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ABUNDANCE AND HABITAT PREFERENCES OF SMALL MAMMALS IN SOUTHWESTERN THAILAND

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ABSTRACT

Habitat preferences and relative abundance were determined for 11 species of small mammals in three types of dry, bamboo-mixed deciduous forest. Lowland bamboo forest was the favoured habitat type, having the most species and the highest frequency of captures. Dry dipterocarp forest had the fewest species aud the lowest capture frequency, making it the least used habitat. Vegetation and soil characteristics affecting use patterns are discussed for each forest type.

INTRODUCTION

Detailed habitat information for the small, forest mammals of southeast Asia is sparse. Most knowledge of habitat use of rodents and insectivores comes from reports of zoological collectors and medical survey teams that include habitat notes only as secondary information. Their vegetation descriptions have often been limited to very generalized terms such as forest, secondary forest or scrub. Few studies have been made comparing preference among forest types by a single species or comparing relative abundance among species within a forest type. This information is necessary before an understanding of the ecology of a species can be developed. This paper reports on small mammal relative abundance and habitat preferences within a hilly region of dry, bamboo-mixed deciduous forest. The results are based on live trapping and observations in Salak Phra Wildlife Sanctuary in southwestern Thailand.

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STUDY AREA

Salak Phra Wildlife Sanctuary is located among the eastern-most foothills of the Tenasserim Mountains in Kanchanaburi province in south-western Thailand. The area, which was designated a sanctuary in 1972, is situated on the eastern edge of the Mae Klong or Khwae Yai River (14°08′ to 14°42′ N and 99°06′ to 99°25′E) and has a total area of 936 km^2. Steep limestone hills alternating with several valleys of 25 to 50 km^2 dominate the landscape. Elevations range from 55 to 1210 m. Some of Thailand's finest bamboo forest is also present. On the northwest side, the sanctuary borders a reservoir behind the newly completed Chao Nen Dam and its associated village resettlement areas. To the southwest, south and east, scrub bamboo forest and cultivated land planted mostly to sugar cane border the reserve. Only in the north does relatively undisturbed forest continue outside the sanctuary boundries.

MOORMAN & RAJANASOONTHAON (1972) distinguish two soil types for this part of Kanchanaburi. Red-brown earths exist in the lowlands, where they have originated from limestone residuum or from alluvial and colluvial deposits derived from limestone. The soil is generally of clayey texture but clay is especially evident in the B horizon where base saturation is medium to high. The second soil type, found on hills and steep terrain, is variable in character but is always very shallow and frequently similar to the lowland red-brown earths.

The climate at Salak Phra is characterized by three basic monsoonal seasons typical of Thailand. A rainy season occurs from May to October when approximately 75% of the annual rainfall occurs, a cool, dry season from November to February, and a hot, dry season from February to May. As is typical for western Thailand, lying in the rain shadow of the Tenasserim Mountains, average annual rainfall is low at 1130 mm. Average maximum air temperature is 32.5°C with an average minimum of 20.1°C. Weather data was collected at Amphoe Si Sawat, a town 45 km northwest of the study area.

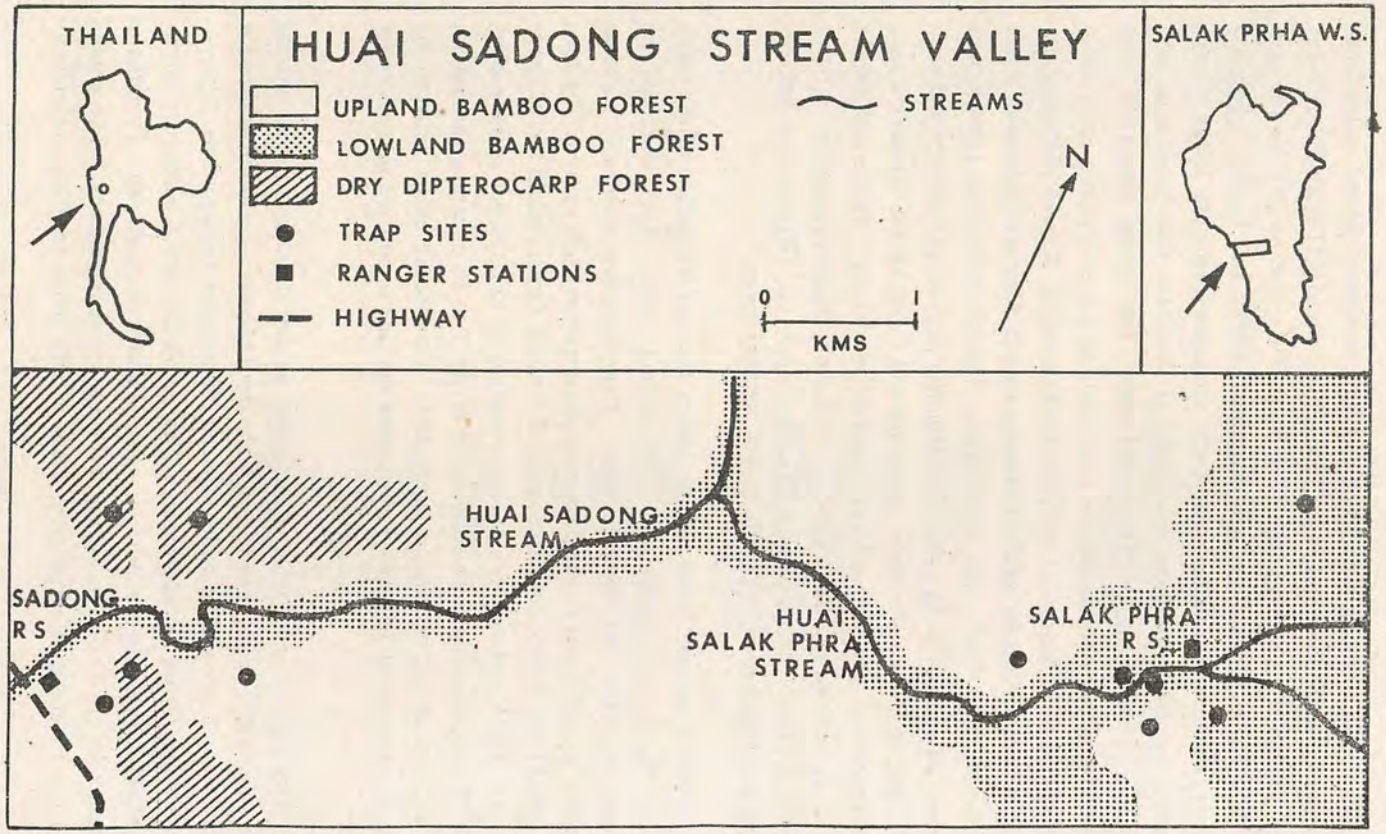

Fig. 1. Location of trap sites and forest types in the Huai Sadong Stream Valley study site. Insets show the positions of Salak Phra Wildlife Sanctuary in Thailand and the study area within the sanctuary.

The main trapping area was an 18-km^2 section of stream valley located between the Sadong and Salak Phra ranger stations (Figure 1). A 9-km portion of the Huai Sadong and Huai Salak Phra streams divides the area in half. Three forest types are contained within it. Lowland bamboo forest is found only in valleys where soil thickness is greatest. Large clumps of thorny bamboo (*Bambusa arundinacea*) dominate this forest type and typically cover 2 to 10% of the ground space. They reach heights of 15 to 25 m and together with deciduous trees such as *Lagerstroemia calyculata, Gmelina arborea, Diospyros mollis, D. rhodocalyx, Sisyrolepis muricata, Homalium tomentosum, Millettia leucantha* and *Crataeva adansonii* make up a forest with a fairly open overstorey. Smaller understorey trees such as *Combretum quadrangulare* and *Cleisthanthus papyraceus* interspersed with woody climbers like *Bauhinia bracteata* and *Caesalipinia hymaenocarpa* reach heights of 4 to 8 m and vary greatly in density. Herbs and shrubs such as *Aglaonema* sp., *Boesenbergia pandurata, Bauhinia scandens, Grewia tomentosa, Harrisonia perforata, Streblus aspers* and *Glyphostylus laoticus* make up a low density, typically thorny, ground cover.

Upland bamboo forest, which covers the largest portion of the study area, is found on hillsides and level upland areas. Rock outcrops are frequent and the soil layer is thin. *Thyrsostachys siamensis* replaces *Bambusa arundinacea* as the dominant plant species while many of the tree, shrub and herb species found in lowland bamboo forest remain but at lower density. The deciduous tree canopy reaches 12 to 20 m but is very open while *T. siamensis* forms a solid layer in the 7 to 15 m strata throughout and at times almost becomes a pure stand. No ecotone exists between the upland and lowland bamboo forests, and the line separating them is easily visible.

Dry dipterocarp forest, also known as dry deciduous forest, indaing (RICHARDS, 1952) or savanna forest, is the third habitat type found within the study area. It consists of widely spaced dipterocarp trees such as *Dipterocarpus obtusifolius, D. tuberculatus, Shorea obtusa* and *S. siamensis* interspersed with *Pterocarpus macrocarpus, Xylia xylocarpa* and *Terminalia chebula* that are 8 to 16 m high and form a sparse overstorey. The ground cover layer consists either of pure grass or with young seedlings intermixed.

Cycads *(Cycas siamensis)* are often present. This type of forest is found on hillsides and in lowlands where soil is thin and rock outcrops are present.

Ground fires annually burn through much of the sanctuary. Their effects are poorly understood, but they certainly play an important role in the ecology of these three forest types, particularly the dry dipterocarp forest.

METHODS

Live trapping of small mammals took place between August 1976 and September 1977. Twenty to twenty-five wire mesh traps (12 by 12 by 30 cm) were set out 3 to 5 nights each month, usually in the same location for 3 nights and 2 days. They were placed in grids with 3 to 5 rows of traps spaced 15 to 20 m apart within each row. Ripened banana was used as bait. In order to sample both diurnal and nocturnal small mammals, traps were checked for animals twice daily, in the morning between 0700 and 0900 hr and again between 1600 and 1800 hr. Fresh bait was added every evening. Animals caught were weighed, measured, sex-determined and numbered by toe clipping before release. Most trapping was done in lowland bamboo forest because of its proximity and the abundance of small mammals there. Observations were used to supplement trapping data and provide additional information on abundance and habitat use, particularly for the squirrels and bamboo rats.

RESULTS AND DISCUSSION

Eleven species of small mammals were captured during trapping or were observed in the study area (Tables 1 and 2). Data on habitat use and relative abundance follow.

Tupaia glis

Habitat for this treeshrew ranges from primary forest to suburban areas, but it is most common in secondary forest and areas with brushy patches (LEKAGUL & MCNEELY, 1977; MEDWAY, 1969; PANTUWATANA *et al.*, 1969). Heavy cover for escape appears to be an important factor in its occurrence. *T. glis* was trapped in all three forest types at Salak Phra. The

highest frequency of catches (2.9%) was obtained in lowland bamboo forest, an indication that it is the preferred habitat type (Table 1). Treeshrews taken in dry dipterocarp and upland bamboo forest were usually captured in or near thickets of grass, brush or *Eupatorium odoratum*. The frequency of day captures was almost double nocturnal captures and reflects the diurnal character of *T. glis*. Those taken during the night period may have been caught in late evening or early morning.

Ratufa bicolor

This giant tree squirrel is restricted to the upper levels of tall trees in both evergreen and deciduous forest (ASKINS, 1977; MEDWAY, 1969; SHORTRIDGE in WROUGHTON, 1915b; HARRISON & TRAUB, 1950). At Salak Phra *R. bicolor* was confined to the scattered sections of lowland bamboo forest containing large deciduous trees. It was not present in either upland bamboo or dry dipterocarp forest, which lack tall trees. This dependence caused it to be the least common of the diurnal tree squirrels.

Callosciurus caniceps* and *C. flavimanus

C. caniceps is often found near villages, cultivated land and scrub growth but is equally abundant in forest, secondary growth and bamboo forest up to 1450 m (ASKINS, 1977; MEDWAY, 1969; SHORTRIDGE in WROUGHTON, 19156; HARRISON & TRAUB, 1950; AUDY & HARRISON, 1953; BONHOTE, 1903; GYLDENSTOLPE, 1914). In contrast, *C. flavimanus* appears to be strictly a forest squirrel found in both deciduous and evergreen forest up to 3000 m (MOORE & TATE, 1965; MEDWAY; 1969; ASKINS, 1977). At Salak Phra both species have similar habits and are often found together in the same trees. Both appear to favour lowland bamboo forest, while their occurrence in upland bamboo forest is generally restricted to areas containing moderate or large numbers of deciduous trees. In dry dipterocarp forest, however, their use is restricted to occasional foraging in trees near the edge of bamboo forest. *C. caniceps* is much more common than *C. flavimanus* throughout the sanctuary.

Menetes berdmorei

This diurnal ground squirrel has a wide range of habitats. It has been found in and along forest edges, in dry forest, bamboo, thick scrub, tall grass and cultivated land (ASKINS, 1977; SHORTRIDGE in WROUGHTON, 1915a, b; GYLDENSTOLPE, 1914; WHARTON, 1966). This is a common species at Salak Phra even though only four individuals were captured in traps. It was observed to be most abundant in lowland bamboo forest. *M. berdmorei* is more dependent on thick patches of grass, brush, *Eupatorium odoratum* and downed bamboo clumps in all three forest types than is *Tupaia glis*. As PANTUWATANA *et al.* (1969) also reported, both species were regularly found in the same brushy thickets.

Hylopetes phayrei

Although apparently a common flying squirrel in southeast Asia, the only previous description of its habitat comes from SHORTRIDGE in WROUGHTON (1915a) who found it at 1000 m in partly cleared forest near cultivated land. Two individuals were caught at Salak Phra at 65 m elevation in lowland bamboo forest, also partly cleared, by a domestic cat near the Sadong ranger station. *H. phayrei* is probably found throughout this forest type but may be limited by tree distribution in upland bamboo forest and excluded from dry dipterocarp forest where larger deciduous trees are absent.

Cannomys badius and *Rhizomys sumatrensis*

Both of these bamboo rats can be found in lowland and hilly regions containing secondary forest with large bamboo stands (LEKAGUL & MCNEELY, 1977; MEDWAY, 1969; HARRISON & TRAUB, 1950; GAIRDNER, 1914). Soil thickness and texture and bamboo distribution are the limiting factors in their presence at Salak Phra. Evidence of burrowing was seen frequently throughout lowland bamboo forest, the preferred habitat type, where these factors are most favourable. Tunneling in upland bamboo forest was noted only in saddles and flat or gently sloping spots on hillsides where the soil was deep enough to allow digging. No use of dry dipterocarp forest was observed. Both *C. badius* and *R. sumatrensis* emerge from their burrows at night and may roam widely while feeding (LEKAGUL & MCNEELY, 1977;

BLANFORD, 1891). This enables them to find and move into new areas on hillsides with sufficient soil that are often isolated by thin or rocky soil and rock outcrops. The relative abundance of the two species was difficult to determine because of the similarity in their burrowing habits. However, based on the animals caught by villagers with bamboo snares and through digging, *C. badius* is the more common species.

Rattus surifer

This is the most abundant and widely distributed rat of natural areas in Thailand (MARSHALL, 1977). It has been found in evergreen, dry dipterocarp, lowland and hill forest, secondary growth, scrub and orchards (MARSHALL, 1977; MEDWAY, 1969; PANTUWATANA *et al.*, 1969; SHORTRIDGE in WROUGHTON, 1915b). At Salak Phra *R. surifer* was the most common small mammal in lowland and upland bamboo forest, making up 63.5% nad 68.2%, respectively, of all animals caught at night (Table 1). The highest frequency of captures occurred in lowland bamboo forest (9.2%), which appears to be the preferred habitat. None were found in dry dipterocarp forest. As MARSHALL (1977) also noted, large numbers of mites and ticks were found on all individuals caught.

Rattus rattus

This is southeast Asia's most ubiquitous rat, being found in almost all natural, agricultural and domestic habitats (MARSHALL, 1977; HARRISON & TRAUB, 1950; PANTUWATANA *et al.*, 1969; MEDWAY, 1969). Trapping results from Salak Phra confirmed this as *R. rattus* was captured in all three types of forest and around the sanctuary's living quarters. The highest frequency of catches (4.4%) occurred in dry dipterocarp forest, which appears to be the favoured habitat type (Table 1). The absence of *R. surifer* from this type indicates the possibility of competition with *R. rattus*. In each kind of bamboo forest, the frequency of *R. rattus* captures was less than half of that for *R. surifer*. However, with *R. surifer* absent, *R. rattus* abundance increased.

Further evidence of the great adaptability of *R. rattus* is its presence in the houses at Salak Phra Checkpoint. This 8-year old ranger station was located in lowland bamboo forest in the middle of the sanctuary, 9 km from

any other buildings. Very few vehicles reach the checkpoint and those that do carry few items that could bring rats in. Thus, *R. rattus* has probably arrived without the help of man. There is most likely a continual, slow movement of rats into the houses from the surrounding forest whereupon they are removed by man.

Rattus neilli

This species was first discovered by man in 1974 and has been found only at Kaeng Khoi district in Saraburi province, 220 km east of Salak Phra, and Sai Yoke district in Kanchanaburi province, 30 km to the west (MARSHALL, 1977). At both locations, *R. neilli* was found only in the upper sections of limestone cliffs. In this study, three individuals were captured in lowland bamboo forest on the Huai Salak Phra valley floor at an elevation of 170 m. The trap sites averaged 115 m (maximum, 130 m) from the base of the nearest limestone mountain. As none of these rats were found in other habitat types, lowland bamboo forest appears to be the preferred forest type. This challenges the belief that *R. neilli* is strictly a cliff-dwelling rat.

Habitat Factors Influencing Abundance

Lowland bamboo forest contains the greatest abundance and diversity of small mammals in the study area. It had the highest frequency of nocturnal animal captures (14.4%) and the most species present (Tables 1 and 2). The variety of bird species was also the highest in this forest type (WILES, 1980). Vegetation and soil features account for this by providing more niches. Large, thorny and entangled clumps of *Bambusa arundinacea* provide excellent escape cover for all species with the possible exception of *Ratufa bicolor* which may not enter bamboo. The roots supply an unlimited food source for bamboo rats. Increased numbers of large deciduous and fruiting trees provide a higher, more diverse overstorey than is found in other types. This suggests greater food production for all animals as well as greater protection and nesting potential for squirrels. Ground dwelling species benefit from a more moist and dense ground cover. Thick soils provide easy burrowing for bamboo rats and rats.

Another partial explanation for the high abundance of rats and squirrels is that 1976 was a mast year for *Bambusa arundinacea*. This species has an intermast period of 30 to 50 years. JANZEN (1976) cites numerous examples of rodent population increases, particularly for *Rattus* spp., caused by bamboo seed crops. Increases may be due to the strong reproductive response of rodents to increased food supplies or to immigration into mast-containing areas from surrounding forest types without a mast crop. No attempts to measure this effect were made in this study. Trapping did not start until after the seed crop became available, making it impossible to determine small mammal pre-crop abundance. Also, failure to trap repeatedly at specific sites within the study area made evaluation of changes in trapping success difficult. Thus no good estimation can be made of the influence of mast year crops on population dynamics.

Small mammal abundance is lower in upland bamboo forest, while diversity remains fairly high. Frequency of captures in the night period dropped to 6.2%; however, at least 8 species remained present (Tables 1 and 2). WILES (1980) showed that the number of bird species was less than half that in lowland bamboo forest. The deciduous overstorey in upland bamboo forest is poorly developed, being smaller, less dense and containing fewer fruit-producing trees than lowland forests. Clumps of *Thyrsostachys siamensis* lack the thorny branches and sturdiness of *Bambusa arundinacea* clumps and are much smaller at ground level. The ground cover is normally sparse. Thus squirrel, rat and treeshrew abundance drops because of a probable decrease in food production and protective cover. Rock outcrops and cliffs add an extra dimension to the habitat and provide rats with holes and crevices for cover. However, no additional species seem to have been attracted by their presence. Bamboo is still found in large quantities, but bamboo rat numbers are lower because thin, rocky soils contain fewer potential digging sites.

Small mammals were most uncommon in dry dipterocarp forest. The frequency of nocturnal captures (5.2%) was the lowest of any forest type and only 5 species were definitely recorded as present (Tables 1 and 2). Similarly, bird diversity was lowest in this forest type in the sanctuary (WILES, 1980). The very low and open overstorey and lack of fruiting

Table 1. Numbers and species of small mammals trapped in three forest types at Salak Phra Wildlife Sanctuary, 1976–1977. Number of trap-periods is number of traps times number of days or nights of trapping: N=night period (1700–0800 hrs); D=day period (0800–1700 hrs). Under each species: No.=number captured; %TC=percentage of trap-periods in which the species was captured; (%FT)= that species as a percentage of all animals captured per forest type.

Forest type	No of. trap-periods	*Rattus surifer* No.	%TC (%FT)	*Rattus rattus* No.	%TC (%FT)	*Rattus neilli* No.	%TC (%FT)	*Tupaia glis* No.	%TC (%FT)	*Menetes berdmorei* No.	%TC (%FT)	*Callosciurus caniceps* No.	%TC (%FT)	Total No.	%TC (%FT)
Lowland	N 662	61	9.2	20	3.0	3	0.5	10	1.5	2	0.3	0	0	96	14.4
bamboo			(63.5)		(20.8)		(3.1)		(10.5)		(2.1)				(100)
forest	D 340	0	0	0	0	0	0	10	2.9	1	3.0	1	0.3	12	3.5
									(83.3)		(8.3)		(8.3)		(100)
Upland	N 349	15	4.3	7	2.0	0	0	0	0	0	0	0	0	22	6.3
bamboo			(68.2)		(31.8)										(100)
forest	D 233	0	0	0	0	0	0	2	0.9	0	0	0	0	2	0.9
									(100.0)						(100)
Dry dip-	N 252	0	0	11	4.4	0	0	2	0.8	0	0	0	0	13	5.2
terocarp					(84.6)				(15.4)						(100)
forest	D 164	0	0	0	0	0	0	1	0.6	1	0.6	0	0	2	1.2
									(50.0)		(50.0)				(100)

Table 2. Relative abundance of small mammals according to forest type at Salak Phra Wildlife Sanctuary, 1976–1977. Key to abundance: **** =very common; ***=common; **=uncommon; *=rare; –=presence was not noted.

Species	Lowland bamboo forest	Upland bamboo forest	Dry dipterocarp forest
Tupaia glis	****	**	**
Ratufa bicolor	*	–	–
Callosciurus caniceps	****	***	*
Callosciurus flavimanus	***	**	*
Menetes berdmorei	***	**	**
Hylopetes phayrei	***	–	–
Cannomys badius	****	**	–
Rhizomys sumatrensis	***	**	–
Rattus surifer	****	**	–
Rattus rattus	***	***	***
Rattus neilli	*	–	–

trees eliminates tree squirrel presence except at the edges of bamboo forest. Bamboo rats are not present because of the absence of bamboo and burrowing sites. *Tupaia glis* and *Menetes berdmorei* occur uncommonly near the forest edge or in infrequent patches of thick ground cover. *Rattus rattus* is the only species that is more abundant in this habitat type than others. WHARTON (1966) believed that the general lack of rodents and insectivores, especially burrowing species, was evidence supporting the fairly recent origin of dry dipterocarp forest in southeast Asia.

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