

## CHIROPTERA FROM LOEI PROVINCE, NORTH-EAST THAILAND

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### ABSTRACT

A study was carried out to investigate the bat species found within the north eastern province of Loei, Thailand. Particular emphasis was placed on bats found in and around Buddhist temples. Loei is an area comprising mostly arable farmland, where the main crops were rice, cotton, maize and cassava.

The present study recorded 24 bat species, four Megachiroptera and 20 Microchiroptera, of which 21 were new records for Loei Province. The number of species recorded at each site varied from 19 species at Wat Tham Maho Lan to only a single species at Tam Pha Phot.

Bats are hunted in Thailand and at all of the cave sites visited evidence was found of the various techniques people employed to catch them. Around entrances were wooden pegs, hammered into crevices, to which mist or fishing nets had been secured to catch bats as they emerged. Fishing nets were found in caves, as were ashes from fires, which would have been used to drive bats out into nets, and long flexible bamboo used to knock bats to the ground.

### INTRODUCTION

For centuries Buddhist monks have protected the wildlife around their temples. An example of this is the practice of making a tree sacred by wrapping a piece of monk's robe around the trunk, to prevent it from being cut down. The fact that temple grounds are considered sacred has to a large extent prevented hunting within them. In some areas monks are actively leading villagers to protect forests, such as at Wat Bueng Pra in Choekchai district, Nakornrajasima Province (ANON., 1990).

In some of the more agricultural areas of north-east Thailand, where vast areas of crops such as rice, cotton and bananas are grown, Buddhist temples represent habitat islands, often containing a rich and diverse fauna and flora not found outside the temple grounds. Many temples are built around large limestone outcrops which often contain extensive cave systems ideal for roosting bats. About half of Thailand's bats are known to roost in caves (LEKAGUL & MCNEELY, 1977; MEDWAY, 1978; PAYNE ET AL., 1986), although the actual number is probably higher. Caves provide a stable environment with a variety of roosting conditions for different species (KUNZ, 1982). Roosts are vital for a bat's survival, providing sites for mating, the rearing of young and the consumption of prey, and give protection from predators and adverse weather conditions.

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Although there are 109 known species of bat in Thailand (CORBET & HILL, 1992; WILSON & REEDER, 1993) little is known of their distribution and abundance. The aim of this study was to investigate the bats found within the north-east province of Loei, particular emphasis being placed on bats found in and around Buddhist temples.

## STUDY AREAS

Information on the bat communities in Loei Province was obtained during February 1992, November 1992 to October 1993 and February 1995. The area was comprised of mostly arable farmland, where the main crops were rice, cotton, maize and cassava. Loei is locally known as “the land of the sea of mountains, the coldest in all Siam” which in part describes the many limestone outcrops found there. These are unsuitable for agriculture, but have stands of mature deciduous and dipterocarp trees and bamboo.

Survey work was conducted mainly, although not exclusively, around limestone outcrops. Surveys for bats were carried out at nine sites (Figure 1):-

- A. Tam Pha Baen (caves in a limestone outcrop), Ban Pha Baen, Amphoe Chiang Khan, Loei Province, 17°56'N 101°47'E, altitude 500 m.
- B. Phu Tork (granite hill, 4 km south east of Chiang Khan), Amphoe Chiang Khan, Loei Province, 17°52'N 101°41'E, altitude 450 m.
- C. Chiang Khan (village), Amphoe Chiang Khan, Loei Province, 17°53'N 101°39'E, altitude 250 m.
- D. Tam Pha Phot (caves in a limestone outcrop), Ban Pha Phot, Loei Province, 17°44'N 101°46'E, altitude 600 m.
- E. Wat Tam Pha Phu (Buddhist temple built around caves in a limestone outcrop), Tambon Najor, Amphoe Mung, Loei Province, 17°34'N 101°42'E, altitude 542 m.
- F. Wat Tam Pha Bing (Buddhist temple built around caves in a limestone outcrop), Ban Na Gar, Tambon Pha Bing, Amphoe Wang Sapung, Loei Province, 17°14'N 101°42'E, altitude 300 m.
- G. Wat Tam Maho Lan (Buddhist temple built around caves in a limestone outcrop), Ban Nong Hin, Loei Province, 17°06'N 101°53'E, altitude 575 m.
- H. Wat Tham Nam (Buddhist temple built around caves in a limestone outcrop), Loei Province, 17°11'N 101°57'E, altitude 400 m.
- I. Wat Tam Had Nimid (Buddhist temple built around caves in a limestone outcrop), Loei Province, 17°04'N 101°55'E altitude 350 m.

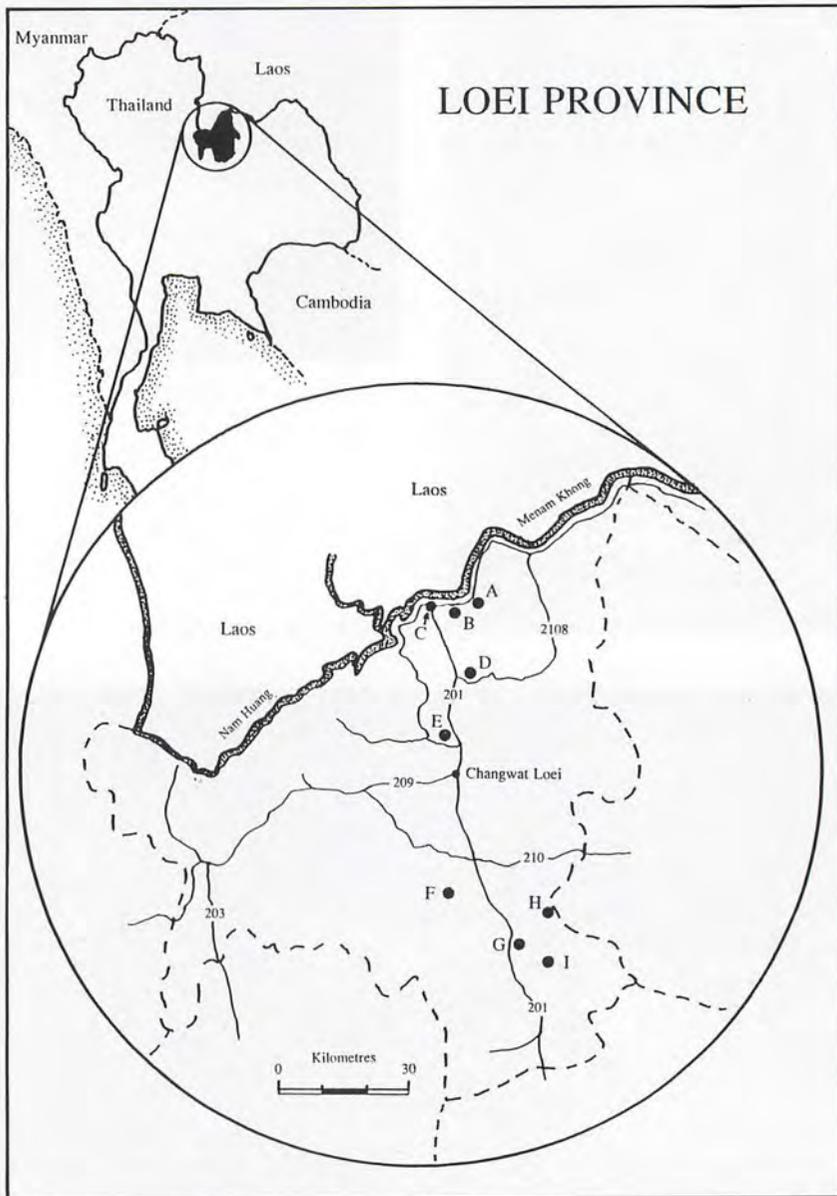


Figure 1. Study areas in Loei Province, north-east Thailand, showing major roads and rivers (the broken line indicates provincial boundaries). A. Tam Pha Baen; B. Phu Tork; C. Chiang Khan; D. Tam Pha Phot; E. Wat Tam Pha Phu; F. Wat Tam Pha Bing; G. Wat Tam Maho Lan; H. Wat Tam Nam; I. Wat Tam Had Nimid.



Figure 3. *Eonycteris spelaea*.

Figure 2. Wat Tam Pha Phu.



Figure 4. *Taphozous melanopogon*.



Figure 5. *Rhinolophus marshalli*.



Figure 6. *Hipposideros pomona*.



Figure 7. *Rhinolophus thomasi*.



Figure 8. *Hipposideros lylei*.



Figure 9. *Hipposideros armiger*



## METHODS

Bats were located by searching caves, culverts and buildings for roosts. The species composition of bat roosts was determined by catching bats while they were roosting or as they emerged from the roost at dusk. The species, sex, age and reproductive condition of all animals caught were determined. Body weight was recorded to the nearest 0.5 g or 1.0 g using 100 g and 300 g Pesola spring balances respectively. The forearm, tail, tibia and ear length were recorded to the nearest 0.1 mm using dial callipers. All animals were released at the site of capture. Population size at roosts was estimated by counting emerging bats at dusk or by visual census within caves.

Bat remains were collected from raptor pellets found within cave entrances and from debris on cave floors. As all of the specimens were recovered from either owl pellets or were dead bats found on cave floors, much of the material was damaged and incomplete. Skull and mandible measurements are presented as the maximum and minimum sizes recorded, with number of measurements indicated in parenthesis, unless otherwise stated. Skull and mandible specimens were deposited in the British Museum of Natural History.

## RESULTS

A total of 24 bat species were recorded from the nine study sites, the distribution of which can be seen in Appendix I.

### PTEROPODIDAE

*Rousettus leschenaulti* (Desmarest, 1820).—Roosts were found at Wat Tam Pha Bing and Wat Tam Maho Lan, containing approximately 200–300 and c. 1500 individuals respectively. They roosted in the dark areas of the domed roof of the caves' main chambers. Weights and measurements of two adult female bats: forearm 85.5, 89.2; ear 19.5, 20.2; weight 119.0, 120.0. At Wat Tam Maho Lan skull and/or mandible fragments of 33 individuals were found. Measurements (BM (NH) 96.55–96.87): greatest length of skull (13) 36.4–40.1; condylobasal length (13) 36.0–38.4; least interorbital width (15) 7.0–8.0; zygomatic width (15) 21.2–25.1; braincase width (14) 15.0–16.1; c–c (alveoli) (18) 5.0–8.0;  $m^2$ – $m^2$  (10) 10.4–11.9; c– $m^2$  (16) 13.3–15.7; complete mandible length from condyles (14) 25.7–30.3; ramus length from condyle (15) 27.0–31.8; c– $m_3$  (21) 14.5–16.5;  $m_3$  (19) 0.8 x 1.6–1.1 x 2.0.

*Rousettus amplexicaudatus* (Geoffroy, 1810).—A damaged skull, c– $m^2$  (alveoli) 11.5, (BM (NH) 96.88) and a maxillary tooththrow, c– $m^2$  (alveoli) 11.8, (BM (NH) 96.89) were recovered from owl pellets at Wat Tam Maho Lan and Tam Pha Baen respectively.

*Cynopterus sphinx* (Vahl, 1797).—Clusters of 20–30 bats were found roosting in the inner light zone of a cave at Wat Tam Nam and under “fan palm” leaves at Wat Tam Pha Bing. Also, a single individual was found roosting in the entrance to a cave at Wat Tam Maho Lan. Weights and measurements of six adult bats, except where indicated: forearm 67.3–

75.8; tail (3) 11.5–14.4; tibia (3) 27.2–28.4; ear 20.0–22.3; weight 43.0–55.5. At Wat Tam Maho Lan a damaged skull and mandible were found on the cave floor. Measurements (BM (NH) 96.90): least interorbital width 5.8; zygomatic width 20.0; braincase width 13.4; c–c (alveoli) 6.6; c–m<sup>1</sup> 10.8; complete mandible length from condyles 22.1; ramus length from condyle 23.1.

*Eonycteris spelaea* (Dobson, 1871).—A group of approximately six individuals was found roosting within a tight cluster of bats containing two other species, *R. leschenaulti* and *Taphozous melanopogon*, at Wat Tam Pha Bing. The cluster was in a roof dome within the inner light zone of a cave. Also, a single individual was caught at Chiang Khan Fish Farm, at a height of 2.0 m, around *Parkia* spp. which were in flower. Weights and measurements of four adults (2 males, 2 females): forearm 65.0–73.7; tail 8.0–14.0; tibia 30.4–36.3; ear 17.4–19.2; weight 53.0–76.0. A damaged skull and mandible (BM (NH) 96.92: c–m<sup>2</sup> 12.2; c–m<sub>3</sub> 13.5; c–c 6.9) were found on a cave floor at Wat Tam Maho Lan and three incomplete mandibles (BM (NH) 96.91) were recovered from owl pellets at Tam Pha Baen.

#### EMBALLONURIDAE

*Taphozous melanopogon* Temminck, 1841.—Clusters of between 1000 and 4000 individuals were found roosting in the light, inner light and dark zones of caves at Wat Tam Pha Bing, Wat Tam Maho Lan, Wat Tam Nam, Wat Tam Pha Phu, Tam Pha Baen and Tam Pha Phot. They roosted in the domed roof of the large main chambers within each cave, ranging in height from 10–30 m, as well as in small chambers, measuring only 1.5 m high. Weights and measurements of thirty adult and immature bats, except where indicated: forearm 62.5–68.0; tail (21) 17.0–28.3; tibia (8) 24.4–26.8; ear (7) 17.1–20.0; weight (29) 20.5–32.0.

Skull and/or mandibles of 62 individuals were found in owl pellets and on the floor of caves at Wat Tam Pha Bing, Wat Tam Maho Lan, Wat Tam Pha Phu and Tam Pha Baen. Measurements (BM (NH) 96.93–96.133): greatest length of skull (47) 19.3–21.4; condylobasal length (43) 18.2–19.9; least interorbital width (43) 4.3–5.0; zygomatic width (37) 12.1–12.9; braincase width (37) 9.7–10.4; mastoid width (28) 10.6–11.5; c–c (alveoli) (36) 3.3–4.4; m<sup>3</sup>–m<sup>3</sup> (44) 8.2–9.0; c–m<sup>3</sup> (23) 8.7–9.3; complete mandible length from condyle 15.2, 16.0; ramus length from condyle (20) 15.8–16.6; c–m<sub>3</sub> (19) 9.5–10.3.

#### MEGADERMATIDAE

*Megaderma spasma* (Linnaeus, 1758).—Six roosts containing 1–12 individuals were found in small caves at Wat Tam Pha Bing, Wat Tam Maho Lan, Tam Pha Baen, Wat Tam Nam and Wat Tam Pha Phu, where they hung in the inner light and dark areas of the caves. Also, four individuals were found roosting in a one metre diameter concrete drainage pipe under the road at Phu Tork. The bats roosted at the far end of the blocked culvert. Weights and measurements of seventeen adult and immature bats, except where indicated: forearm 56.7–62.0; tibia (4) 33.3–35.8; ear (12) 37.6–43.5; weight (15) 17.5–30.0. A

damaged skull (BM (NH) 96.134): condylobasal length 21.9; zygomatic width 14.5;  $c-m^3$  9.5) was found on the floor of a cave at Wat Tam Pha Bing.

*Megaderma lyra* Geoffroy, 1810.—Tightly packed clusters of 20–30 individuals were found roosting in the inner light zone of a cave at Wat Tam Maho Lan. Ten adults (5 male and 5 female) were caught as they emerged from the cave at dusk (forearm 68.0–73.1; tibia 36.0–48.8; ear 37.0–48.5; weight 41.0–48.0). Four sets of skulls and mandibles were found in a cave at Wat Tam Maho Lan. Measurements (BM (NH) 96.135–96.138): greatest length of skull (3) 29.4–30.2; condylobasal length (4) 26.5–27.2; least interorbital width (3) 5.3–5.5; zygomatic width (3) 15.3–17.7; braincase width (4) 12.7–13.1; mastoid width (3) 13.5–13.8;  $c-c$  (alveoli) (4) 5.9–6.3;  $m^3-m^3$  (4) 9.9–10.5;  $c-m^3$  (4) 11.5–12.1; complete mandible length from condyle 20.8; ramus length from condyle 21.3, 21.7;  $c-m_3$  (3) 12.8–13.2.

#### RHINOLOPHIDAE

*Rhinolophus paradoxolophus* (Bourret, 1951).—A mandibular ramus (BM (NH) 96.139) provisionally identified as *R. paradoxolophus* was found on a cave floor at Wat Tam Maho Lan. The alveolus of the second lower premolar ( $pm_3$ ) is centrally placed between  $pm_2$  and  $pm_4$ . This is a situation that exists in relatively few Thai *Rhinolophus* species, and where it does occur the toothrow ( $c-m_3$ ) is approximately 7.0, versus 8.0 in this specimen (Hill, pers. comm.).

*Rhinolophus marshalli* Thonglongya, 1973.—A single adult male (forearm 45.0; tail 20.6; tibia 18.5; ear 28.7; weight 41.0–48.0) was caught as it emerged, approximately one hour after dusk, from a cave at Tam Pha Baen.

*Rhinolophus coelophyllus* Peters, 1867.—Roosts of approximately 100–150 bats were found in caves at Tam Pha Baen and Wat Tam Pha Phu. The roosts were in the dark zones of caves. Weights and measurements of seven adult and immature bats, except where indicated: forearm 41.7–45.5; tail 18.8–22.8; tibia (2) 21.1–23.0; ear 16.5–18.0; weight 6.2–8.0.

*Rhinolophus pearsonii* Horsfield, 1851.—Four adults (forearm 47.8–52.4; tail 18.7–21.5; tibia 25.0–26.0; ear 24.4–25.7; weight 9.5–14.5) were caught in a mist-net, while flying at a height of 0.5–1.5 m in bamboo forest around the edge of limestone outcrops at Wat Tam Maho Lan.

*Rhinolophus lepidus* Blyth, 1844.—A single adult male (forearm 41.3; tail 21.8; tibia 16.8; ear 19.7; weight 6.0) was caught, while flying in bamboo forest around the edge of limestone outcrops at Wat Tam Maho Lan.

*Rhinolophus malayanus* Bonhote, 1903.—Roosts containing clusters of 100–400 bats were found in the dark zone of caves at Wat Tam Pha Phu, Tam Pha Baen, Wat Tam Maho Lan and Wat Tam Pha Bing. Weights and measurements of twenty-three adult and immature bats, except where indicated: forearm 38.3–43.4; tail (19) 18.4–26.3; tibia (9) 17.0–18.0;

ear (20) 16.0–20.0; weight 6.0–8.0.

*Rhinolophus thomasi* Andersen, 1905.—At Wat Tam Pha Bing, Wat Tam Maho Lan and Wat Tam Nam eleven individuals, one, nine and one respectively, were caught in mist-nets at dusk, as they emerged from caves. Weights and measurements of eleven adult bats, except where indicated: forearm 40.8–43.9; tail (9) 23.8–27.5; tibia 17.6–19.2; ear 16.8–19.1; weight 6.5–11.5.

## HIPPOSIDERIDAE

*Hipposideros pomona* Andersen, 1918.—Clusters of *H. pomona* were found at Wat Tam Pha Phu and Wat Tam Maho Lan. At both sites the bats roosted in the dark zone of the caves. At Wat Tam Pha Phu approximately 300 individuals were found roosting in a dome in the cave ceiling at a height of c. 15 m. However, at Wat Tam Maho Lan small clusters of 4 - 15 bats were found in three separate caves. Weights and measurements of fifteen adult and immature bats, except where indicated: forearm 39.4–43.0; tail 26.9–39.8; tibia (13) 18.0–20.6; ear 21.6–25.2; weight (14) 5.0–6.5. Skulls and/or mandibles from thirteen individuals were found on cave floors at Wat Tam Maho Lan. Measurements (BM (NH) 96.140–96.148): condylocanine length 15.1; zygomatic width (7) 8.5–8.9;  $m^3$ – $m^3$  (7) 5.6–5.9;  $c$ – $m^3$  6.0, 6.1;  $c$ – $m_3$  6.5, 6.3.

*Hipposideros lylei* Thomas, 1913.—A cluster of approximately 50 individuals were found roosting in the dark zone of a cave at Wat Tam Maho Lan. Also, single bats were caught as they emerged from caves at both Tam Pha Baen and Wat Tam Pha Phu. Weights and measurements of three adult bats: forearm 78.1–79.0; tail 51.9–56.5; tibia 36.3–37.7; ear 27.3–27.7; weight 33.0–38.0. Thirteen skulls and/or mandibles were found in a cave at Wat Tam Maho Lan. Measurements (BM (NH) 96.149–96.159): condylocanine length (5) 25.0–25.8; least interorbital width (6) 3.7–4.5; zygomatic width (5) 15.3–16.3; braincase width 11.4, 11.5; mastoid width 14.5;  $c$ – $c$  (alveoli) (7) 6.8–7.7;  $m^3$ – $m^3$  (7) 9.9–10.9;  $c$ – $m^3$  (5) 10.6–11.3; complete mandible length from condyle 18.3, 19.0; ramus length from condyle (4) 18.9–19.9;  $c$ – $m_3$  (7) 11.8–12.5.

*Hipposideros armiger* (Hodgson, 1835).—Caught in caves at Wat Tam Maho Lan, Wat Tam Nam and Tam Pha Baen, where clusters of 300, 1500 and 5 were found respectively. Weights and measurements of eleven adult and immature bats, except where indicated: forearm 90.9–97.4; tail (10) 55.5–65.0; tibia (10) 40.5–43.0; ear (10) 31.4–34.0; weight (10) 40.0–51.5. Skulls and/or mandibles from thirty-two individuals were found on cave floors at Wat Tam Maho Lan, Wat Tam Had Nimid and Wat Tam Pha Phu. Measurements (BM (NH) 96.160–96.180): condylocanine length (4) 29.0–29.3; least interorbital width 4.1, 3.6; zygomatic width (12) 18.4–19.4; braincase width 11.3; mastoid width 15.1;  $c$ – $c$  (alveoli) (4) 8.9–9.4;  $m^3$ – $m^3$  (15) 12.0–13.2;  $c$ – $m^3$  (4) 12.8; ramus length from condyle (4) 22.2–23.2;  $c$ – $m_3$  (9) 13.5–14.2.

*Hipposideros larvatus* (Horsfield, 1823).—Clusters of 50–100 bats were found roosting in the dark zone of caves at Wat Tam Maho Lan, Wat Tam Pha Bing, Wat Tam Pha Phu and Tam Pha Baen. Weights and measurements of eleven adult and immature bats, except

where indicated: forearm 54.1–64.1; tail 26.0–36.4; tibia (3) 23.0–25.2; ear 20.0–23.3; weight 12.0–19.5. Skulls and/or mandibles from twenty-eight individuals were found on cave floors at Wat Tam Maho Lan, Wat Tam Pha Bing, Wat Tam Pha Phu and in owl pellets at Tam Pha Baen. Measurements (BM (NH) 96.181–96.202): greatest length of skull 22.1; condylocanine length (4) 18.9–19.5; least interorbital width (3) 2.9–3.4; zygomatic width (10) 11.8–12.8; braincase width 8.6, 8.9; mastoid width 11.0; c–c (alveoli) (5) 5.2–6.0;  $m^3$ – $m^3$  (16) 7.9–9.1; c– $m^3$  (10) 8.0–8.8; ramus length from condyle (3) 14.2–15.5; c– $m_3$  (7) 8.6–9.5.

## VESPERTILIONIDAE

*Myotis siligorensis* Horsfield, 1855.—A roost of 200 - 300 bats was found at Tam Pha Baen. Also, a single individual was caught as it emerged from a cave at Wat Tam Maho Lan. Weights and measurements of twelve adult and immature bats, except where indicated: forearm 29.4–32.5; tail (3) 26.4–35.6; tibia (3) 13.7–14.3; ear (3) 10.0–11.6; weight 3.0–3.5.

*Scotophilus heathii* Horsfield, 1831.—A cluster of ten individuals was found roosting in the south facing gable apex of a crematorium roof at Wat Porm Chai, Chiang Khan. A single adult male was caught: forearm 62.8; tail 63.2; ear 17.2; weight 38.5. Also, 13 damaged skulls were recovered from owl pellets at Wat Tam Pha Phu. Measurements (BM (NH) 96.203–96.211): greatest length of skull (10) 18.9–22.0; condylobasal length (10) 18.6–20.2; least interorbital width (5) 5.1–5.2; zygomatic width (8) 14.9–16.2; braincase width (4) 9.9–10.6; mastoid width (3) 13.4–14.2; c–c (alveoli) (4) 6.8–7.2;  $m^3$ – $m^3$  (10) 9.2–10.0; c– $m^3$  (6) 7.4–7.7; complete mandible length from condyle 14.6; ramus length from condyle (3) 15.8–16.1; c– $m_3$  (5) 8.0–8.6.

*Pipistrellus cadornae* Thomas, 1916.—A damaged skull (BM (NH) 96.212) was found on the floor of a cave at Wat Tam Maho Lan (greatest length of skull 13.8; condylobasal length 13.2; zygomatic width 8.7; interorbital width 3.8; braincase width 6.7; c–c (alveoli) 4.1; c– $m^3$  (alveoli) 4.8;  $m^3$ – $m^3$  (alveoli) (6.1).

*Miniopterus magnater* (Sanborn, 1931).—An adult male was found roosting in a small dome (300 mm high, 200 mm dia.) in the cave ceiling, in a light area of the cave at Wat Tam Pha Bing, 2.5 m from the ground. Five adult male bats (forearm 48.4–50.5; tail 54.5–61.8; tibia 20.2–21.6; ear 12.4–13.6; weight 13.0–16.5); four at Wat Tam Pha Bing and one at Wat Tam Maho Lan, were caught as they emerged from caves at dusk. Also, a single lower mandible (BM (NH) 96.213, c– $m^3$  7.3), fur and one wing (forearm (dry) 47.5) were found on the floor of a cave at Wat Tam Pha Bing and a damaged skull (BM (NH) 96.214; greatest length of skull 15.8; condylobasal length 15.5; zygomatic width 9.5; braincase width 8.7; c– $m^3$  (alveoli) 6.6;  $m^3$ – $m^3$  (alveoli) 7.2) was recovered from an owl pellet at Wat Tam Pha Baen.

*Miniopterus pusillus* Dobson, 1876.—A cluster of approximately 100 individuals was found roosting one metre off the ground in a small domed chamber in the dark area of a

cave at Wat Tam Pha Bing. Weights and measurements of two adult bats: forearm 40.6, 40.8; tail 47.5, 48.0; weight 8.5, 8.5.

## MOLOSSIDAE

*Tadarida plicata* (Buchanan, 1800).—Twenty-five skulls and/or mandibles were recovered from owl pellets collected within a cave entrance at Tam Pha Baen. Measurements (BM (NH) 96.215–96.238): greatest length of skull (8) 18.4–18.9; condylobasal length (8) 16.7–17.4; least interorbital width (18) 3.0–3.8; zygomatic width (11) 10.1–11.0; braincase width (8) 8.5–9.2; mastoid width (6) 9.8–10.3; c–c (alveoli) (10) 4.5–5.2;  $m^3$ – $m^3$  (12) 7.8–8.3; c– $m^3$  (13) 6.6–7.0; complete mandible length from condyle (3) 12.0–12.2; ramus length from condyle (17) 11.8–12.8; c– $m_3$  (18) 7.1–7.6. Also, a single dead specimen was found at the entrance to a cave at Wat Tam Pha Phu.

## DISCUSSION

### Species Distribution

Prior to this study there had only been five species of bat, *Megaerops niphanae*, *Cynopterus sphinx*, *Rousettus leschenaulti*, *Taphozous melanopogon* and *Tylonycteris pachypus*, recorded from Loei Province (YENBUTRA & FELTEN, 1983; YENBUTRA & FELTEN, 1986). This, however, undoubtedly reflects the lack of work carried out in the area. In the present study, a total of 24 bat species were recorded, four Megachiroptera and 20 Microchiroptera, of which 21 were new records for the province. The number of species recorded at each site varied from 19 at Wat Tam Maho Lan to a single species at Tam Pha Phot. At all but Wat Tam Pha Bing the cave systems were quite extensive and were not completely explored, either because of their inaccessibility or the lack of time and equipment available. Therefore, the number of species and individuals within the caves may have been higher.

The four species of Megachiroptera recorded were *R. leschenaulti*, *C. sphinx*, *Eonycteris spelaea* and *R. amplexicaudatus*. *E. spelaea* and *R. amplexicaudatus* had not been previously recorded from the province. *E. spelaea* is a common and widespread species in Thailand and across much of South East Asia, however, *R. amplexicaudatus* was only previously known from western and southern Thailand (ROOKMAAKER & BERGMANS, 1981; CORBET & HILL, 1992).

Of the 20 species of Microchiroptera recorded in the present study, 13 of them, *T. melanopogon*, *M. spasma*, *M. lyra*, *R. coelophyllus*, *R. pearsonii*, *R. malayanus*, *R. thomasi*, *H. pomona*, *H. armiger*, *H. larvatus*, *H. lylei*, *S. heathii* and *T. plicata*, are species which have a widespread distribution across much of Thailand (LEKAGUL & McNEELY, 1977; YENBUTRA & FELTEN, 1986; CORBET & HILL, 1992), although *T. melanopogon* is the only Microchiroptera which had been previously recorded in Loei province, at Phu Kradung (YENBUTRA & FELTEN, 1986). In the present study *T. melanopogon* was found to be widespread, being found at six of the nine sites visited. All of the individuals examined were thought to represent the subspecies *T. m. fretensis* (THOMAS, 1916a) being generally

pale in colour.

*Rhinolophus paradoxolophus*, a species first described from a single specimen collected from Lao Key Province, Tonkin, Northern Vietnam, (BOURRET, 1951) has since only been caught twice, both times in Thailand (THONGLONGYA, 1973; YENBUTRA & FELTEN, 1986). A mandible recovered in the present study, from Wat Tam Maho Lan, represents only the fourth known record of this species. A single specimen of *R. marshalli* was caught as it emerged from a cave at Tam Pha Baen. This species was previously known from only four localities, the type locality in Chanthaburi (THONGLONGYA, 1973), two areas in Chiang Mai (YENBUTRA & FELTEN, 1986; YOSHIYUKI, 1990) and from Phetchabun (YOSHIYUKI, 1990). Similarly, *R. lepidus*, which was caught at Wat Tam Maho Lan, was recorded previously from only northern and southern Thailand (YENBUTRA & FELTEN, 1986; CORBET & HILL, 1992).

*Myotis siligorensis* was found roosting in caves at both Tam Pha Baen and Wat Tam Maho Lan. This species had never been recorded in east or northeast Thailand, and was previously known from only a few locations in north, central and peninsular Thailand (YENBUTRA & FELTEN, 1986; CORBET & HILL, 1992).

A skull of *P. cadornae* was found on a cave floor at Wat Tam Maho Lan. This specimen represents only the second record of this species in Thailand, the previous being recorded in Phetchabun, Thung Salang, Luang (HILL & THONGLONGYA, 1972), a site c. 70 km south west of Wat Tam Maho Lan. Outside Thailand the species is only known from the holotype, from NE India (THOMAS, 1916b), and three specimens from Upper Burma (HILL, 1962),

Two species of *Miniopterus* were recorded, *M. magnater* and *M. pusillus*, both of which are known from only a few localities in north, south east, central and peninsular Thailand.

### Guano Collecting and Hunting

In Thailand there is a long-established tradition of collecting bat guano to use as fertiliser. In the past, whole villages have derived all their income from the sale of guano. At Khao Chong Pran Cave, Ratchaburi Province, the collection of bat guano has been strictly controlled by monks and in conjunction with the town mayor. The sale of guano has not only provided support for village people, but has also financed the building of a local school and provided scholarships for children in higher education (TUTTLE, 1983). In recent years disturbance caused by the over-exploitation of this natural resource and the catching of bats, has caused a decline in bat numbers and hence in guano production at some sites in Thailand (STEBBINGS, 1987).

In five of the seven cave sites visited, flimsy ladders of bamboo were present within the caves. These had been used to reach the more inaccessible areas of caves where clusters of bats could be found, and hence guano collected. Local people were observed collecting guano at four of these sites. Guano was collected by both local village people and monks, who did not consider that they were disturbing the bats. However, some caves were so small that just walking into them caused a great deal of disturbance.

Great risks are often taken to collect the highly-prized guano, which has a high market value of 300 Baht (approximately US\$ 12.00) for a 25 kg sack, costing three times as

Table 1. Small mammal species found at nine sites in Loei Province, north-east Thailand. **A.** Tam Pha Baen; **B.** Phu Tork; **C.** Chiang Khan; **D.** Tam Pha Phot; **E.** Wat Tam Pha Phu; **F.** Wat Tam Pha Bing; **G.** Wat Tam Maho Lan; **H.** Wat Tam Nam; **I.** Wat Tam Had Nimid.

Species	Study area								
	A	B	C	D	E	F	G	H	I
<i>Rousettus leschenaulti</i>						+	+		
<i>Rousettus amplexicaudatus</i>	+						+		
<i>Cynopterus sphinx</i>						+	+	+	
<i>Eonycteris spelaea</i>	+		+			+	+		
<i>Taphozous melanopogon</i>	+			+	+	+	+	+	
<i>Megaderma spasma</i>	+	+			+	+	+	+	
<i>Megaderma lyra</i>							+		
<i>Rhinolophus paradoxolophus?</i>							+		
<i>Rhinolophus marshalli</i>	+								
<i>Rhinolophus coelophyllus</i>	+				+				
<i>Rhinolophus pearsonii</i>							+		
<i>Rhinolophus lepidus</i>							+		
<i>Rhinolophus malayanus</i>	+				+	+	+		
<i>Rhinolophus thomasi</i>						+	+	+	
<i>Hipposideros pomona</i>					+		+		
<i>Hipposideros lylei</i>	+				+		+		
<i>Hipposideros armiger</i>	+				+		+	+	
<i>Hipposideros larvatus</i>	+				+	+	+		+
<i>Myotis siligorensis</i>	+						+		
<i>Scotophilus heathii</i>			+		+				
<i>Pipistrellus cadornae</i>							+		
<i>Miniopterus magnater</i>	+					+	+		
<i>Miniopterus pusillus</i>						+			
<i>Tadarida plicata</i>	+				+				

much as factory-made fertiliser. So highly regarded is guano that a bat logo is used to advertise one Thai brand of manufactured fertiliser.

At all of the sites visited evidence was found of the various techniques people employed to catch bats. Around cave entrances were wooden pegs, hammered into crevices, to which mist or fishing nets had been secured to catch bats as they emerged. Fishing nets were found in caves, as were ashes from fires, which would have been used to drive bats out into nets and long flexible bamboo canes which would have been used to knock bats to the ground, a technique which has been used to capture *Pteropus hypomelanus*, (LEKAGUL & MCNEELY, 1977) and *Emballonura nigrescens* (MCKEAN, 1972), as well as the unique Kitti's hog-nosed bat, *Craseonycteris thonglongyai*, which was subsequently stuck to cards and sold to tourists (Stebbing, pers comm.). Both *H. armiger* and *Taphozous spp.* are known to be caught for food in Thailand (DUANGKHAE, 1990). Monks at one cave said that people regularly caught 100 to 200 bats at a time.

Mist-nets are easily obtained in Thailand. They can be bought in most towns and villages for approximately 75 Baht (US\$ 3.00). Although they are made of coarse thread, approximately 110 denier (as opposed to usual mist-nets of c. 50 denier), and are generally not good for catching echolocating bats such as *R. malayanus*, or *H. armiger*, which are cave dwelling, they would be effective if bats were frightened into them by being chased or smoked out of the cave. Also, most caves contained *T. melanopogon*, a species known to be sold for food at Chiang Khan market in Loei Province (ROBINSON, 1994). These are fast-flying bats and consequently are unable to avoid any nets placed at an entrance. Because of the clustering habit of bats they can often be caught in large numbers over a relatively short period of time.

The degree of protection cave temples receive, by their association with the temples, does not completely stop hunting, but prevents it occurring on a large scale. However, the regular hunting of bats, which at best produce one young per year, is of obvious detriment to the survival of the species. In the Pacific Islands the hunting of fruit bats, for food and their supposed medicinal properties, has so reduced populations that some species have become extinct (BRAUTIGAM & ELMQVIST, 1990). If the present practices continue, then bat numbers will decline rapidly and extinctions can be expected in Thailand.

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