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SMALL MAMMALS OF THUNG YAI NARESUAN AND HUAI KHA KHAENG WILDLIFE SANCTUARIES IN WESTERN THAILAND

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ABSTRACT

A project was carried out to investigate the status and distribution of the small mammal community in Thung Yai Naresuan and Huai Kha Khaeng Wildlife Sanctuaries. Surveys for small mammals were carried out in 15 study sites, 10 in Thung Yai and five in Huai Kha Khaeng, between 19 May 1993 and 28 October 1993, and during March 1994. The sanctuaries cover an area of 6222 km^2 and are made up of a diverse mosaic of habitat types, including dry evergreen, dry dipterocarp, mixed deciduous and bamboo forest, and a large area of savannah.

A total of 70 species of small mammal were recorded; three Insectivora, one Scandentia, 41 Chiroptera, 24 Rodentia and one Lagomorpha. Twenty-four of these were new records for the sanctuaries, bringing the total number of known small mammal species to 95, representing 47% of Thailand's small mammals.

Analysis of prey remains yielded information about the diet of predatory mammals and raptors. The remains of 10 species and two additional genera were found in carnivore faeces. Four species were found to be eaten by the carnivorous bat *Megaderma lyra* and the remains of nine species and two other genera were found in whole and dissociated raptor pellets.

INTRODUCTION

Thailand is situated in a zoogeographically important area of South-East Asia. It is part of the Indochinese subregion which stretches from Assam across to southern China and south through Vietnam, Laos, Cambodia, Burma and Thailand as far as the Isthmus of Kra (CORBET & HILL, 1992). This area contains many tropical genera which extend north from the Sunda, but not beyond the northern and western boundaries of this region, such as *Tupaia, Berylmys* and *Hapalomys.* It also contains some temperate species which extend south from China, such as *Anourosorex squamipes, Ia io,* and *Arctonyx collaris,* and species from the Indian and Himalayan subregions which reach their southern most limit around the Isthmus of Kra, such as *Vandeleuria oleracea, Bandicota indica* and *Niviventer fulvescens.* The peninsula is part of the Sundaic subregion containing many genera which do not extend north of the Isthmus of Kra (CORBET & HILL, 1992).

Thailand has a rich and diverse fauna with 271 species of terrestrial mammals (CORBET & HILL, 1992; JENKINS & SMITH, in press), of which 74% (n = 200) are small mammals. Many of Thailand's mammals are dependent on forests. According to official estimates, forest cover had declined in Thailand to 29% of the total land area by 1989 (ROYAL

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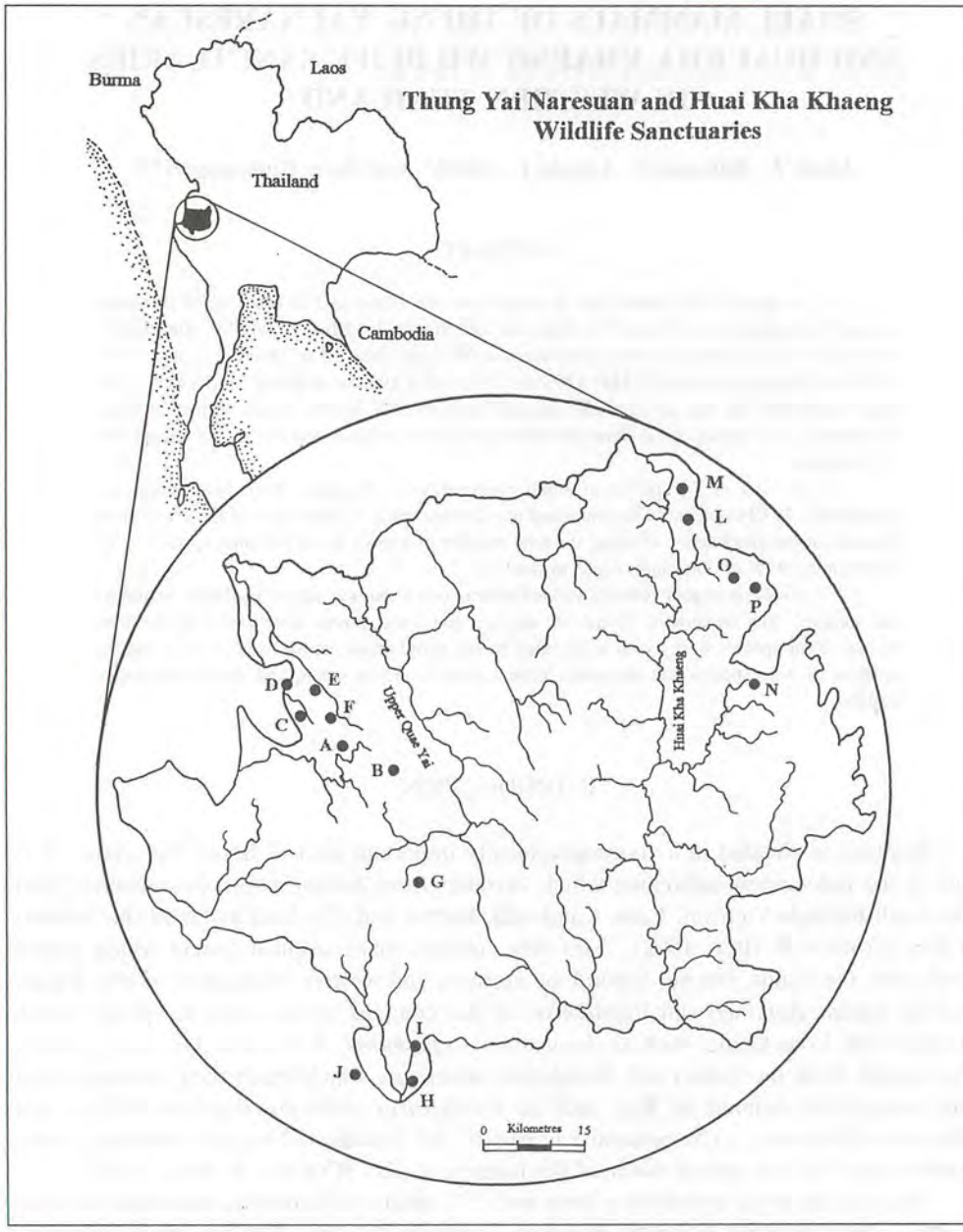

Figure 1. Study areas in Thung Yai Naresuan and Huai Kha Khaeng Wildlife Sanctuaries in Western Thailand, showing major rivers and tributaries. **Thung Yai Naresuan: A.** Mae Kasat Guard Station; **B.** The Thung Caves; **C.** Ban Jagae Guard Station; **D.** Ban Jagae Limestone Outcrop; **E.** Tham Mong kw; **F.** Thimu Limestone Outcrop; **G.** Headquarters; **H.** Lum Khao Ngu Guard Station; **I.** Lum Khao Ngu Limestone Outcrop; **J.** Ban Hua Sia. Huai Kha Khaeng: **L.** Kapuk Kapeang Guard Station; **M.** Kapuk Kapeang Research Plot; **N.** Khao Nang Rum Wildlife Research Station; **O.** Tham Khi Nok; **P.** Headquarters.

FOREST DEPARTMENT, 1991), although this is considered by some to be an overestimate (EUDEY, 1991). Around 52,000 km^2 of this is protected by national park or wildlife sanctuary status (LEKAGUL & ROUND, 1991), which represents about 10% of Thailand's total land area.

Thung Yai Naresuan and Huai Kha Khaeng Wildlife Sancturaries cover an area of 6222 km^2. These constitute the largest area of dry tropical forest in the region, and together with the surrounding protected forest, this area is effectively one of the largest legally protected nature reserves in South-East Asia with a total area of 12,083 km^2, comprising one of the most important conservation areas in the whole of South-East Asia. Although birds and large mammals have been well surveyed, little is known about the small mammal communities, particularly in Thung Yai Naresuan. Small mammals play a vitally important role in the forest ecosystem. The high reproductive rate and small size of rodents and insectivores make them an abundant source of food for many predatory animals, such as raptors, cats and civets. Fruit bats are major pollinators and seed dispersers in tropical forest ecosystems and insectivorous bats are the major controllers of night-flying insects.

The project aimed to investigate the status and distribution of the small mammal community in TYN–HKK. In the present study small mammals include species of the orders Insectivora, Scandentia, Chiroptera, Rodentia and Lagomorpha.

STUDY AREA

The TYN–HKK complex has a wide range of habitat types including mixed deciduous, dry evergreen, hill evergreen and dry dipterocarp forest and savannah, providing a wide variety of niches for the extensive wildlife which it supports. In addition, pure bamboo forest covers 183 km^2 or 3% of the sanctuary, mostly at the southern end of Huai Kha Khaeng. Three mountain ridges of limestone and granite run from north to south, each one exceeding 1500 m. These are separated by the Upper Quae Yai and the Huai Kha Khaeng rivers, each of which have two tributaries. In addition there are five smaller rivers. These all retain water throughout the year. TYN–HKK is the only protected area in Thailand to have relatively undisturbed riverine habitats within its boundaries (LEKAGUL & ROUND, 1991).

Thung Yai Naresuan Wildlife Sanctuary

Thung Yai Naresuan is a mountainous area of Permian limestone, covered by predominantly mixed deciduous forest and dry hill evergreen forest (Mahidol University Center for Conservation Biology database). It has a large area of savannah, covered with grass and herbs, with low densities of small trees mixed with many *Cycas* spp. There are fires each year in the dry season and an annual rainfall of 2000–2400 mm. The monsoon climate results in a highly stable ecosystem reflected in the number of plants and animals (PHUMPAKAPUN & KUTINTARA, 1983). Surveys were carried out between 19 May 1993 and 8 August 1993, in nine areas of Thung Yai Naresuan; Mae Kasat Guard Station, the Thung Caves (Fig. 10), Ban Jagae Guard Station, Ban Jagae Limestone Outcrop, Tham

Mong Kw, Thimu Limestone Outcrop, Thung Yai Naresuan headquarters, Lum Khao Ngu Guard Station, Lum Khao Ngu Limestone Outcrop and one area in the Thung Yai Naresuan Buffer Zone, Ban Hua Sia (Fig. 1).

Huai Kha Khaeng Wildlife Sanctuary

Huai Kha Khaeng has large areas of lowland forests such as evergreen foothills and dry dipterocarp foothills with 1200–1400 mm of rain per year (Mahidol University Center for Conservation Biology database). Surveys were carried out between 9 August 1993 and 28 October 1993 and during March 1994 in five areas; Kapuk Kapeang Guard Station, Kapuk Kapeang Research Plot, Khao Nang Rum Wildlife Research Station, Tham Khi Nok and Huai Kha Khaeng Headquarters (Fig. 1).

METHODS

Information on small mammals other than bats was obtained from the analysis of animal remains from raptor pellets, terrestrial carnivore faeces and from beneath feeding roosts of the carnivorous bat, *M. lyra*. The prey remains of *M. lyra* were found, along with droppings characteristic of *M. lyra,* in piles below known feeding roosts. They consisted of skull and jaw fragments only anterior to the last molar, the posterior portion having been chewed off. These fragments were often joined to limbs and the tail by a strip of skin.

Also, skeletal fragments were collected from debris on cave floors. In addition, species were recorded from observations of animals in the field and evidence such as holes in bamboo which are characteristic of *Hapalomys longicaudatus* (MEDWAY 1964).

There is no key for the identification of Thai small mammals which uses only cranial and dental characteristics, but a combination of literature (MUSSER, 1972, 1973, 1981; JENKINS, 1976, 1982; MARSHALL 1977a, 1977b; ASKINS, 1977; LEKAGUL & MCNEELY, 1977; MUSSER ET AL., 1979; ABE, 1983; MUSSER & NEWCOMB, 1985; CORBET & HILL, 1992) and comparison with known specimens at Thailand Institute of Science and Technological Research (TISTR) and the British Museum of Natural History was used.

Bat roosts were located by searching for caves in the outcrops of Permian limestone which is prevalent in much of west Thung Yai Naresuan and in small areas of Huai Kha Khaeng. Additional roosts were located by searching holow trees and buildings. The species composition of each roost site was determined by catching bats while they were roosting or as they emerged from the roost at dusk. In order to catch foraging or commuting bats, static mist-nets were set in the forest understorey, at heights of between 0.5 and 6 m, in differing habitat types. Also, mist-nets were set across small tributaries and larger slow-flowing rivers. Roosts were searched for skeletal fragments of dead bats, providing additional information on the species of bats using the site in the past.

The species, sex, age and reproductive condition of all animals caught was determined in the field. All animal were released at the site of capture. Body weight was recorded to the nearest 0.5 g or 1.0 g using 100 g and 300 g Pesola spring balances, respectively. Measurements of toothrows, head & body, hind foot (excluding claws), forearm, tail, tibia and ear length were recorded to the nearest 0.1 mm using dial callipers. Toothrow

Figure 2. The insectivorous bat, *Aselliscus stoliczkanus.*

Figure 3. The insectivorous bat, *Harpiocephalus morda.*

Figure 4. The insectivorous bat, *Rhinolophus pearsonii.*

Figure 5. The carnivorous bat, *Megaderma lyra.*

measurements were alveolar except where indicated in the text.

Skeletal specimens obtained from raptor pellets, terrestrial carnivore faeces and from beneath feeding roosts of the carnivorous bat, *M. lyra* are to be stored in the British Museum of Natural History and Thailand Institute of Scientific and Technological Research.

RESULTS

A total of 70 species, three Insectivora, one Scandentia, 41 Chiroptera, 24 Rodentia and one Lagomorpha, were recorded from 15 study sites, 10 in Thung Yai Naresuan and 5 in Huai Kha Khaeng. The distribution of all small mammals recorded in the present study can be seen in Appendix I.

INSECTIVORA, ERINACEIDAE

Hylomys suillus (Muller, 1841).—The skeletal remains of 7 *H. suillus* were found. In Thung Yai Naresuan they were found in debris at the entrance to a cave on the Thung, an area of savannah with few trees, and in carnivore faeces from Thimu Limestone Outcrop, in mixed deciduous forest. In Huai Kha Khaeng they were found in carnivore faeces from Kapuk Kapeang Guard Station, in dry evergreen forest, and Khao Nang Rum Research Station, which is predominantly dry dipterocarp forest.

INSECTIVORA, SORICIDAE

Crocidura fuliginosa (Blyth, 1856).—Skull fragments were found in Thung Yai Naresuan in caves at Ban Jagae Limestone Outcrop, Lum Khao Ngu Limestone Outcrop and on the Thung. In Huai Kha Khaeng they were found in Tham Khi Nok. All the caves are in areas of deciduous or dry dipterocarp forest with bamboo, except for the Thung which is savannah. Fragments of 19 animals were found in total, these all were prey remains of the carnivorous bat *M. lyra*. Upper toothrows (i^1-m^3) of 3 specimens were complete and measured 10.5–10.9 (crowns).

Crocidura pullata vorax (Allen, 1923).—The taxonomy of this species is currently in a state of flux. It was originally listed as *C. russula vorax* by ALLEN (1923) and was described as a subspecies of *Crocidura russula* by LEKAGUL & MCNEELY (1977). However, it is currently grouped with *Crocidura pullata* (HUTTERER, 1993). Small shrew skulls resembling this species have been found in the sanctuary and have been provisionally identified as *C. ? vorax* (Jenkins, pers. comm.). Thirty-nine specimens have been identified in this study, one in large carnivore faeces from Kapuk Kapeang Research Plot, and one each from caves at Mae Kasat Guard Station and Lum Khao Ngu Guard Station and Limestone Outcrop, 4 from caves at Ban Jagae Limestone Outcrop and 31 from Tham Khi Nok, which were *M. lyra* prey remains. Although the research plot is dry evergreen forest, the surrounding area is dry dipterocarp and mixed deciduous forest with bamboo clumps,

while the forest around Tham Khi Nok is also dry dipterocarp with bamboo. Upper toothrow lengths (i^1-m^3) of 14 specimens measured 8.0–8.6 (crowns).

SCANDENTIA, TUPAIIDAE

Tupaia belangeri (Wagner, 1841).—The northern tree shrew, *T. belangeri,* was observed on two occasions in mixed deciduous forest at Khao Nang Rum.

CHIROPTERA, PTEROPODIDAE

Rousettus leschenaulti (Desmarest, 1820).—Caught at three sites in Huai Kha Khaeng; Kapuk Kapeang Guard station and Research Plot, and at Khao Nang Rum. While flying in the understorey of dry evergreen and mixed deciduous forest, at heights of 2–6 m. A total of 20 individuals: 3 adults (2 males, 1 female) and 17 juveniles, were caught. Weights and measurements of 3 adults: forearm 78.2–82.5; tail 15.9–9.9; tibia 33.3–37.8; ear 18.7–19.6; weight 64.0–84.0.

Rousettus amplexicaudatus (Geoffroy, 1810).—The remains of two lower mandibles (c-m_3 14.4; m_3 1.0x1.3) were found on cave floors at Ban Jagae Limestone Outcrop and Tham Khi Nok.

Cynopterus sphinx (Vahl, 1797).—Caught while flying at a height of 2–6 m in bamboo forest, and in the understorey of dry dipterocarp, dry evergreen and mixed deciduous forest, and around the flowers of cultivated varieties of banana *Musa* spp. and the trees *Oroxylum indicum* and *Parkia* spp., in forest clearings which were surrounded by mixed deciduous forest. Fifty-two individuals; 33 adults (16 males and 17 females, 10 lactating), 1 immature and 18 juveniles were caught. Weights and measurements of 32 adult and immature bats: forearm 65.9–74.4; tail 7.0–16.2; tibia 24.7–29.5; ear 17.4–22.2; weight 44.0–59.0.

Cynopterus horsfieldii (Gray, 1843).—Two adults (1 male and 1 female) and one immature bat (forearm 71.4–76.4; tail 10.4–14.5; tibia 26.9–29.0; ear 18.6–20.4; weight 52.0–65.0) were caught while flying at a height of 6 m in bamboo forest at Lum Khao Ngu Guard Station and at a height of approximately 2 m around the flowers of cultivated varieties of banana, *Musa* spp., in mixed deciduous forest at Kapuk Kapeang Guard Station and Khao Nang Rum (Fig. 9).

Megaerops spp. (Peters, 1865).—Three juvenile females were caught while flying at a height of 1–3 m in dry dipterocarp forest at Mae Kasat Guard Station in Thung Yai Naresuan, and at Kapuk Kapeang Guard Station and Khao Nang Rum.

Eonycteris spelaea (Dobson, 1873). Caught at five sites; Mae Kasat Guard Station, Ban Jagae Guard Station, Lum Khao Ngu Guard Station, Kapuk Kapeang Guard Station and

Khao Nang Rum, while flying at heights of 1–6 m in dry evergreen and mixed deciduous forest, and around flowers of cultivated varieties of banana *Musa* spp., and the trees *O.indicum* and *Parkia* spp. in forest clearings, surrounded by mixed deciduous forest. Fifteen *E. spelaea;* 7 adults (5 males and 2 females), one immature and 7 juveniles were caught. Weights and measurements of 8 adult and immature bats, except where indicated: forearm 66.2–74.8; tail (7) 11.2–17.0; tibia (7) 28.7–34.9; ear 16.4–19.4; weight 50.0–76.0.

Macroglossus sobrinus (Andersen, 1911).—A heavily pregnant female was caught at Kapuk kapeang, at the flowers of a cultivated variety of banana *Musa* spp., in a forest clearing which was surrounded by dry dipterocarp forest. A damaged mandible of *M. sobrinus,* c-m_3 11.4, was found at the entrance to a cave on the thung.

CHIROPTERA, EMBALLONURIDAE

Taphozous spp. (Geoffroy, 1818).—A lower mandible indentified to the genus *Taphozous,* c-m_3 10.0, was found on the floor of Tham Khi Nok. This mandible, because of its size, represents either *T. melanopogon* or *T. longimanus.*

CHIROPTERA, MEGADERMATIDAE

Megaderma spasma (Linnaeus, 1758).—Caught at eight sites, flying in dry evergreen, mixed deciduous and dry dipterocarp forest, at heights ranging from 0.25–2.0 m. In 14 roosts, 1 to 9 individuals were found in the inner light zone of the cave or occasionally in the dark area. Eighteen individuals: 13 adults (8 males, 5 females, 2 lactating) and 5 juveniles were caught. Weights and measurements of 10 adult bats : forearm 58.0–60.6; tibia 32.0–35.3; ear 39.2–43.8; weight 19.5–27.0.

Megaderma lyra (Geoffroy, 1810).—Three adults (1 male and 2 females) (forearm 69.2–71.2; tibia 37.0–38.0; ear 38.9–42.4; weight 47.0–51.0) were caught while roosting in the inner light zone or dark area of caves at Ban Jagae Limestone Outcrop, Lum Khao Ngu Guard Station and Tham Khi Nok (Fig. 5). A badly damaged skull of *M. lyra* was found on the floor of a cave at Ban Jagae Limestone Outcrop.

CHIROPTERA, RHINOLOPHIDAE

Rhinolophus luctus (Temminck, 1834).—Recorded from seven sites. It was caught while flying in the understorey of both dry evergreen and mixed deciduous forest at heights ranging from 1.5–2.5 m. Five roosts were found in the light or inner light zone of rock shelters and a bamboo hut. Bats roosted individually, or occasionally an adult roosted with a single juvenile. Eight individuals : 6 adults (1 male and 5 females, 1 lactating) and 2 juveniles, were caught. Weights and measurements of 6 adult bats : forearm 69.3–79.3; tail 52.5–61.0; tibia 36.8–39.4; ear 38.4–44.0; weight 37–56.

Rhinolophus coelophyllus (Peters, 1867).—Caught while flying at heights ranging from 1.5 to 2 m, in the understorey of mixed deciduous forest and on one occasion around cultivated varieties of banana, in forest clearings surrounded by dry dipterocarp forest. A single roost was found where a cluster of approximately 900 bats roosted in the dark area of the cave. Seventeen individuals; 13 adults (6 males and 7 females, 2 lactating) and 4 immatures, were caught. Weights and measurements of 17 bats, except where indicated: forearm 43.3–45.4; tail 16.5–23.7; tibia 20.5–22.4; ear 18.1–22.3; weight (16) 6.5–10.0.

Rhinolophus pearsonii (Horsfield, 1851).—Nine caves contained *R. pearsonii,* where they roosted in the dark areas, often in small passages. Small numbers ranging from between 1 and 35 individuals were found hanging in loose clusters. In late May and early June individuals were seen roosting with babies attached to their undersides. Torpid individuals were found roosting in caves during the day in July. *R. pearsonii* was caught in the understorey of mixed deciduous and bamboo forest at heights ranging from 0.5 to 2.5 m.

Individuals were observed using feeding perches, from which they either sallied "flycatcher style" (i.e. sit and wait) or by flying 1 m off the ground in short foraging beats of 10-20 m. The same perches were used on consecutive nights. One individual was observed to have at least four perches within 20 m of each other. The perches were all within, or on the edge of, bamboo clumps. Fifty-five individuals were caught; 30 adults (13 males, 17 females) 5 immatures and 20 juveniles. Weights and measurements of 30 adult and immature bats, except where indicated: forearm (32) 48.1–51.9; tail 18.2–25.5; tibia 24.2–26.8; ear 23.3–29.2; weight 10.5–16.0.

Rhinolophus acuminatus (Peters, 1871).—A single adult male (forearm 48.2; tail 26.0; tibia 22.6; ear 13.5; weight 13.5) was caught while flying at a height of 0.5 m, in the dry evergreen forest at Kapuk Kapeang Research Plot.

Rhinolophus pusillus (Horsfield, 1823).—Found roosting in clusters of 55 and 1500 individuals, one cluster each in the dark area of two caves (Fig. 4). It was caught in dry evergreen and mixed deciduous forest, and clearings surrounded by dry dipterocarp forest, flying at heights ranging from 0.25 to 1.5 m. On 2 August 93, 3 *R. pusillus* were observed foraging at 1725 h, 81 minutes before sunset (sunset 1846 h, Bangkok), 20 m from a known roost. The bats foraged at a height of 0.25 m around clumps of bamboo and small limestone boulders. Thirteen individuals were caught; 6 adults (3 males, 3 females, 1 lactating), 4 immatures and 3 juveniles. Weights and measurements of 10 adult and immature bats : forearm 36.6–39.9; tail 14.5–19.7; tibia 15.5–16.5; ear 14.3–17.7; weight 4.0–6.0

Rhinolophus megaphyllus (Gray, 1834).—Two females; 1 adult and 1 immature (forearm 48.9, 48.6; tail 20.0, 19.7; tibia 25.5, 24.4; ear 24.5, 26.0; weight 12.0, 13.0) were caught while flying at a height of 1.5 m, in mixed deciduous forest at Ban Jagae Guard Station.

Rhinolophus malayanus (Bonhote, 1903).—Found roosting in the dark areas of nine caves, in numbers ranging from single individuals to a cluster of approximately 3000. Torpid

individuals were found roosting during the day in July. *R. malayanus* was caught in the understorey of mixed deciduous and dry dipterocarp forest at heights of 0.5–2 m. Thirty individuals were caught; 20 adults (11 males, 9 females, 1 lactating) 2 immatures and 8 juveniles. Weights and measurements of 18 adult and immature bats, except where indicated: forearm (20) 39.8–43.0; tail (17) 19.0–25.5; tibia 15.8–20.8; ear 15.0–20.4; weight 6.5–9.0.

Rhinolophus stheno (Andersen, 1905).—Three roosts were found, each in the dark areas of caves, where they roosted as individuals or in tightly packed clusters. The largest cluster found contained approximately 1200 individuals. In July, torpid individuals were found roosting during the day. Twelve individuals; 8 adults (1 male, 7 females) and 4 immatures (forearm 42.8–45.2; tail 15.8–21.2; tibia 20.3–22.0; ear 16.0–19.3; weight 6.0–8.5), were caught while flying in the understorey of mixed deciduous and dry dipterocarp forest.

Rhinolophus affinis (Horsfield, 1823).—A single cluster of approximately 2100 bats was found roosting in the dark area of a cave. The species was also caught in the understorey of dry evergreen, mixed deciduous and dry dipterocarp forest. Nineteen individuals were caught; 12 adults (4 male, 8 female, 4 lactating) 4 immatures and 3 juveniles. Weights and measurements of 16 adult and immature bats: forearm 49.7–53.1; tail 22.5–30.2; tibia 23.2–26.0; ear 19.1–22.0; weight 13.0–16.5.

CHIROPTERA, HIPPOSIDERIDAE

Hipposideros pomona (Andersen, 1918).—Observed foraging 0.5 m from the ground, in short beats of 10-15 m, up and down a single track dirt road at Thung Yai Naresuan Headquarters. A single individual repeatedly hung inside the kitchen at Mae Kasat Guard Station, during intermittent bouts of feeding. Three individuals were caught; 2 adults (1 male, 1 female) (forearm 41.2, 41.5; tail 30.5, 29.5; tibia 18.4, 19.2; ear 22.7, 22.0; weight 7.0, 6.5) and 1 juvenile. Also, several cranial fragments of *H. pomona* [c-m^3 (crowns) (6) 6.0–6.3; c^1-c^1 (crowns) 3.6, 39; m^3-m^3 (crowns) (3) 6.0–6.3; c-m_3 (crowns) (6) 6.1–6.5], were recovered from the floor of Tham Khi Nok.

Hipposideros cineraceus (Blyth, 1853).—Three were caught: 1 adult male (forearm 33.7; tail 23.4; tibia 14.4; ear 15.9; weight 4.0) and 2 juveniles (Fig. 8). Three individuals, 2 of which were subsequently caught, were observed foraging around the ranger accommodation block at Lum Khao Ngu Guard Station, at approximately 20–50 cm from the building. They flew slowly, almost fluttering, at a height of 15–20 cm. above the ground. Although it was raining, they kept dry by foraging beneath the roof overhang. A single individual was caught at Ban Jagae Guard Station.

Hipposideros halophyllus (Hill & Yenbutra, 1984).—Two individuals were caught; 1 adult male and 1 immature female, (forearm 39.6, 38.2; tail 32.0, 26.6; tibia 19.2, 18.3; ear 14.5, 14.3; weight 4.5, 4.5) as they emerged from Tham Khi Nok. The cave contained a cluster of at least 200 individuals.

Hipposideros lylei (Thomas, 1913).—Eighty-five were found roosting in the dark area of a single cave at Lum Khao Ngu Limestone Outcrop. Four individuals were caught; 3 adult males and 1 immature male. Weights and measurements of 4 adult and immature bats: forearm 77.5–81.0; tail 50.8–59.9; tibia 35.8–38.3; ear 27.0–30.4; weight 30.0–38.0. A badly damaged skull of *H. lylei* (m3-m3 (crowns) 10.5; inter-orbital width 4.1; braincase width 11.4) was found on a cave floor at Ban Jagae Limestone Outcrop.

Hipposideros armiger (Hodgson, 1835).—Found in 14 caves, where loose clusters of between 1 and 500 individuals roosted in the inner light or the dark zone of the cave. In early June they were seen roosting with babies. Clusters of approximately 200 bats were found torpid in late September. *H. armiger* was caught while flying at a height of 1-5 m, in mixed deciduous, dry dipterocarp and dry evergreen forest. Individuals were frequently seen foraging around the top of the canopy. Eighteen were caught; 11 adults, 6 immatures and 1 juvenile. Weights and measurements of 13 adult and immature bats : forearm 90.3–99.4; tail 55.7–65.4; tibia 41.1–44.8; ear 30.6–40.0; weight 45.0–63.0.

Hipposideros larvatus (Horsfield, 1823).—Loose clusters of between 100 and 600 individuals were found roosting in the inner light or dark zone of three caves. Clusters of approximately 150 individuals were found torpid in late July. *H. larvatus* was caught while flying at heights of 1-5 m in mixed deciduous, dry dipterocarp and dry evergreen forest. Twenty-five were caught; 19 adults, 5 immatures and 1 juvenile. Weights and measurements of 20 adult and immature bats, except where indicated : forearm (22) 55.2–67.3; tail 31.0–39.5; tibia 23.3–28.2; ear 19.7–24.4; weight (22) 18.0–30.5.

Hipposideros diadema (Geoffroy, 1813).—Two adult males (forearm 89.9, 86.6; tail 49.9, 52.8; tibia 36.3, 36.1; ear 29.0, 29.0; weight 50.0, 45.0) were caught while flying at heights of 1.5 and 2.5 m, in mixed deciduous and dry evergreen forest respectively, at Khao Nang Rum (Fig. 6).

Aselliscus stoliczkanus (Dobson, 1871).—Found in 14 caves, where loose clusters of between 3 and 2000 individuals could be found roosting in the dark zone of the cave (Fig. 2). They roosted with a distance of approximately 23 cm between them. In late May, they were seen roosting with babies attached to their undersides. *A. stoliczkanus* was caught while flying at heights of 1–2 m, in and around the kitchens at Ban Jagae, Mae Kasat and Lum Khao Ngu Guard Stations. Nine adults were caught; 6 males and 3 females, including one lactating and one pregnant (forearm 41.4–44.5; tail 31.2–38.2; tibia 18.4–20.8; ear 9.0–12.5 weight 5.0–6.5).

Coelops frithii (Blyth, 1848).—The badly damaged skull of *C. frithii* (c-m^3 (crowns) 4.9) was found on the floor of a cave at Ban Jagae Limestone Outcrop.

CHIROPTERA, VESPERTILIONIDAE

Myotis siligorensis (Horsfield, 1855).—A single roost site was found, where approximately

1200 individuals were roosting in the dark zone of a cave. Four adult males, two pregnant females and an immature female (forearm 31.5–33.5; tail 32.4–37.8; tibia 13.1–14.4; ear 10.3–12.0; weight 3.0–4.5) were caught while foraging either in forest clearings, surrounded by deciduous forest or over slow-flowing water.

Myotis muricola (Temminck, 1840).—Three adult males and an adult female (forearm 34.5–37.5; tail 36.3–42.6; tibia 14.9–15.9; ear 11.0–11.8; weight 4.5–5.5), were caught while flying at heights of 1.5–2.5 m, in dry dipterocarp and dry evergreen forest.

Myotis horsfieldii (Temminck, 1840).—An adult male and an immature female (forearm 38.2, 35.2; tail 41.6, 41.5; tibia 17.8, 16.2; ear 13.0, 12.2; weight 8.0, 7.0), were caught while flying low over slow-flowing water in mixed deciduous forest at Lum Khao Ngu Guard Station.

Eptesicus serotinus (Schreber, 1774).—A single female (forearm 58.4; tail 54.8; tibia 24.9, ear 19.1; weight 25.0) was caught at a height of 3 m in the understorey of dry evergreen forest at Kapuk Kapeang Research Plot. An incomplete skull of *E. serotinus* (skull length 22.8; zygomatic width 16.3; condylobasal length 21.5; c-m^3 (crowns) 8.3) was found on the floor of a cave at Ban Jagae Limestone Outcrop.

Ia io (Thomas, 1902).—A single individual was seen roosting in the dark zone of a cave on the Thung, hanging from the roof of a large chamber 10 m high, 4 m wide and 15 m long (Fig. 7). An adult male (forearm 78.7; tail 67.0; tibia 35.3; ear 23.8; weight 45.0) was caught in a mist-net as it emerged from the cave at dusk. A badly damaged skull and lower mandible (c-m^3 (crowns) 11.3; c-m_3 (crowns) 12.1) were found on the floor of a second cave on the Thung.

Tylonycteris pachypus (Temminck, 1840).—A lactating female (forearm 25.8; tail 28.7; tibia 11.9; ear 8.8; weight 4.5), was caught in the understorey of mixed deciduous forest at Ban Jagae Guard Station.

Tylonycteris robustula (Thomas, 1951).—Fourteen individuals, 12 adults (7 males, 5 females), 1 immature and 1 juvenile were caught while flying in mixed deciduous, bamboo and dry evergreen forest, at heights of 1.5–4 m. Weights and measurements of 9 adult and immature bats, except where indicated: forearm (13) 26.4–29.4; tail 26.0–31.7; tibia 11.8–13.2; ear 6.8–11.6; weight (12) 4.0–7.5.

Pipistrellus javanicus (Gray, 1838).—Four adult males and 2 adult females (forearm 29.8–36.3; tail 33.0–37.7; tibia 11.8–14.3; ear 10.0–13.3; weight 3.5–6.0) were caught while flying in the understorey of dry dipterocarp and dry evergreen forest, at heights of 2–3 m. A single individual was found roosting in a cavity between two stalactites in a small rock shelter. The roost was surrounded by mixed deciduous forest.

Pipistrellus pulveratus (Peters, 1817).—An adult male (forearm 33.2; tail 31.3; tibia 12.8; ear 9.4; weight 5.0) was caught in the understorey of dry evergreen forest at Kapuk Kapeang Research Plot.

Miniopterus magnater (Sanborn, 1931).—Three damaged skulls (c-m^3 (crowns) 6.6; m^3-m^3 (crowns) 7.4–7.5) were found on the floor of a limestone cave 2 km southeast of Ban Hua Sia. A cluster of 30 individuals was seen roosting between stalactites on the cave ceiling.

Murina cyclotis (Dobson, 1872).—Three individuals; an adult male, an adult female (forearm 31.0, 34.0; tail 37.9, 39.4; tibia 17.0, 18.5; ear 13.0, 15.8; weight 5.0, 6.5) and a juvenile female, were caught while flying at heights of 1–2 m, in the understorey of mixed deciduous forest at Ban Jagae Guard Station and Lum Khao Ngu Limestone Outcrop.

Harpiocephalus mordax Thomas, 1923.—Three individuals; 2 adult males and a lactating adult female (forearm 48.6–52.1; tail 44.8–53.3; tibia 22.3–24.8; ear 19.8–20.4; weight 17.0–21.0), were caught while flying at heights of 1–2.5 m, in the understorey of dipterocarp forest at Kapuk Kapeang Research Plot and mixed deciduous forest at Ban Jagae Guard Station.

Kerivoula papillosa (Temminck, 18400).—The rostrum of two individuals, c-m^3 (crowns) (1) 7.1, were found on the floor of a cave in the Ban Jagae Limetone Outcrop.

Kerivoula hardwickii (Horsfield, 1824).—An adult female (forearm 31.4; tail 40.3; tibia 15.4; ear 13.1; weight 4.0) was caught while flying at a height of 2.5 m, in the understorey of dry evergreen forest at Khao Nang Rum.

CHIROPTERA, MOLOSSIDAE

Tadarida plicata (Buchannan, 1800).—A cluster of wrinklelipped bats, *T. plicata,* was found roosting in a rock crevice at Khao Keo near Khao Nang Rum.

RODENTIA, SCIURIDAE

Ratufa bicolor (Sparrman, 1778).—The giant arboreal squirrel, *R. bicolor,* was observed in mixed deciduous forest at Mae Kasat Guard Station and in dry dipterocarp forest at Kapuk Kapeang Guard Station.

Callosciurus erythraeus (Pallas, 1779).—Observed in Thung Yai Naresuan, in mixed deciduous forest at Lum Khao Ngu, both at the guard station and at a limestone outcrop, and in Huai Kha Khaeng, in dry dipterocarp forest at Khao Nang Rum.

Callosciurus finlaysonii (Horsfield, 1823).—Observed in mixed deciduous forest at Mae Kasat Guard Station.

Callosciurus caniceps (Gray, 1842).—Observed in mixed deciduous forest at Mae Kasat Guard Station.

Figure 6. The insectivorous bat, *Hipposideros diadema.*

Figure 7. The insectivorous bat, *Ia io.*

Figure 8. The insectivorous bat, *Hipposideros cineraceus.*

Figure 9. The fruit bat, *Cynopterus horsfieldii.*

Figure 10. Limestone outcrops, the site of "The Thung Caves", situated on the edge of the "The Thung" in Thung Yai Naresuan.

Tamiops mcclellandii (Horsfield, 1840).—Observed at both Mae Kasat Guard Station, in mixed deciduous forest, and at Khao Nang Rum, in dry dipterocarp forest.

Menetes berdmorei (Blyth, 1849).—The remains of the ground squirrel *M. berdmorei* (maxillary toothrow 9.7) were found in cave debris, possibly from dissociated raptor pellets, at Ban Jagae Limestone Outcrop and in carnivore faeces at Kapuk Kapeang Guard Station and Khao Nang Rum.

RODENTIA, PTEROMYIDAE

Trogopterus pearsonii (Gray, 1842).—The flying squirrel *B. pearsonii* was found at Khao Nang Rum, where it was caught in a mist-net in mixed deciduous forest.

Hylopetes spadiceus (Blyth, 1847).—Remains of the red-cheeked flying squirrel *H. spadiceus* (maxillary toothrow 7.3) were recovered from an owl pellet found in an area of mixed deciduous forest close to Mae Kasat Guard Station.

Hylopetes lepidus (Horsfield, 1822).—A female grey-cheeked flying squirrel, *H. lepidus* (weight 81.0; tail 110.5; hind foot 23.7), was caught in a mist-net in bamboo and mixed deciduous forest at Ban Jagae Guard Station.

Hylopetes phayrei (Blyth, 1859).—A female (weight 147.0; head & body 187.8; tail 150.0; hind foot 30.4) was caught in a mist-net in a clearing, surrounded by dry dipterocarp forest, at Kapuk Kapeang Guard Station.

RODENTIA, MURIDAE

Mus cookii (Ryley, 1914).—Found on three occasions in Thung Yai Naresuan: at Mae Kasat Guard Station, where a male was caught by a domestic cat; at the entrance to a cave at the Thung, where it was possibly *M. lyra* prey remains; and the corpse of a female was found on the road leading to Thung Yai Naresuan Headquarters. The Thung is a savannah area with low densities of small trees and Mae Kasat has small grassy areas of savannah around the station. Measurements of the 2 complete specimens were as follows: head & body 80.6, 76.2; tail 78.1, 91.8; hind foot 18.7, 17.6; m^1-m^3 4.6, 4.5.

Mus cervicolor (Hodgson, 1845).—The remains of only one specimen, m^1-m^3 4.4, was found and this was the forestdwelling sub-species *M.c. poppaea,* which is larger than *M.c. cervicolor,* with shorter incisive foramina. It was found in the research plot at Kapuk Kapeang, in large carnivore faeces.

Mus pahari (Thomas, 1916).—A skull, m^1-m^3 4.0, was found in Tham Khi Nok, where it is thought to have been the prey remains of *M. lyra* which roosts in the cave. Tham Khi Nok is a cave in a limestone outcrop suurounded by dry dipterocarp forest with many

clumps of bamboo.

Mus spp. (Linnaeus, 1758).—Remains of 34 specimens of *Mus* spp. were found in carnivore faeces or caves at eight sites in Thung Yai Naresuan and Huai Kha Khaeng. They were not found at Thimu Limestone Outcrop, Ban Hua Sia or Huai Kha Khaeng Headquarters, which were all visited only briefly and where few specimens of any kind were collected, or at Khao Nang Rum Station where many faeces were collected, although they were found in faeces at other sites. Of the toothrows that could be measured: m^1-m^3 (2) 3.9, 4.5; m_1-m_3 (5) 3.4–3.6.

Rattus rattus (Linnaeus, 1758).—Identified at two sites; in cave debris at Ban Jagae Limestone Outcrop and from a live female (head & body 185.0; tail 170.0; hind foot 33.0; weight 130.0) found in a house at Khao Nang Rum. The sites where it was found consist of mixed deciduous, dry dipterocarp and bamboo forests.

Rattus losea (Swinhoe, 1871).—Identified from three sites (m^3-m^3 (3) 6.5–7.0): in cave debris near Ban Jagae Limestone Outcrop, in mixed deciduous and bamboo forest; in a water butt in a cave at Wat Hua Sia, where there is dry evergreen and mixed deciduous forest with bamboo; and one specimen (weight 93.0; head & body 145.3; tail 160.5; hind foot 31.3; ear 21.0) was caught by a domestic cat in the kitchen at Kapuk Kapeang Guard Station, an area of dry dipterocarp forest with many saplings and some bamboo clumps.

Rattus spp. (Fischer, 1803).—Remains of 78 specimens of *Rattus* spp. were found in carnivore faeces and cave debris at all sites except Thimu Limestone Outcrop, a site visited only briefly and where few specimens of any kind were found. Few toothrows could be measured: m^1-m^3 (6) 6.6–8.0; m_1-m_3 (5) 6.6–7.5.

Bandicota indica (Bechstein, 1800).—A pair of lower mandibles of a juvenile, m_1-m_3 9.3, were found in Tham Khi Nok, a limestone cave surrounded by dry dipterocarp forest with many bamboo clumps.

Chiropodomys gliroides (Blyth, 1856).—Remains of 21 individuals were found in cave debris at six sites; Mae Kasat, the Thung, Ban Jagae, Lum Khao Ngu Guard Station and Limestone Outcrop, and Tham Khi Nok. At each site it was found as prey remains beneath known feeding roosts of *M. lyra.* Remains of 3 specimens were found in carnivore faeces at Kapuk Kapeang Research Plot and Khao Nang Rum. Of the toothrows that could be measured: m_1-m_3 (13) 3.6–4.5.

Hapalomys longicaudatus (Blyth, 1859).—Mandibles of the arboreal rat, *H. longicaudatus,* m_1-m_3 7.6, 7.9, were found in caves in bamboo forest at Ban Jagae Limestone Outcrop. The mandibles were found on the cave floor, and thought to be old prey remains of an owl which had roosted in the cave. Characteristic holes made by *H. longicaudatus,* averaging 35 mm across, were found in bamboo 2 km from Ban Jagae and 4 km from Lum Khao Ngu.

Niviventer spp. (Marshall, 1976).—Remains were found in caves and carnivore faeces at Mae Kasat, the Thung, Ban Jagae Guard Station and Ban Jagae Limestone Outcrop. in addition they were found in carniove faeces at Lum Khao Ngu Guard Station, Kapuk Kapeang Guard Station and Khao Nang Rum. It is not known from which species of *Niviventer* the specimens are, but they can be narrowed down to *N. confucianus, N. cremoriventer,* or *N. tenaster* by size. Of the 19 toothrows found, 6 could be measured: m_1-m_3 (6) 6.1–6.5.

Leopoldamys sabanus (Jentinck, 1879).—Remains were found in carnivore faeces and in cave debris at Khao Nang Rum, Ban Jagae Guard Station and Limestone Outcrop, and only in cave debris at Tham Khi Nok, Mae Kasat Guard Station, the Thung, Wat Hua Sia and in a limestone cave 2 km southeast of Ban Hua Sia. Two live *L. sabanus* rats were seen in a cave at Wat Hua Sia. In total, remains of 4 specimens were found in faeces and 11 specimens in caves, at five sites in mixed deciduous forest, bamboo forest, savannah and dry dipterocarp forest. Of the toothrow lengths that could be measured: m^1-m^3 (5) 9.6–10.2; m_1-m_3 (6) 9.0–10.4.

Maxomys surifer (Miller, 1900).—Found in carnivore faeces at Kapuk Kapeang Guard Station and Research Plot, Khao Nang Rum, Mae Kasat Guard Station, Ban Jagae Guard Station, Thimu Limestone Outcrop, Thung Yai Naresuan Headquarters, and Lum Khao Ngu Guard Station and Limestone Outcrop. At Ban Jagae Limestone Outcrop a single mandible (m_1-m_3 6.1) was found in a cave where it was thought to originally be from an owl pellet. Although 39 remains of *M. surifer* were found, few could be measured: m^1-m^3 (5) 6.3–6.7; m_1-m_3 (10) 6.1–6.7.

Berylmys berdmorei (Blyth, 1851).—Recovered from carnivore faeces found in forests of mixed deciduous and dry dipterocarp trees with some bamboo. A single specimen was identified from each of three localities; Lum Khao Ngu Guard Station and Limestone Outcrop, and Huai Kha Khaeng Headquarters (m^1-m^3 6.8, 7.1).

Rhizomys spp. (Gray, 1831).—Teeth from a *Rhizomys* spp. were found in Lum Khao Ngu Limestone Outcrop, an area where characteristic marks made by these animals were also found on bamboo.

Cannomys badius (Hodgson, 1841).—Identified in faeces from Mae Kasat Guard Station, Ban Jagae Guard Station and Limestone Outcrop, Lum Khao Ngu Guard Station and Kapuk Kapeang Guard Station. It was also found in cave debris at two sites in Thung Yai Naresuan; Mae Kasat and the Thung. Remains of 11 specimens were found, but only 2 toothrows could be measured (m_1-m_3 10.8, 12.8)

RODENTIA, HYSTRICIDAE

Hystrix brachyura (Linnaeus, 1758).—Spines of *H. brachyura* were found in caves at Mae Kasat Guard Station, the Thung Caves, Tham Mong Kw and Tham Khi Nok. Spines were

also found in tiger faeces from Mae Kasat. Observations were made of 3 individuals in caves at Lum Khao Ngu Guard Station and of 1 animal at Khao Nang Rum.

Atherurus macrourus (Linnaeus, 1758).—Mandible fragments were found at the entrance to a cave on the Thung, and spines were found in caves at Wat Hua Sia. Two individuals were observed in caves at Ban Jagae Limestone Outcrop.

LAGOMORPHA, LEPORIDAE

Lepus peguensis (Blyth, 1856).—The Siamese hare, *L. peguensis,* was seen on many occasions around Khao Nang Rum. Although no remains were found in faeces, several tufts of fur, identified as being from the tail of the hare, were found along the side of the road at Khao Nang Rum. These are thought to have been pulled out when attacked by a predator.

DISCUSSION

Thailand has 201 known species of small mammal (CORBET & HILL, 1992; WILSON & REEDER, 1993; JENKINS & SMITH, in press), but few surveys have been undertaken, particularly of insectivores, and many records are based on just a few specimens. Consequently, little is known of the true distribution of some of these species. Within Thung Yai Naresuan and Huai Kha Khaeng Wildlife Sanctuaries little research has been done on small mammal populations, and the work that has been carried out has been mainly focused around Khao Nang Rum Wildlife Research Station in Huai Kha Khaeng (ROJANADILOK ET AL., 1988; WALKER & RABINOWITZ, 1992; SRIKOSAMATARA, 1993). Prior to the present study 71 species of small mammal were known for the sanctuaries; 5 Insectivora, 2 Scandentia, 40 Chiroptera, 23 Rodentia and the 1 Thai species of Lagomorpha (NAKHASATHIEN & STEWART-COX, 1990). The present work provides the first detailed assessment of the species of small mammals found in Thung Yai Naresuan and Huai Kha Khaeng, providing information on distribution, status and ecology.

The present survey for small mammals resulted in a total of 70 species being recorded: 3 Insectivora, 1 Scandentia, 41 Chiroptera, 24 Rodentia and 1 Lagomorpha. Twenty-four species were new records for the sanctuaries, bringing the total number of known small mammal species there to 95, representing 47% of Thailand's small mammals.

Of the 3 Insectivora recorded, *H. suillus, C. fuliginosa* and *C.p. vorax,* the latter was previously unknown to the sanctuaries. The remains found closely resemble *C.p. vorax* which has been recorded once from Thailand, on Doi Inthanon in the North (ALLEN & COOLIDGE, 1940), although an earlier specimen was found at Lat Bua Kao (KLOSS, 1919) and misidentified an *C. fuliginosa* (JENKINS & SMITH, in press). The nomenclature of this species is in a state of flux and currently it is grouped with *C. pullata* (HUTTERER, 1993), hence the specimens found can only be provisionally identified as *C.p. vorax* (Jenkins, pers. comm). Several skulls of the same species have recently been found in owl pellets in northeast Thailand (JENKINS & SMITH, in press; ROBINSON & SMITH, in prep.).

A total of 41 species of bats was recorded in the present study; 33 and 28 were found in Thung Yai Naresuan and Huai Kha Khaeng, respectively. Sixteen of these, *R. amplexicaudatus, C. horsfieldii, R. luctus, R. acuminatus, R. pusillus, R. megaphyllus, R. affinis, H. pomona, M. siligorensis, M muricola, M horsfieldii, E. serotinus, I. io, M. cyclotis, K. papillosa* and *T. plicata,* are new records for the sanctuaries. This brings the current total of bat species to 56 which represents 52% of Thai bat species and 5.7% of bat species worldwide.

The 2 fruit bats, *R. amplexicaudatus* and *C. horsfieldii,* are within the known range of both species (CORBET & HILL, 1992). However, both species are known from only a few records in Thailand (GYLDENSTOLPE, 1919; HILL & THONGLONGYA, 1972; ROOKMAAKER & BERGMANS, 1981; YENBUTRA & FELTEN, 1987).

A total of 9 species of *Rhinolophus* were found. All except *R. megaphyllus* were found roosting in caves. Of the 5 species of *Rhinolophus* previously unrecorded in the sanctuaries, 4 species, *R. luctus, R. acuminatus, R. pusillus* and *R. affinis,* are known to occur in the area surrounding the sanctuaries (LEKAGUL & MCNEELY, 1977; YENBUTRA & FELTEN, 1987; CORBET & HILL, 1992). However, *R. megaphyllus* has only previously been recorded from Surat Thani (LEKAGUL & MCNEELY, 1997) and Chiang Mai (MCFARLANE & BLOOD, 1986).

In the present study *H. pomona* was recorded in Thung Yai Naresuan and Huai Kha Khaeng for the first time. However, there has long been confusion over bats of the *H. bicolor* group in Southeast Asia, of which *H. pomona* is one (HILL ET AL., 1986). *H. bicolor,* as recorded by PHUMPAKAPUN ET AL. (1985), may indeed have been *H. pomona.* YENBUTRA & FELTON (1986), in a list of bat species and their distribution Thailand according to the colletion in TISTR and Forschungsinstitut and Naturmuseum Senckenberg, Germany, record *H. bicolor* as widespread in Thailand. However, a recent visit to the TISTR collection revealed that out of 9 dried specimens labelled as *H. bicolor,* 7 were in fact *H. pomona.* HILL ET AL., (1986) found *H. bicolor* to occur only in the peninsular region, whereas *H. pomona* is known to range from south to north Thailand.

Three species of *Myotis; M. siligorensis, M. muricola* and *M. horsfieldii,* were caught in the sanctruary. *M. muricola* is widespread throughout Thailand, however, *M. siligorensis* is known from only a few records (SHAMEL, 1942; HILL & THONGLONGYA, 1972; YENBUTRA, & FELTEN, 1987). *M. horsfieldii* was caught flying low over water at Lum Khao Ngu Guard Station. This species was first recorded in Thailand by SHAMEL (1942) in Chiang Mai. It has since only been recorded from Pathum Thani (YENBUTRA & FELTEN, 1987).

E. serotinus was recorded in Thung Yai Naresuan and Huai Kha Khaeng in the present study. This is only the second record for this species in Thailand, the first being from Chiang Mai (HILL, 1975). This also represents the most southerly record of *E. serotinus* (CORBET & HILL, 1992). *I. io,* a species only twice previously recorded in Thailand, in Chiang Mai (ALLEN & COOLIDGE, 1940, BLOOD & MCFARLANE, 1988), was found roosting in a cave on the Thung. *M. cyclotis,* a widespread species throughout Thailand (CORBET & HILL, 1992), was recorded in Thung Yai Naresuan. In a recent study, MCBEE ET AL. (1986) recorded *K. papillosa* from Surat Thani Province, the first record of this species in Thailand. The present record therefore represents only the second, as well as being a new record for the sanctuary.

T. plicata, found roosting at Khao Keo near Khao Nang Rum, represents the first record of this species for the sanctuary. This is a species widespread throughout South-East Asia (CORBET & HILL, 1992).

The rare endemic bat *H. halophyllus* was previously known from only a few localities in Thailand including Huai Kha Khaeng (HILL & YENBUTRA, 1984; YENBUTRA & FELTEN, 1987; TISTR, 1991) and the type locality is threatened by limestone mining (TISTR, 1991). A cluster of at least 200 individuals was found in Tham Khi Nok. This possibly represents the most important roost known for this species because the sanctuary protects it from disturbance and habitat loss.

Ten species of squirrel, 6 and 4 from the families Sciuridae and Pteromyidae, respectively, were found in the present study. Two species, *T. pearsonii* and *H. spadiceus,* (Pteromyidae) were previously unrecorded.

T. pearsonii is also known as *Belomys pearsonii* (ASKINS, 1977; HOFFMANN, *et al.* 1993), but CORBET & HILL (1992) consider the two genera so close as to be one. In this study it was caught in dry deciduous forest at Khao Nang Rum. It has previously been recorded in central Thailand (CORBET & HILL, 1992).

H. spadiceus, recovered from a raptor pellet near Mae Kasat Guard Station, has been previously recorded in west and south Thailand (CORBET & HILL, 1992).

Two species of mouse, *M. cookii* and *M. pahari* and 3 species of rat *R. losea, B. indica* and *H. longicaudatus,* were recorded as new for the sanctuaries. With the exception of *H. longicaudatus* all 4 species are known to be widespread in Thailand (CORBET & HILL, 1992).

There are few records of *H. longicaudatus,* although it appears to be widespread throughout south Burma, west and south Thailand and Peninsular Malaysia (MUSSER, 1972). To date there are four published records of this arboreal rat in Thailand. In 1914 one was collected from bamboo and teak forest on the Khwae (or Quae) Noi River, Kanchanaburi (GAIRDNER, 1914), and another one was found 4.8 km away in Sai Yoke (GAIRDNER, 1915). Ten years later, one was collected from near the Mae Wong River, west Thailand (MUSSER, 1972). An earlier specimen was recorded from Pattani (FLOWER, 1900) but this is unverified (MUSSER, 1972). In this study mandibles were found in caves at the Ban Jagae Limestone Outcrop, in bamboo forest. Characteristic holes made by *H. longicaudatus* (MEDWAY, 1964) were found in bamboo 2 km east of Ban Jagae Guard Station and 4 km north from Lum Khao Ngu Guard Station. In Malaysia, MEDWAY (1964) found it nesting exclusively in one species of bamboo, *Gigantochloa scortechinii,* which is plentiful in secondary forest as a result of shifting cultivation by the Temiar.

In this study *Crocidura* spp., *C. gliroides, H. spadiceus, Rattus* spp., *Niviventer* spp., *L. sabanus* and *C. badius* were found in raptor pellets, and additional species of *R. rattus, R. losea, H. longicaudatus, M. surifer* and *M. berdmorei* were from dissociated pellets.

The carnivorous bat *M. lyra* consumed smaller prey, not exceeding 26 g in weight. The following species were found as *M. lyra* prey remain : *C. fuliginosa, C. p. vorax, M. pahari* and *C. gliroides.* In addition, *H. longicaudatus* and *Rattus* spp. mandibles were found in areas used by *M. lyra* and a raptor. The mandibles had been broken off at the last molar, as is characteristic of *M. lyra* prey, and were very small in size, with the third molar only partially erupted, indicating that the animals were juveniles. Weights of juvenile *H. longicaudatus* have been recorded as low as 15 g (Michael Carleton, pers. comm.). although the evidence is not conclusive, it is feasible that they are *M. lyra* prey remains.

The commonest prey items found overall in carnivore faeces were *Rattus* spp. followed by *M. surifer,* with *C. badius* and *Niviventer* spp. present in smaller numbers. Less commonly found species were *L. sabanus, B. berdmorei, H. suillus, H. brachyura, C. p. vorax, M. berdmorei, M. cervicolor* and *C. gliroides.* From Khao Nang Rum, the most common prey items were *Rattus* spp. and *M. surifer* in almost equal numbers. RABINOWITZ & WALKER (1991), however, found that the most common small mammal prey item found in faeces from Khao Nang Rum was *M. surifer* with *C. badius* next, while *R. rattus, L. sabanus, C. gliroides, Mus* spp., *Crocidura* spp. and 6 species of squirrel were found in small numbers. They did not find *B. berdmorei* or *N. bukit* in any faeces, despite capturing a few individuals of each in the same area (WALKER & RABINOWITZ, 1992). However, they found large numbers of unidentified species which, had they been identified, could have resulted in a different picture.

WALKER & RABINOWITZ (1992) also surveyed small mammals by live trapping in two areas of Khao Nang Rum; mixed deciduous/dry dipterocarp and evergreen/mixed deciduous. In both areas *M. surifer* was the most abundant species captured, while only a few specimens of *R. rattus* were captured in each area. WILES (1981) also found that where *M. surifer* was present with *R. rattus,* the latter was found in fewer numbers, suggesting competition between the two species. Both surveys were carried out using similar techniques, that of placing traps baited with banana along census lines on the ground. However, it is possible that the results were biased as *R. rattus* is semi-arboreal while *M. surifer* is strictly ground dwelling, making it more likely to enter traps on the ground.

Of the *Niviventer* specimens collected in the present study, there were few complete upper toothrows, however, the lower alveolar toothrow length (m_1-m_3) was 6.1–6.5 m, indicating a maxillary toothrow length of 6.1–7.2 mm (specimens in TISTR show a maxillary toothrow length equal to or longer than the lower toothrow length by up to 0.7 mm). The species found are therefore likely to be a large species such as *N. tenaster,* found just across the border from Thung Yai Naresuan in Burma, or *N. cremoriventer* or *N. confucianus,* which have not been previously recorded in this area of Thailand. Another large species, *N. langbianis,* has only four roots on the first upper molar (ABE, 1983; MUSSER, 1973), but of the upper molars found of this genus, all had five roots, hence there is no evidence that this species is in the area.

The addition of 24 species of small mammal new to Thung Yai Naresuan and Huai Kha Khaeng, as a result of the present work, is not wholly surprising considering the size of the sanctuaries and the diversity of habitat types. As many as 35-45 species of small mammal may yet be discovered in the area, based on published distributions of species (LEKAGUL & MCNEELY, 1977; YENBUTRA & FELTEN, 1987; CORBET & HILL, 1992). Species such as *T. longimanus, Scotophilus kuhlii* and *S. heathii* which are usually found roosting in buildings (LEKAGUL & MCNEELY, 1977) may roost outside the sanctuary, but commute in to forage at night. Also, it is thought likely that species such as the endemic *Craseonycteris thonglongyai* known to occur in Sai Yok National Park (PYE & PYE, 1981, HALL, 1982, STEBBINGS & TUTTLE, 1982; DUANGKHAE, 1990; DUANGKHAE, 1991), approximately 100 km away, may be found in the limestone ranges of south Thung Yai Naresuan (Duangkhae, pers. comm.).

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Appendix 1. Small mammal species found in sixteen sites in Thung Yai Naresuan and Huai Kha Khaeng Wildlife Sanctuaries. **Thung Yai Naresuan:** A. Mae Kasat Guard Station; **B.** The Thung Caves; **C.** Ban Jagae Guard Station; **D.** Ban Jagae Limestone Outcrop; **E.** Tham Mong Kw; **F.** Thimu Limestone Outcrop; **G.** Headquarters; **H.** Lum Khao Ngu Guard Station; **I.** Lum Khao Ngu Limestone Outcrop; **J.** Wat Hua Sia, Ban Hua Sia; **K.** Cave 2km SE of Ban Hua Sia. **Huai Kha Khaeng: L.** Kapuk Kapeang Guard Station: **M.** Kapuk Kapeang Research Plot: **N.** Khao Nang Rum Wildlife Research Station: **O.** Tham Khi Nok: **P.** Headquarters.

Species	Study area															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Insectivora																
Hylomys suillus		+				+						+		+		
Crocidura fuliginosa		+		+					+						+	
Crocidura ? vorax	+			+				+	+				+		+	
Scandentia																
Tupaia belangeri														+		
Chiroptera																
Rousettus leschenaulti												+	+	+		
Rousettus amplexicaudatus				+											+	
Cynopterus sphinx			+				+	+				+		+		
Cynopterus horsfieldii								+				+		+		
Megaerops spp.	+											+		+		
Eonycteris spelaea	+		+					+				+		+		
Macroglossus sobrinus		+										+				
Taphozous spp.															+	
Megaderma spasma		+	+	+		+	+	+		+		+		+		
Megaderma lyra				+				+							+	
Rhinolophus luctus			+	+		+		+	+			+	+			
Rhinolophus coelophyllus			+		+			+				+				+
Rhinolophus pearsonii	+	+	+	+		+		+								
Rhinolophus acuminatus													+			
Rhinolophus pusillus			+		+	+		+	+	+		+	+	+		
Rhinolophus megaphyllus			+													
Rhinolophus malayanus			+	+	+	+		+	+	+	+				+	
Rhinolophus stheno			+		+			+		+		+				
Rhinolophus affinis	+	+	+		+	+							+	+		
Hipposideros pomona	+		+				+								+	
Hipposideros cineraceus			+					+								
Hipposideros halophyllus															+	
Hipposideros lylei				+					+							
Hipposideros armiger		+	+	+				+	+		+		+	+	+	
Hipposideros larvatus	+	+	+	+	+				+	+		+		+	+	+
Hipposideros diadema														+		
Aselliscus stoliczkanus	+	+	+					+	+		+					
Coelops frithii				+												
Myotis siligorensis			+		+			+								
Myotis muricola												+	+			
Myotis horsfieldii								+								
Eptesicus serotinus				+									+			
Ia io		+														

Species	Study area															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Tylonycteris pachypus			+													
Tylonycteris robustula	+		+	+		+						+	+		+	
Pipistrellus javanicus				+								+	+	+		
Pipistrellus pulveratus													+			
Miniopterus magnater											+					
Murina cyclotis			+						+							
Harpiocephalus mordax			+									+				
Kerivoula papillosa				+												
Kerivoula hardwickii														+		
Tadarida plicata														+		
Rodentia																
Ratufa bicolor	+											+				
Callosciurus erythraeus								+	+					+		
Callosciurus finlaysonii	+															
Callosciurus caniceps	+															
Tamiops mcclellandii	+													+		
Menetes berdmorei				+								+		+		
Trogopterus pearsonii														+		
Hylopetes spadiceus	+															
Hylopetes lepidus			+													
Hylopetes phayrei												+				
Mus cookii	+						+	+								
Mus cervicolor poppaea													+			
Mus pahari															+	
Mus spp.	+	+	+	+				+				+	+		+	
Rattus rattus				+										+		
Rattus losea				+						+		+				
Rattus spp.	+	+	+	+			+	+	+	+		+	+	+	+	+
Bandicota indica															+	
Chiropodomys gliroides	+	+		+				+	+				+	+	+	
Hapalomys longicaudatus				+					+							
Niviventer spp.	+	+	+	+				+				+		+		
Leopoldamys sabanus	+	+	+	+						+	+			+	+	
Maxomys surifer	+		+	+		+	+	+	+			+	+	+		
Berylmys berdmorei								+	+							+
Rhizomys spp.									+							
Cannomys badius	+	+	+	+				+				+				
Hystrix brachyura	+	+			+			+						+	+	
Atherurus macrourus		+		+						+						
Hystrix / Atherurus spp.		+		+						+		+			+	
Lagomorpha																
Lepus peguensis														+		