory trees (> 3-5 m tall; 11 ± 6.0 stems) and dense understory saplings (0.5-3 m in height; 187 ± 110.5 stems). There was a significant difference between areas selected by females and random areas (Tree height >5 m: Kruskal-Wallis *H*-test, $\chi^2 = 8.4$, df = 1, $p<0.05$; understory tree height >3-5 m: Kruskal-Wallis *H*-test, $\chi^2 = 3.9$, df = 1, $p<0.05$; tree height 0.5-3 m: Kruskal-Wallis *H*-test, $\chi^2 = 30.1$, df = 1, $p<0.05$).

4.4 Influence of topography on habitat use

Habitat use by both female Siamese Firebacks for the majority of their reproductive cycle was significantly influenced by topography. Both females selected topographically flatter areas (shallower slopes) during mating (Period 1), when they were alone with chicks (Period 3) and when they were in groups with their chicks (Period 4) than that available in the randomly located areas (Female 1: Kruskal-Wallis *H*-test, $\chi^2 = 45.3$, df = 3, $p<0.0001$; Female 2: Kruskal-Wallis *H*-test, $\chi^2 = 44.7$, df = 3, $p<0.0001$), but not during nesting/incubation (Period 2).

4.5 Patterns of habitat use during reproductive periods

There was a noticeable difference in the way understory vegetational characteristics influenced habitat use by both female Siamese Firebacks during different periods of the reproductive cycle (Table 4.2). During the mating period (Period 1) the habitat used by Female 1 was not influenced by understory vegetation, whereas Female 2 had densely distributed trees of 0.5-3 m in height and denser coverage of trees > 5 m in height. There was difference in which vegetation characteristics influenced habitat use by both females during Periods 3 and 4. When both females were alone with chicks (Period 3), habitat selection was significantly influenced by both tree density 0.5-3 m, and tree coverage >3-5 m. In addition, both females selected a habitat with tree density 0.5-3 m. However, the vegetation was not observed an influence when both females were in groups with their chicks (Period 4).

Table 4.2 Results of forward stepwise multinomial logistic regression showing the influence of understory vegetation characteristics on habitat use by female Siamese Fireback during different periods of the reproductive cycle. Significant results (α<0.01) are highlighted in bold.

Variables in three phases	Female 1				Female 2			
of year cycle	Mean	Coefficient	df	*p-value*	Mean	Coefficient	df	*p-value*
Female with group (mating) n=30								
Tree density: height 0.5-3 m	135 stems	-0.007	1	0.023	335 stems	0.015	1	**<0.0001**
Tree density: height >3-5 m	-	-	-	-	15 stems	0.021	1	0.814
Tree coverage: height >3-5 m	35.70%	-0.009	1	0.436	55.70%	0.043	1	0.127
Tree coverage: height >5 m	68.30%	0.023	1	0.04	76.10%	0.059	1	**0.002**
Female alone with chicks n=30								
Tree density: height 0.5-3 m	508 stems	0.015	1	**<0.0001**	394 stems	0.02	1	**<0.0001**
Tree density: height >3-5 m	-	-	-	-	11 stems	0.495	1	**<0.0001**
Tree coverage: height >3-5 m	52.10%	0.047	1	**0.007**	19.60%	-0.253	1	**<0.0001**
Tree coverage: height >5 m	51.50%	-0.037	1	0.027	49.70%	-0.006	1	0.766
Female in group with chicks n=30								
Tree density: height 0.5-3 m	239 stems	0.004	1	0.041	181 stems	<0.0001	1	0.918
Tree density: height >3-5 m	-	-	-	-	14 stems	0.51	1	0.417
Tree coverage: height >3-5 m	41.90%	0.007	1	0.548	46.70%	0.009	1	0.649
Tree coverage: height >5 m	64.10%	0.012	1	0.286	68.70%	0.023	1	0.05
Goodness of fit test			504	0.962			504	1
AIC values		AIC=357.797				AIC=282.922		

- = The variable is not selected into the model

4.6 Nest site selection by female Siamese Fireback

A total of 11 nests of five different females were observed during the study period. Nine nests were located in the buttresses of large trees (in genera *Aphananthe, Ficus, Balakata, Nephelium, Mastisia and Cleistocalyx*), one nest was located in a clump of *Rattan* sp. and another nest was located on the ground covered by rattan leaves. The average clutch size was 8 ± 3 (maximum = 14 eggs, minimum = five eggs) (Figure 4.2). All eggs from five of the eleven nests (45%) hatched. Females appeared to prefer to place nests on steeper slopes in the study area although the differences were not statistically significant (Mann-Whitney *U*-test, $z = -1.852$, $p=0.064$). Forward stepwise binary logistic regression analysis indicated that there were significant differences in under-story vegetational characteristics between nest sites and randomly selected areas, and that females mostly avoided locating their nests in areas with a higher percent coverage of trees >3-5 meters in height (Coefficient = -0.094, Wald=5.968, df = 1 $p<0.05$).

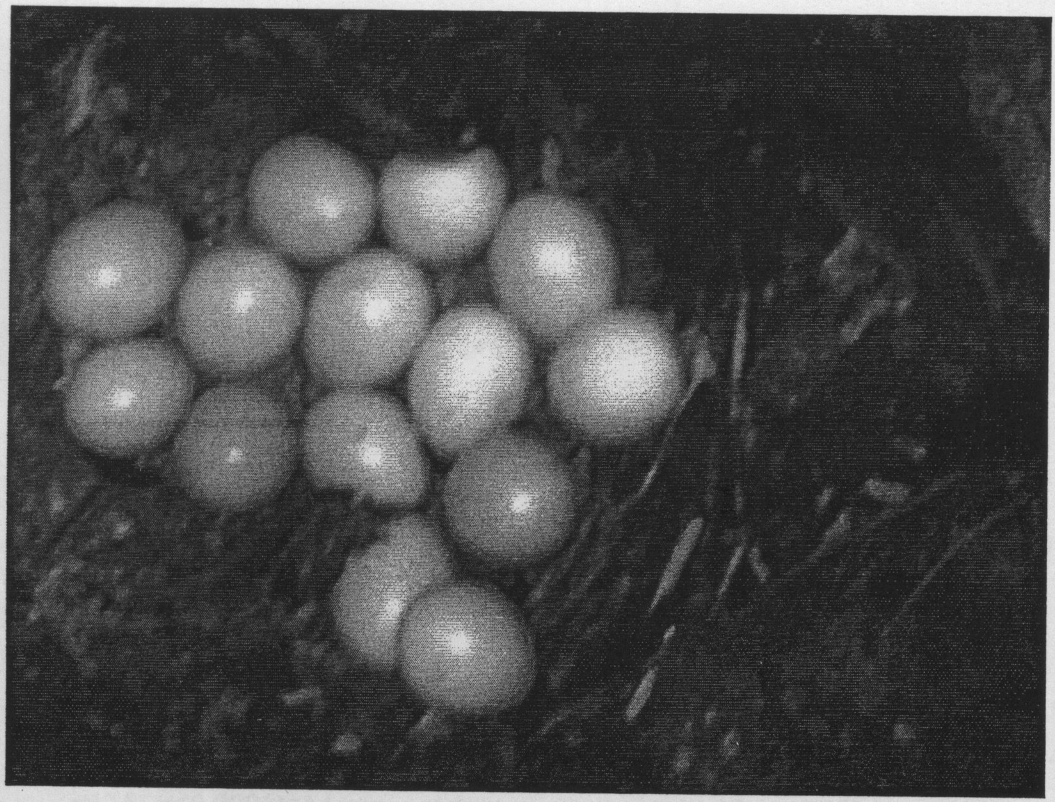

Figure 4.2 The maximum clutch size of Siamese Fireback found 14 eggs.

4.7 Altitudinal differences between Siamese Fireback and Silver Pheasant

Four groups of Siamese Firebacks and one group of Silver Pheasants were observed during the sixteen month study. The topography of the habitats used by all four groups of Siamese Fireback (SMF) did not differ significantly from that available across the study site (Kruskal-Wallis *H*-test, $\chi^2 = 4.8$, $n_{\text{SMF group1}} = 107$, $n_{\text{SMF group2}} = 118$, $n_{\text{SMF group3}} = 120$, $n_{\text{SMF group4}} = 114$, p=0.185). There was however a significant difference in the gradient of habitats used by Siamese Fireback compared to the gradient of habitats used by Silver Pheasant (SPH) (Mann-Whitney *U*-test, z = -9.3, $n_{\text{SMF}} = 459$, $n_{\text{SPH}} = 50$, $p<0.0001$) with Silver Pheasant found mainly on slopes and Siamese Fireback found mostly on flat areas (Figure 4.3).

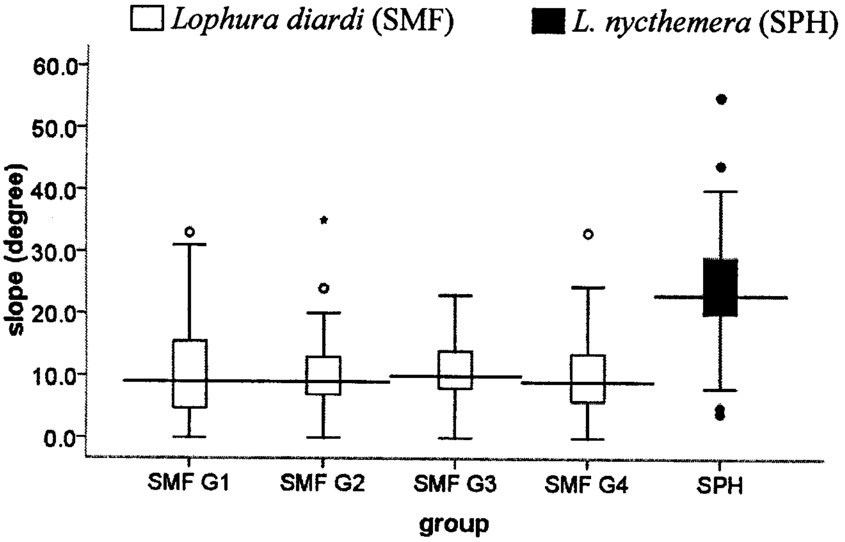

Figure 4.3 The slope comparison between four Siamese Fireback groups and Silver Pheasant.

The elevation use between the four Siamese Fireback groups was significantly different (Kruskal-Wallis *H*-test, $\chi^2 = 250.4$, $n_{\text{SMF group1}} = 114$, $n_{\text{SMF group2}} = 118$, $n_{\text{SMF group3}} = 143$, $n_{\text{SMF group4}} = 115$, $p<0.0001$). Moreover, there was also a significant difference between the two

Lophura species (Kruskal-Wallis *H*-test, $\chi^2 = 262.2$, $n_{\text{SMF group1}} = 114$, $n_{\text{SMF group2}} = 118$, $n_{\text{SMF group3}} = 143$, $n_{\text{SMF group4}} = 115$, $n_{\text{SPH}} = 79$, $p < 0.0001$). Silver Pheasant was found at higher elevations only when compared to Siamese Fireback group 1, but used lower elevations when compared with Siamese Fireback group 2, 3 and 4 (Figure 4.4).

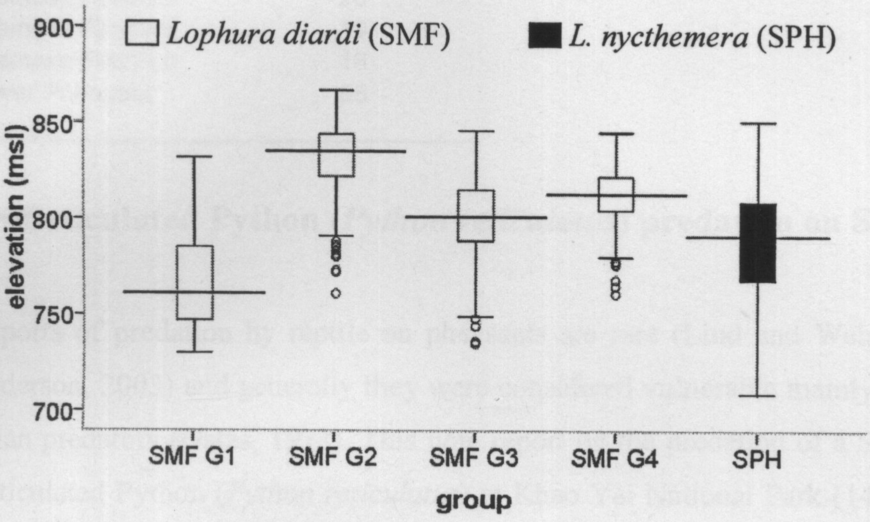

Figure 4.4 Elevation comparisons between four Siamese Fireback groups and Silver Pheasant.

The nests from Siamese Fireback were on terrain with a gradient higher than 15 degrees while one nest of Silver Pheasant also found on steep slope (Table 4.3).

Table 4.3 The topography of nest site of two pheasant species.

Species	Slope (degree)
Siamese Fireback	35
Siamese Fireback	18
Siamese Fireback	27
Siamese Fireback	25
Siamese Fireback	24
Siamese Fireback	26
Siamese Fireback	19
Siamese Fireback	18
Silver Pheasant	55

4.8 Reticulated Python (*Python reticulatus*) predation on Silver Pheasant

Reports of predation by reptile on pheasants are rare (Lind and Welsh, 1990; Bezy and Enderson, 2003) and generally they were considered vulnerable mainly to mammalian and avian predators (Gates, 1972). This note report on the predation of a Silver Pheasant by a Reticulated Python (*Python reticulatus*) at Khao Yai National Park (14°26' N 101°22' E), Thailand, at about 850 m above sea level in an area of seasonally wet, evergreen forest.

A Silver Pheasant female (weight 950 g) was radio-tagged on 16 April 2007; it was flushed into a large mesh mist-net set on the ground during the last week of incubation (Dzus and Clark, 1996). After chicks hatched, the bird was relocated on average every day for collecting data on ranging, habitat use, behavior and development of the chicks. The female was last located on 12 August 2007 when she was observed together with a group of Siamese Fireback sympatric in the area (Round and Gale, 2008). The pheasant was relocated again in the morning of 24 August 2007 which the radio signal was detected in the area with highly density of liannas (Figure 4.5) at an elevation of 736 m and at a distance of about 496 m from the area of the last observation. The signal was detected near a fallen tree under which we observed a Reticulated Python about 2 m in length (Figure 4.6). The python coiled on the ground without alarm and the pheasant shape was not observed on the python body. We marked the location, but left the snake undisturbed.

Figure 4.5 The habitat where the predation was observed.

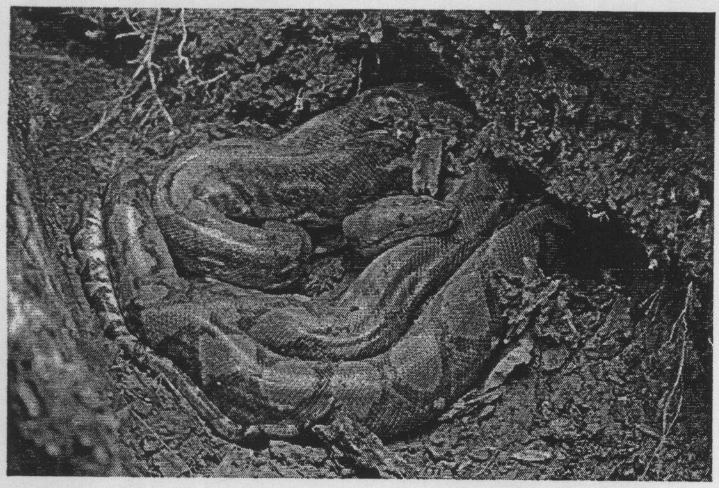

Figure 4.6 Reticulated Python (~2.0 m) coiled under a fallen tree.

During the afternoon of 26 August 2007 the python was relocated, using the radio signal of the ingested radio collar, at about 10 m from the point of the first observation under a pile of dead vine. The python was still coiled at the same place when relocated on 28 August 2007. During the morning 31 August 2007 while relocating the python we found only its dung with the color band, metal ring and radio collar inside (Figure 4.7). The python dung was collected and still functioning radiotag was retrieved.

Figure 4.7 The python dung with the color band, metal ring and radio collar inside.

CHAPTER 5 DISCUSSIONS AND CONCLUSIONS

Female Siamese Firebacks showed a distinct preference for areas that were topographically relatively flat in the sub-montane study area during the three periods of their reproductive cycle. An exception was the nest site location which appears to be on significantly steeper slopes (Figure 5.1 and 5.2). During mating season (Period 1) females select areas with denser understory coverage (>5 m) which appear to be similar to what observed in the lowland population in Binh Chau-Phuoc Buu Nature reserve in southern Vietnam (Vy et al., 1998). Further in the breeding season, when they were alone with young chicks (Period 3), Siamese Fireback females preferred areas with higher density of understory stems (Table 4.2 and Figure 5.3). Finally, when with grown chicks re-joined their respective groups (Period 4; Table 2) the selection of a specific vegetation characteristics was not found.

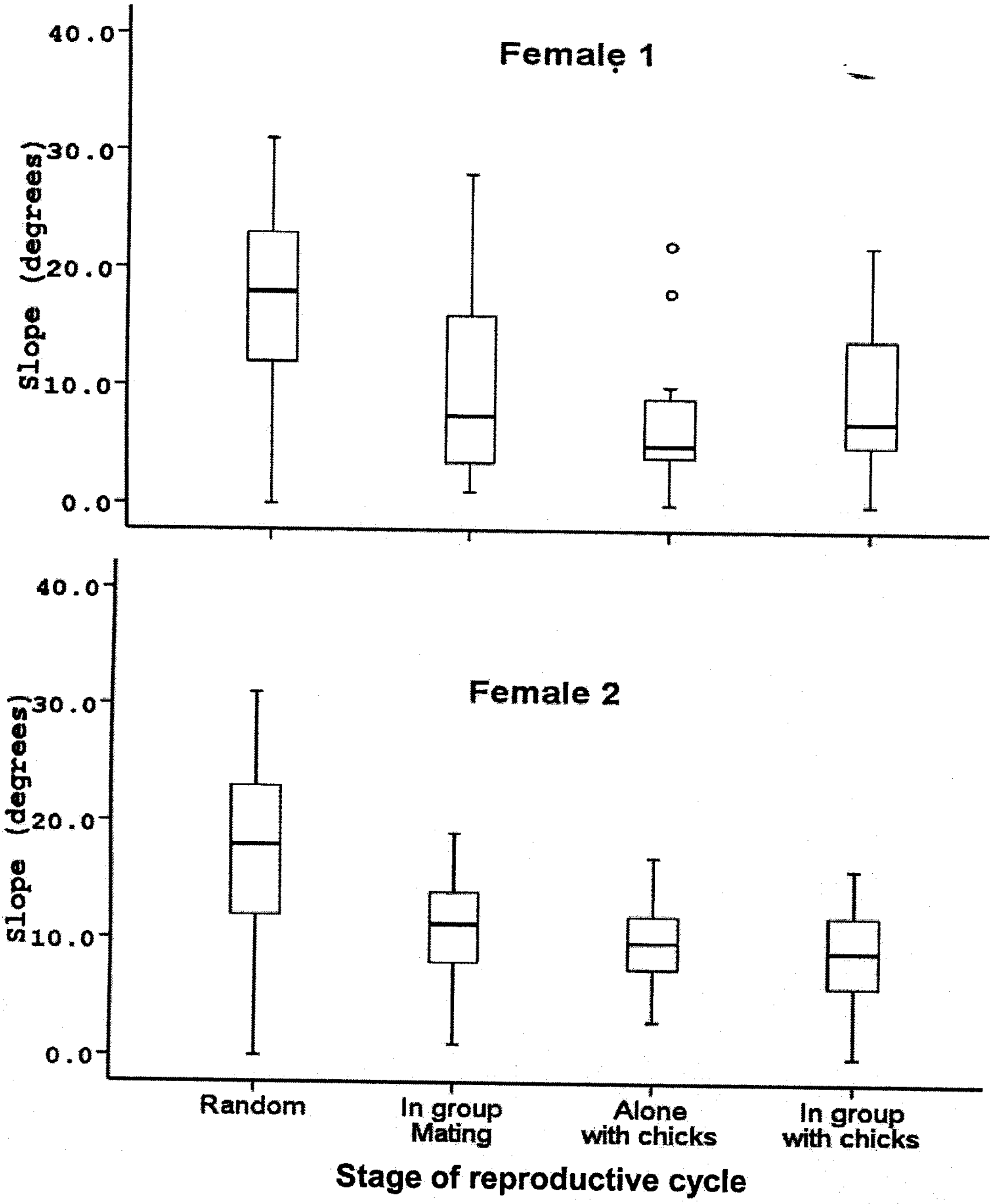

Figure 5.1 A comparison of slope in areas used during different periods of the year cycle and randomly chosen areas for Female 1 (a) and Female 2 (b).

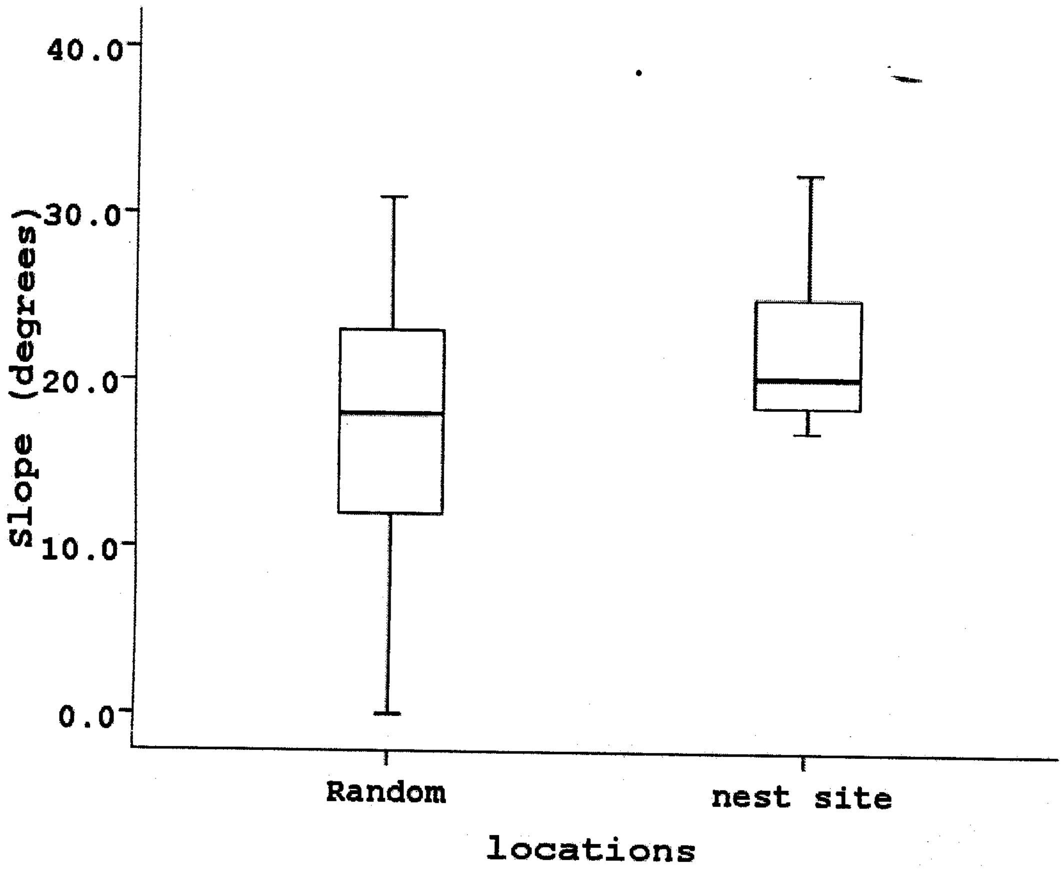

Figure 5.2 A comparison of slope between nest site locations (n=10) and random areas (n=90).

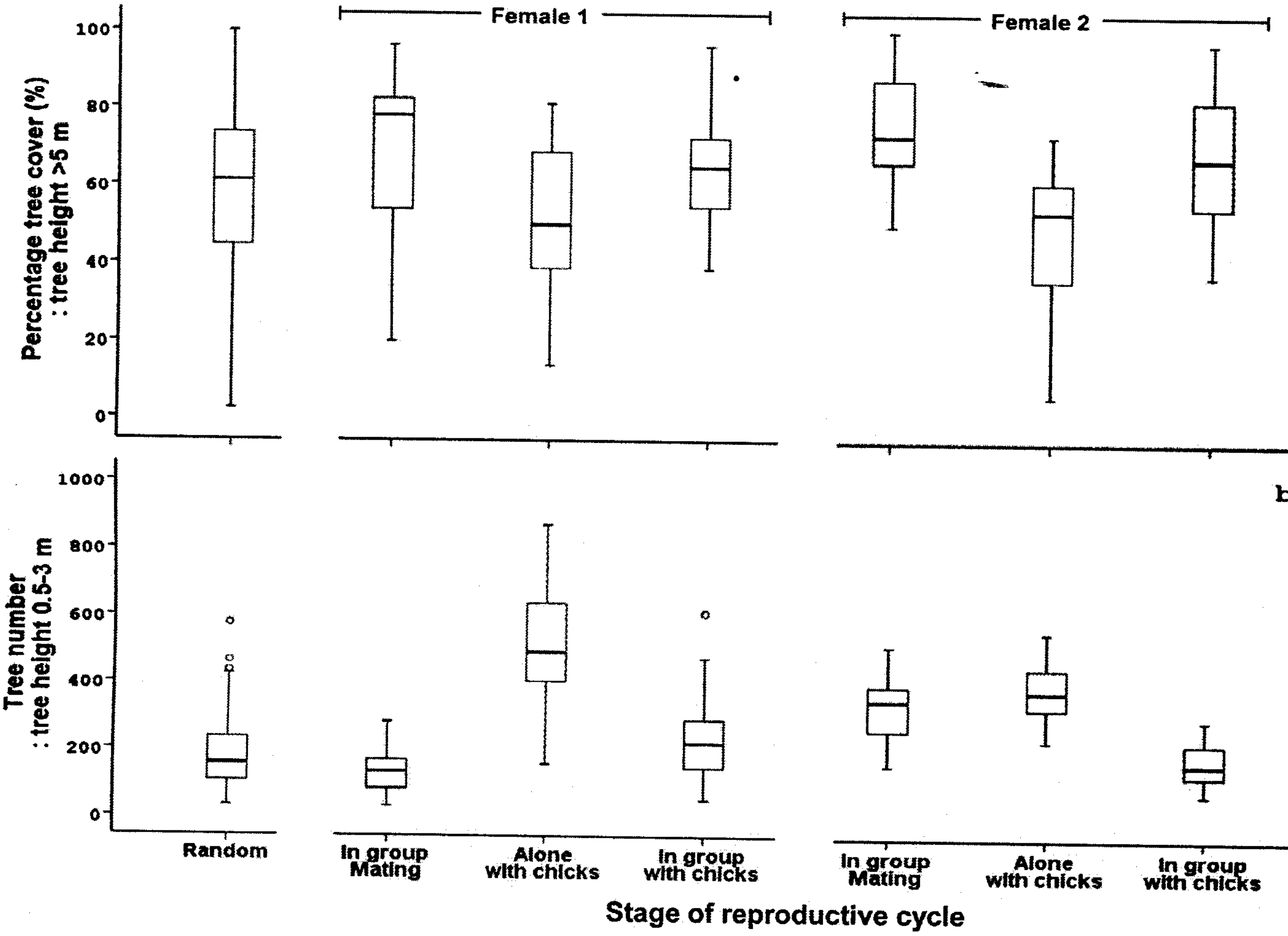

Figure 5.3 The comparison of percentage tree cover (height >5 meters) between used areas during the three year cycle periods and random areas of Female 1 and Female 2 (a), and the comparison of tree density (height 0.5-3 meters) between used areas during the three periods and random areas of Female 1 and Female 2 (b).

This use of dense understory vegetation by females during they are alone with young chicks (Period 3) may be a response to predation risk. Many species, including Galliformes with young chicks, tend to use densely vegetated areas (Lima, 1993; Peh et al., 2005) since the mortality of young chicks for some species is highest in the first few weeks of life, e.g. Ring-neck Pheasant *Phasianus colchicus* (Riley et al., 1998) and Rio Grande Wild Turkey *Meleagris gallopavo intermedia* (Spears et al., 2005). Similar behavior has been observed for female Hume's Pheasant (*Syrmaticus humiae*) in mixed evergreen forest associated with pines ranging between 1100 and 1600 m elevation in northern Thailand (Iamsiri & Gale, 2008). Similarly, predation avoidance could be the potential factor influencing the selection of denser habitat, at least in one of the two females, in the mating season (Period 1). During this season Siamese Fireback's tend to utter a loud whistling call, in addition to the typical *Lophura* wing-whirring display (Johnsgard, 1999), which could further increase their risk of being detected by mammalian and avian predators. This was observed by Hale (2004) where the playbacks of Black-breasted wood-quail (*Odontophorus leucolaemus*) choruses was approached by predators during survey. Collectively, similar vegetation characteristics are known to influence patterns of habitat use by male Sichuan Hill Partridge's (*Arborophila rufipectus*) in southern China. During the breeding season, males range mostly in evergreen broadleaf forest habitats with a dense, tall canopy vegetation cover, and open understory vegetation (Bo et al., 2009). These patterns of habitat use provide males with greater protective cover from canopy or sub-canopy dwelling predators and probably increase the likelihood of detecting predators as they approached at ground level (Bo et al., 2009). Habitat use by females was influenced by fewer vegetation characteristics during Period 4 of the reproductive cycle.

5.1 Selection of nesting locations

During our study, the nesting period for Siamese Fireback occurred between April and June, corresponding the nesting period for known lowland populations (Baker, 1928; Riley, 1938). The major difference in our study was the mean number of eggs per clutch (mean= 8 ± 3 with a maximum clutch size of 14 eggs), which was noticeably higher than previously reported for this species (mean = 6 ± 2, Madge and McGowan, 2002). Whether this observed difference is, in part, attributed to the range shift of female Siamese Fireback's to higher sub-montane elevations, or simply an attribute of the scarcity of information on this species throughout its known biogeographic range, remains unknown.

Another interesting result of our study was the use of topographically steeper slopes by nesting females. Selection of these sites was not influenced by any of the recorded vegetation characteristics. One reason therefore could be that nest site selection by females is influenced by a range of factors (operating at multiple scales) that were not recorded during our study. Alternatively, locating nests on steeper slopes can facilitate 'escape-flushing' down-slope in response to predation risk – a common phenomenon recorded for several Galliformes (e.g. Lima, 1993; Sukumal and Savini, 2009) and other bird species (e.g. Hanners and Patton, 1998).

5.2 Home range

The home range size of both female Siamese Firebacks significantly declined whilst they were alone with young chicks (Period 3) but later expanded again when the females and chicks returned to their original group (Period 4). Few quantitative data exist regarding the home range size of this species in their preferred lowland forest habitat, but we suspect that the reduction in home range size during Period 3 is related to the reduced mobility of young chicks (e.g. Klinger and Riegner, 2008). Davison (1981) estimated a home range of 20 to 25 ha for a closely related lowland species, the Crested Fireback (*L. ignita*) in lowland forest habitat (<150 m), Peninsular Malaysia. If we assume that lowland populations of Siamese Fireback have a similar home range size, we could conclude that the home range size of Siamese Fireback's in sub-montane forests could be potentially double of lowland populations. Our results also show that Siamese Fireback's tend to cluster in topographically flatter, wetter areas, which might force them to increase their range size because these areas are patchily distributed at sub-montane elevations in the Mo Singto area (Round and Gale, 2008).

We are unsure as to how representative our results are for the species as a whole across its known biogeographic range since our conclusions are based on a very small sample size (only two females) from one location. Low sample size was mainly a consequence of the difficulty in catching and, consequently, radio collaring birds in a hilly terrain where vegetation was particularly dense. Increasing the sample size could eventually be achieved by increasing the mist netting effort during the breeding season when the birds appear less attentive to their surroundings. To date, no quantitative data exist regarding patterns of habitat selection by females in other forest habitats throughout its range, and consequently, no comparisons can be made. The selection for flatter, wetter areas by both females could be a consequence of trying to occupy habitat with similar lowland understory vegetation characteristics (Johnsgard, 1999). Alternatively, these patterns could be a constraint influenced by interspecific competition with the sympatric Silver Pheasant, which tends to occupy drier, steeper slopes (Sukumal and Savini, 2009). Further detailed research is needed in lowland populations of Siamese Fireback to (a) investigate their habitat use and the size of their home range, (b) nest-site location and (c) their social structure.

5.3 Altitudinal differences between Siamese Fireback and Silver Pheasant

The results confirm our predictions, that Silver Pheasant mostly occupied slopes, while Siamese Fireback mostly occupied flat areas, although soil types between slope and flat areas will be required to test the difference in micro-habitat. The topographical separation between Siamese Fireback and Silver Pheasant occurs at a gradient of roughly 15 degrees, physically separating the two species. An exception to this pattern was observed where Siamese Fireback also selected nesting areas located on steep slopes. Overall our hypothesis, for which topography influences habitat selection and use by each of the two pheasant species, can be accepted.

The topography of the Mo Singto Long Term Biodiversity Research Plot is an undulating plateau ranging in elevation between 600 to 890 m, with over 80% of the area lying above 750 m which is the elevation where mostly Silver Pheasant were previously found (Round and Gale, 2008). In Thailand, Siamese Fireback is the species that is characteristic of lowland semi-evergreen forest, occupying drier plains and foothills. In contrast, Silver Pheasant, the montane species, occupy uphill evergreen forest, where the structure is varied with both drier ridges and moister slopes (Round, 1988). Although they have been moving to higher elevations, Siamese Fireback seem to use areas with the same topography that they use in the plains. Where flat areas are located on ridge tops and along streams the new niche is the most similar to the one found in the lowland habitat. Elevation itself did not appear to be the driving force for their range limitation as elevation did not correlate with topography in our study site.

Although topographical variation in our study site might be related to the different vegetation, with consequent difference in food supplies, both pheasant species seem to have similar diets and foraging behavior, consuming a wide range of invertebrates and plant matter (Johnsgard, 1999). We have never observed direct feeding competition between these two species but can assume that topographical variation does not cause food limitation as food supplies do not appear to belimiting the use of specific areas within the study site.

Nest locations, on steep slopes for both species, can be interpreted as a strategy to make the nests less accessible to predators and facilitate flushing downslope in steep terrain to escape predators as is common among the Galliformes (Lima, 1993). However, such behavior has yet to be quantified at the site because of the small sample of nests; additional research focusing on this issue is on-going at the site.

Syntopy in avian congeners has been studied with two flycatcher species *Elaenia flavogaster* and *E. martinica* in the Windward Islands and Trinidad (Crowell, 1968). Although the diets between these two closely related species were similar in food composition, their feeding behaviour and habitat preference appeared to be different. In contrast, two sympatric gibbon species. *Hylobates agilis* and *H.* (*Symphalangus*) *syndactylus* in the Sumatran rain forest showed similar use of forest structure and composition of their habitat, but their dietary overlap was reduced with *H. agilis* having a high fruit component of the diet while *H. syndactylus* showing a larger leaf component (O'Brien et al. 2004). On our study site, two gibbon species, *H. lar* and *H. pileatus,* show a similar use of habitat and a similar diet resulting in mixed-species groups that appear to be hybrids.

Our results show that there is a topographical threshold in the use of habitat that might reduce the risk of interbreeding between the two pheasants observed in captive birds (Ghigi, 1968:241) and between other wild ranging species of the genus *Lophura* such as Silver Pheasant and Kalij Pheasant (*L. leucomelana*) in Yunnan and Burma (Johnsgard,

1999) and between Edwards's (*L. edwardsi edwardsi*) or Vietnamese (*L. edwardsi imperialis*) and Silver Pheasant resulting in the Imperial pheasant, long considered an separate species (Johnsgard, 1999; Robson, 2000; Hennache et al., 2003). However, a small area of overlap, around the 15 degree threshold, has been observed where both species sporadically occur. Second, mixed-species groups between these two species have been observed in the area. This social formation has been explained as the consequence of a difference in the mating behaviours of the males in each species (Savini and Sukumal, 2009).

5.4 Reticulated Python (*Python reticulatus*) predation on Silver Pheasant

Predation on radio-collared animal has been sporadically reported: e.g. Malayan sun bear (*Helarctos malayanus*) predated by Reticulated Python (Fredriksson, 2005), and Agouti (*Dasyprocta punctata*) predated by Ocelot (*Leopardus pardalis*) (Aliaga-Rossel et al., 2006). At least in one of those cases the predation event on radio-collared animal highlighted the potential predation pressure by unexpected predator.

This observation gives us clearer information on the nature of pheasant predator in a tropical habitat. Most of pheasant predation events have been reported for ring-necked pheasant (*Phasianus colchicus*) for which the majority of predators were mammalian and avian (raptors) (Gates, 1972). For those predator groups the escape strategy by Galliformes group is mostly by sudden fly to woody vegetation or downslope in steep terrain (Lima, 1993). Although the beginning of this predation was unclear, the Silver Pheasant might have been foraging close to the Burmese Python without detecting it and been caught after a sudden stroke. Sudden stroke is the classic predation strategy by those cryptic large snakes which tend to ambush prey by relying on its camouflage (Fredriksson, 2005).

On average, digestion, nutrients absorption, excretion and defecation by Python occur within 8-14 days after feeding (Starck and Beese, 2001). As this predation event was observed for 8 days, from 24 to 31 August 2007, we can assume the predation event to have happened around the 18-23 August 2007. After the predation the python coiled in the burrow under fallen tree and started the digestion of its prey. The Python changed a place in the second observation most likely as the consequence of our disturbance during the first observation.

We still do not know how common predation on pheasant by large snake is. We also do not know what the anti-predator strategy might be. However, in the investigation of ecological factors affecting Galliformes the density of large snake should be considered.

5.5 Conclusions

Although suggestions have been made (Round and Gale, 2008), it still remains largely unclear what is the driving force for Siamese Fireback in Khao Yai National Park to expand their range into higher elevation forests. Independently from the cause generating the observed shift our study tried to examine habitat use by a lowland forest bird species which is now found ranging into sub-montane forest, Across habitat and elevational gradients some bird species appear physiologically highly tolerant to both micro-climate and micro-habitat changes (Martin, 2001). If populations of Siamese Fireback at Mo Singto are tolerant to similar abiotic and biotic factors across the elevational gradient, then there may be two main/principal reasons as to why this lowland species is expanding 'upward'either : (1) as a direct response to lowland habitat degradation, or (2) the 'amount' of available optimal habitat at higher sub-montane elevations has significantly increased providing the species with an alternative to lowland habitat saturation. However, few long-term data exist regarding the relative abundance of the lowland Siamese Fireback populations or changes in forest micro-habitat structure (e.g. over the past 20 yr) to test either hypothesis.

Overall, the results shown here indicate how a lowland pheasant, Siamese Fireback (*Lophura diardi*), can adapt and survive after expanding their range to sub-montane habitat by reducing competition and risk of interbreeding with the resident montane pheasant species, Silver Pheasant (*L. nycthemera*). Topography is a predominant factor in influencing habitat use between *Lophura* pheasants, Silver Pheasant occupy predominantly steep slope while Siamese Fireback occupied mainly flat and gently sloping habitat patches.

The micro-habitat structure in sub-montane forest also influenced patterns of habitat use by female Simaese Fireback during different periods of the reproductive cycle. They mostly occupied topographically flat areas with high understory plant, as observed in a lowland population (Deignan, 1945; Vy et al., 1998), during the mating season and when females were alone with young chicks, confirming their adaptation and survival in a new environment where predation pressure remain high. However, this study also highlight the general lack of detailed information on ecology and biology of Siamese Fireback a near threatened species for who still little is known. The gap appears even larger when the entire group of Southeast Asian Galliformes is considered.

In order to be fully reliable the information obtained with this study still needs to be compared with a more quantitative work conducted on Siamese Fireback inhabiting their original lowland habitat. This will fill the gap of knowledge of this threatened pheasant species (McGowan and Garson, 1995; Madge and McGowan, 2002). The habitat key variable for maintaining a Siamese Fireback population is a topographical flat area covered by with dense understory plants. This information could be referable information for other places where the management for this species is needed, for example in Vietnam and Laos where the lost of suitable habitat is high (McGowan and Garson, 1995).

Concerning the impact of habitat modification generated by global climate change, this study provides information on how a lowland species can get benefit from expanding their range to higher altitudinal habitat. Range expansion to higher elevation for species which are normally restricted to lowland habitat has been predicted the effects to the resident species on those higher habitats by reducing their population size as consequence of direct competition increase (Shoo et al., 2005). However, a previous work by Round and Gale (2008) showed that the detection rate of the montane Silver Pheasant remained unchanged while a significant increase for the lowland Siamese Fireback in the area was recorded. In this regard the results here presented show a clear topographical separation between the two species that might limit direct interaction between them. Moreover a slight difference in their mating behaviour has also been reported (Savini and Sukumal, 2009). However, with the current knowledge, I cannot exclude a potential risk of hybridization between the two resident species on a longer term. Hybridization is also considered as a potential threat when closely related species are that usually separated geographically, come into contact. Although no inbreeding has been so far documented, mixed-species groups have been reported and explained (Savini and Sukumal, 2009). The interbreeding of pheasant in the wild within similarity genera have been reported before between Silver Pheasant (*L. n. occidentalis*) and Kalij Pheasant (*L. leucomelana lathami*) in northwestern Yunnan and northeastern Burma where they overlap in habitat use (Johnsgard, 1999). Famous is also the case of the Imperial Pheasant (*L. imperialis*) long being considered a very rare species and now known to a hybrid between Edwards's (*L. edwardsi*) or Vietnamese Pheasant (*L. hatinbensis*) and Silver Pheasant as their habitat overlap in Vietnam (Hennache et al., 2003).

We conclude that the Siamese Fireback population including others bird species within the Khao Yai National Park is a suitable candidate for such long-term research. If the factors that provide the driving force behind the elevational range expansion of birds' community across temporal scales can be identified, then these could enable ecologists to predict with greater accuracy the responses of other lowland species to changes in regional climate patterns, and to changes in agricultural/forestry land-use patterns, themselves often brought about by climate change.

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