

## CHIROPTERA SURVEY: XE PIANE NATIONAL BIODIVERSITY CONSERVATION AREA, LAO P.D.R.

*Mark F. Robinson*<sup>1</sup>

### ABSTRACT

To formulate comprehensive and effective management plans for the conservation of Xe Pian's biodiversity it is vital that baseline data are obtained on the species present and their ecological requirements. Prior to this work little was known of the bats in Xe Pian; indeed this was the first study of bats in the area.

A total of 19 species of bat were recorded, 5 Megachiroptera and 14 Microchiroptera. Three species, *Rousettus amplexicaudatus*, *Taphozous theobaldi* and *Hesperoptenus blandfordi*, had not been recorded before in Lao PDR. The nearest previous record of *H. blandfordi* was from over 700 km to the west, in Huai Kha Khaeng Wildlife Sanctuary, western Thailand.

A systematic search for bat roosts resulted in the discovery of 15 sites of 8 species: *T. theobaldi*, *Megaderma lyra*, *M. spasma*, *Rhinolophus acuminatus*, *Hipposideros pomona*, *H. cineraceus* and *H. larvatus*. Eleven were in hollow tree trunks, with the remainder in caves/rock shelters and a hollow log on the forest floor. Nine roosts of *M. spasma* were found, all in hollow trunks of trees, 7 of which were *Lagerstroemia calyculata*, a species which becomes hollow with age. Three cave roosts were found, although these were only small shallow structures, which each contained up to approximately 700 bats of two or three species.

In a non-limestone region such as Xe Pian, cave roosts will be a limited resource, and so many species of bat will be heavily dependent upon trees with hollow cavities and fissures for roost sites. Also, quality forest will be important for foraging, not only for bats. It is vital that Xe Pian's mature, relatively undisturbed, forests are protected. Ideally, the removal of any timber by commercial companies within the NBCA should be prohibited, and the clearance of forest areas by local people for agriculture and for timber should be controlled.

There was no evidence of villagers from within the protected area hunting bats, and interviews with villagers revealed that bats were seldom caught for any reason. However, there is clearly a need for further work, particularly to investigate their detailed ecological requirements, so that suitable habitats can be maintained to ensure their continued survival within the protected area.

### INTRODUCTION

Xe Pian is one of 18 areas formally declared National Biodiversity Conservation Areas (NBCAs) in October 1993, along with a further 11 recommended areas. The NBCA covers 2,665 km<sup>2</sup> within the districts of Pathoumphon, Kong and Sanamxai, Champassak Province. The boundaries of Xe Pian are formed in the south and east by the Lao PDR/Cambodian border and to the west by Route 13, the main road running south from the town of Pakse to Cambodia. People from the 12 villages within the NBCA boundary grow rice and practise a small amount of shifting cultivation at a subsistence level (STEINMETZ &

---

<sup>1</sup> 11 Newton Road, Little Shelford, Cambridgeshire CB2 5HL, U.K.  
Received 2 January 1998; accepted 20 June 1998.

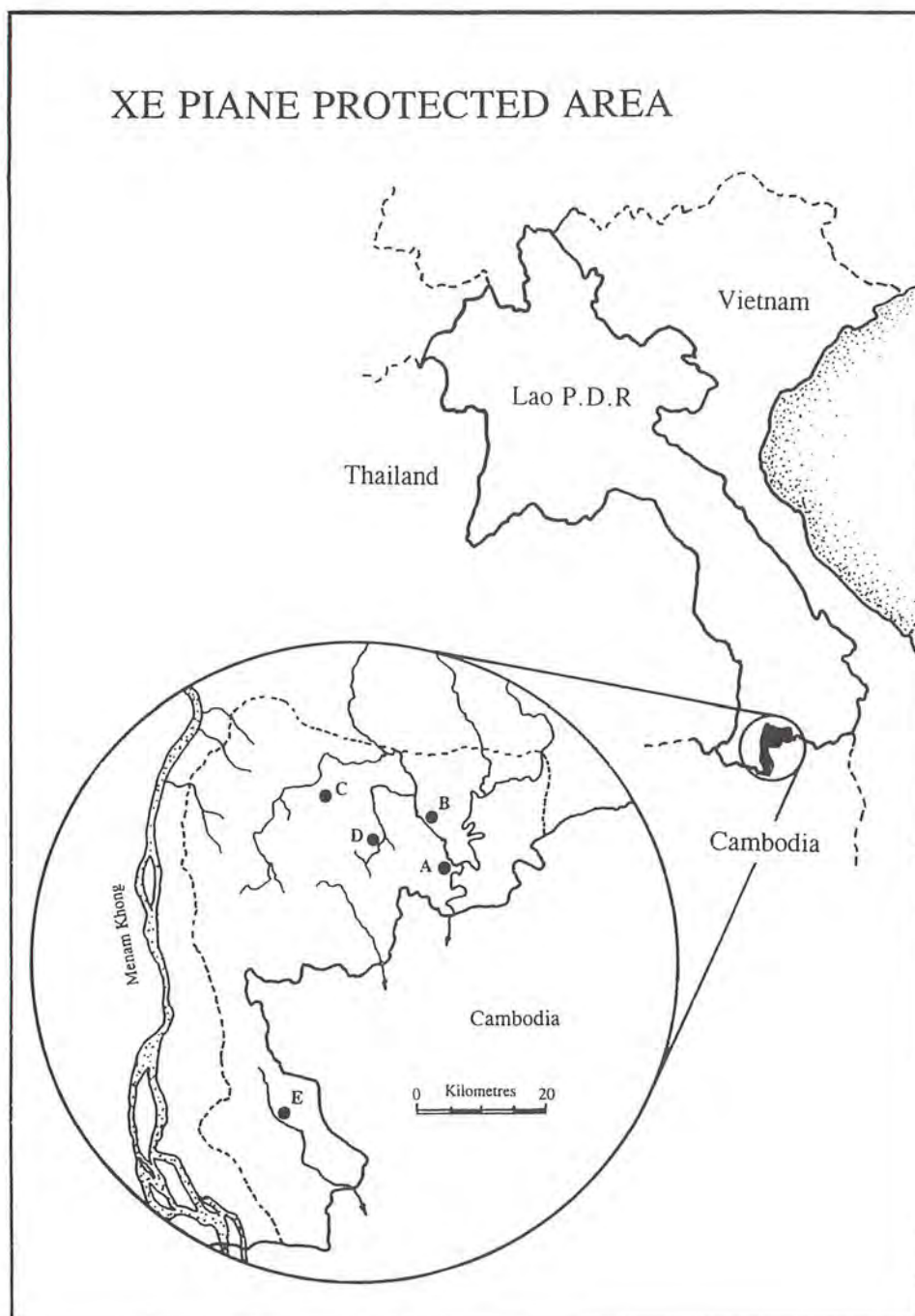


Figure 1. Study areas in Xe Piane National Biodiversity Conservation Area, Lao P.D.R., showing major rivers and tributaries (the broken line indicates the boundary of Xe Piane NBCA). A. Camp 1; B. Ban Nong Kae; C. Camp 2; D. Ban Taong; E. Camp 4.

BAIRD, 1996). They also collect forest products and hunting is widespread (BERKMULLER *ET AL.*, 1995).

Previous wildlife surveys in Xe Piane have been predominantly of birds (DUCKWORTH *ET AL.*, 1993), mammals (excluding bats) (COX *ET AL.*, 1991; DUCKWORTH *ET AL.*, 1994; DUCKWORTH *ET AL.*, 1995) or fish (Baird, pers. comm.). To date there has been no study of bats within Xe Piane and indeed little work on them has been conducted in Lao PDR.

Bats play a vital role in the forest ecosystem. As pollinators and seed dispersers, fruit and nectarivorous bats play a major role in the maintenance and regeneration of tropical forests. Insectivorous bats are major controllers of night-flying insects. However, populations in South-east Asia have declined, largely due to disturbance from guano collectors and tourists, hunting, and loss of habitat caused by extensive logging, which has resulted in most forests being confined to national parks and protected areas. Bats have low reproductive rates relative to their size; many species give birth to only one young each year. Consequently population increase is slow and large losses are not easily recouped.

The present study set out to record the diversity of bats found in Xe Piane and the type of roost sites used.

## STUDY AREAS

The Xe Piane NBCA has 93% forest cover, 47% (1,252 km<sup>2</sup>) of which is mature forest. The major habitat types include semi-evergreen (53%, 1412 km<sup>2</sup>), dry dipterocarp (26%, 693 km<sup>2</sup>) and mixed deciduous forest (14%, 373 km<sup>2</sup>) (BERKMULLER *ET AL.*, 1995). There are permanent wetlands and riverine systems which form major habitat features (BERKMULLER *ET AL.*, 1995). The highest elevation is 844 m asl, although 55% of the area is below 200 m. Survey work was conducted at 5 sites (Figure 1).

**Camp 1** (14°30'55"N, 106°20'35"E) was situated at an altitude of 70 m, on the Xe Kong Plains, at the confluence of the Xe Piane and Xe Khampho (Rivers Piane and Khampho), 9 km east and 7.5 km south from the Cambodian border. The camp site was 9.5 km southeast of the village Ban Nong Kae. The habitat in the area was mixed deciduous forest, dominated by the tree *Lagerstroemia calyculata* Kurz (Lythraceae), which in some areas comprised c. 70–80% of the tree species. Bamboo was present along the edges of the rivers.

**Ban Nong Kae** (Crocodile Swamp Village) (14°35'15"N, 106°17'25"E) was on the east bank of the Xe Khampho, at an altitude of 90 m, and consisted of 40 families. The Cambodian border was c. 13 km to the south and 19 km to the east. The village was surrounded by heavily degraded mixed deciduous forest with extensive bamboo stands. Most of the large trees had been removed, either for houses, boat building, or to make way for rice paddies. Kapok, *Ceiba pentandra*, and cultivated varieties of banana *Musa* spp., all of which are bat pollinated, were grown in the village.

**Camp 2** (14°33'45"N, 106°12'45"E) was situated at an altitude of 140 m, on the banks of the Houay Gua (Salt Stream), 11.5 km southeast of Ban Taong and 15.5 km northwest of Camp 1. The area comprised mainly semi-evergreen forest with areas of bamboo.

**Ban Taong (Taong village)** (14°37'50"N, 106°07'40"E), at an altitude of 150 m, was composed of 42 families of Brao/Lao Luum ethnic origin. The villagers grew rice and vegetables for subsistence. Also, kapok (Figure 2), and cultivated varieties of banana were grown in the village. The village and rice paddies were surrounded by heavily degraded mixed deciduous forest with a lot of bamboo. Many of the large trees had been removed for timber, either for houses or when clearing areas for cultivation.

There were two small caves near Ban Taong. Tam Hong Ewen (14°38'35"N, 106°06'15"E), altitude 220 m, was 2.5 km northwest of the village and Tam Phu Kim (14°38'25"N, 106°09'05"E), altitude 250 m, was 3 km to the northeast. Both caves were surrounded by degraded mixed deciduous forest and bamboo.

**Camp 4** (14°07'15"N, 106°03'40"E), at an altitude of 70 m, was on the Houay Kaliang, a seasonal stream with perennial deep water pools. The habitat was a mosaic of dry dipterocarp, mixed deciduous and semi-evergreen forest. The dominant habitat was dry dipterocarp, with patches of semi-evergreen forest in wetter areas, particularly along the streams and rivers (Figure 3). Mixed deciduous forest often formed transitional zones between the dry dipterocarp and semi-evergreen forest. The area had undergone selective logging, removing many of the larger trees for building purposes.

There was a small cave, Tam Nang Keo Hi Louang (14°06'40"N, 106°02'20"E), altitude 140 m, in a rocky outcrop on the south side of the Sayphou Ridge, 3 km west of Camp 4 (Figure 4). The ridge was surrounded by dry dipterocarp forest, with semi-evergreen forest along the top of the ridge.

## METHODS

To catch foraging or commuting bats, mist-nets were set in the forest understorey of differing habitat types, at various heights from 0.5 m up to 18 m, and across small tributaries and larger slow-flowing rivers. Mist-nets used ranged in length from 3.6–12.0 m and in depth from 2.1–3.0 m. Nets were monitored continuously.

Bat roosts were located by searching hollow logs and trees, overhangs on river banks, and caves and fissures in rocky outcrops. The species composition of each site was determined by catching bats either within the roost or as they emerged at dusk. The sizes of bat populations within roosts were determined by dusk emergence counts and by visual estimates of numbers of roosting bats. Roosts were searched for remains of dead bats. The size and type of each site were recorded, as well as evidence of hunting or disturbance such as long thin bamboo poles used to knock down roosting or flying bats, discarded nets, or clay catapult balls.

The species, sex, age and reproductive condition of all animals caught were determined in the field. Juveniles were identified by the presence of unfused epiphyses of the metacarpal-phalangeal joints. Immatures were identified by their undescended testes and intensely dark pigmented tunica vaginalis in males, or in females, unsuckled nipples which appeared rudimentary and often covered with hairs. Adult males possess descended testes and/or tunica vaginalis with dispersed pigment, and adult females are considered to be those which have given birth, as indicated by the keratinized appearance of nipples with no hairs,

or with short wavy hairs, showing that they have been suckled. Body weight was recorded to the nearest 0.5 g or 1.0 g using 50 g and 300 g Pesola spring balances, respectively. Measurements of forearm, tail, tibia and ear length, and noseleaf width, of bats from the families Rhinolophidae and Hipposideridae were measured to the nearest 0.1 mm using dial callipers. All bats caught were marked by clipping a small area of fur mid-dorsally, allowing recaptured bats to be recognised.

All bats caught were released at the site of capture, with the exception of voucher specimens, which were preserved in 70% alcohol. These are stored in the British Museum (Natural History) and their catalogue numbers are given below.

## RESULTS

Surveys for bats and their roosts were carried out at five sites: Camp 1, Ban Nong Kae, Camp 2, Ban Taong and Camp 4 (Figure 1), in Xe Piane NBCA, Lao PDR, between 24 January and 19 February, 1997. A total of 19 species: 5 Megachiroptera and 14 Microchiroptera, were recorded and a total of 15 roost sites were found either in caves (3 sites), hollow tree trunks (11 sites), or in a hollow log lying on the forest floor (1 site). The distribution of bats recorded in the present study is given in Table 1.

### Species Accounts

#### PTEROPODIDAE

***Rousettus amplexicaudatus* (Geoffroy, 1810).**— In Ban Taong 5 individuals were caught at a height of 6.5–8 m, while they were feeding on kapok flowers. Weights and measurements of 5 adults (2 females and 3 males): forearm 72.2–85.7; tail 13.7–17.0; tibia 30.0–38.7; ear 17.3–21.5; weight 45.0–90.0.

***Rousettus leschenaulti* (Desmarest, 1820).**— Two adult males were caught in Ban Taong, at heights of 6–8 m, while they were feeding on kapok flowers. Weights and measurements: forearm 78.6, 84.2; tail 14.0, 16.0; tibia 35.8, 38.0; ear 19.7, 20.8; weight 79.0, 83.0. A single specimen (BM(NH)97.271) was collected. Measurements: greatest length of skull 37.2; condylobasal length 35.2; least interorbital width 7.4; zygomatic width 23.1; braincase width 14.8; mastoid width 14.7; c–c (alveoli) 6.7;  $m^3$ – $m^3$  11.0; c– $m^2$  13.6; complete mandible length from condyle 27.7; ramus length from condyle 29.2; c– $m_3$  15.0;  $m_3$  1.0 x 1.5.

***Cynopterus sphinx* (Vahl, 1797).**— A parous female was caught as it flew at a height of 1.5 m, up the Houay Kaliang, 1 km north of Camp 4.

***Megaerops niphanae* Yenbutra & Felten, 1983.**— Twenty-two individuals, 16 adults (1 male and 15 females) and 6 immatures, were caught, 20 at Camp 2 and 2 at Camp 4. All but one individual were caught while flying at a height of 1–3 m along dry river beds which had scattered small pools. A single bat was caught at a height of 11 m as it flew over a slow-flowing river. Weights and measurements: forearm 53.8–60.1; tibia 21.3–26.2; ear 16.6–21.0; weight 19.0–34.0.

Table 1. Chiroptera species found at five sites in Xe Piang NBCA, Lao PDR. **A.** Camp 1; **B.** Ban Nong Kae; **C.** Camp 2; **D.** Ban Taong; **E.** Camp 4.

Species	Study area				
	A	B	C	D	E
<i>Rousettus leschenaulti</i>				+	
<i>Rousettus amplexicaudatus</i>				+	
<i>Cynopterus sphinx</i>					+
<i>Megaerops niphanae</i>			+		+
<i>Eonycteris spelaea</i>		+			
<i>Taphozous theobaldi</i>					+
<i>Megaderma spasma</i>	+	+	+		+
<i>Megaderma lyra</i>				+	
<i>Rhinolophus acuminatus</i>	+		+	+	+
<i>Rhinolophus malayanus</i>			+		
<i>Hipposideros pomona</i>				+	
<i>Hipposideros cineraceus</i>				+	
<i>Hipposideros larvatus</i>					+
<i>Myotis muricola</i>	+				+
<i>Myotis sp.</i>			+		
<i>Pipistrellus tenuis</i>	+				+
<i>Hesperoptenus tickelli</i>					+
<i>Hesperoptenus blandfordi</i>			+		+
<i>Murina cyclotis</i>	+				

*Eonycteris spelaea* (Dobson, 1873).— Five individuals were caught at Ban Nong Kae while they were feeding on nectar from the flowers of cultivated varieties of banana. Weights and measurements of 5 adults (4 males and 1 female): forearm 66.4–77.1; tail 11.0–15.8; tibia 29.4–36.3; ear 19.3–21.4; weight 58.0–81.0.

#### EMBALLONURIDAE

*Taphozous theobaldi* Dobson, 1872.— The cave, Tam Nang Keo Hi Louang, near Camp 4, was found to contain approximately 600 individuals. The cave was surrounded by dry dipterocarp forest. Two dead males (BM(NH)97.274, 97.275) were found on the floor, by the cave entrance, both with well defined black beards. Measurements: forearm 74.1 (dry), c. 73.5 (both forearms broken); greatest length of skull 22.8, 23.5; condylobasal length 22.2, 22.7; least interorbital width 5.5, 5.5; zygomatic width 14.6, 14.8; braincase width 11.1, 11.2; mastoid width 12.8, 12.9; c–c (alveoli) 4.9, 5.0; m<sup>3</sup>–m<sup>3</sup> 10.2, 10.3; c–m<sup>3</sup> 10.5, 10.6; complete mandible length from condyle 17.9, 18.2; ramus length from condyle 18.7, 19.0; c–m<sub>3</sub> 11.6, 11.7.





Figure 2. Ban Taong, with kapok *Ceiba pentandra*, a bat pollinated tree, in the foreground. Two species of fruit bat, *Rousettus leschenaulti* and *R. amplexicaudatus*, were caught feeding in these trees.



Figure 3. The Houay Kaling, a seasonal stream, with perennial deep water pools. The riparian habitat was semi-evergreen forest with mixed deciduous forest forming a transitional zone between it and the surrounding dry dipterocarp forest.

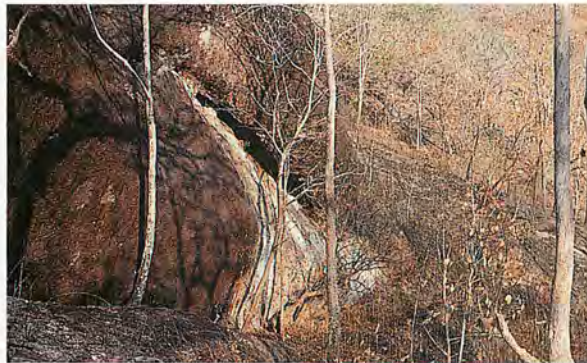


Figure 4. The cave Tam Nang Keo Hi Louang on the south side of the Sayphou Ridge, 3 km west of Camp 4. The cave was used by *Taphozous theobaldi*, *Rhinolophus acuminatus* and *Hipposideros larvatus*. The ridge was surrounded by dry dipterocarp forest, with semi-evergreen forest along the top.





Figure 5. A typical roost site of *Megaderma spasma* in the tree *Lagerstroemia calyculata*, a species which often becomes hollow with age.



Figure 6. A *Lagerstroemia calyculata* tree which had a hole cut in the trunk with an axe to allow a monitor lizard to be captured from within. The tree was used as a roost by *Rhinolophus acuminatus*.



## MEGADERMATIDAE

***Megaderma spasma* Linnaeus, 1758.**— Caught at three sites; in mixed deciduous forest at Camp 1, an area dominated by *L. calyculata*, around cultivated varieties of banana, in Ban Nong Kae, and in semi-evergreen forest at Camp 2. Individuals were caught at heights of 1 to 2 m. A total of 9 roosts were found, 5 at Camp 1 and 2 each at Camps 2 and 4, all in hollow trees, 6 of which were *L. calyculata* (Figure 5). The roosts contained up to 7 bats. Six adults (4 males and 2 females) were caught. Weights and measurements: forearm 54.0–57.5; tibia 32.0–35.3; ear 39.2–43.8; weight 19.5–27.0. A dead male (BM(NH)97.272) was found on the forest floor c. 1.5 km north of Camp 1, in mixed deciduous forest dominated by *L. calyculata*. Measurements: greatest length of skull 23.0; condylobasal length 20.7; least interorbital width 3.5; zygomatic width 13.4; braincase width 10.0; mastoid width 10.8; c–c (alveoli) 5.0; m<sup>3</sup>–m<sup>3</sup> 7.9; c–m<sup>3</sup> 9.4; complete mandible length from condyle 15.7; ramus length from condyle 16.3; c–m<sub>3</sub> 10.4. Also, the remains of an individual (BM(NH)97.273), c–m<sup>3</sup> 9.2; m<sup>3</sup>–m<sup>3</sup> 8.2; c–c 5.2; interorbital width 4.0; c–m<sub>3</sub> 10.1, were found, at Camp 4, in the base of a hollow *L. calyculata* tree, in a small area of forest dominated by this species which formed a transition zone between mixed deciduous and dry dipterocarp forest.

***Megaderma lyra* Geoffroy, 1810.**— A roost of c. 8–12 individuals was found in a cave, Tam Phu Kim. One adult male (forearm 67.5; tibia 35.5; ear 37.5; weight 43.0) was caught.

## RHINOLOPHIDAE

***Rhinolophus acuminatus* Peters, 1871.**— Clusters of approximately 50 bats were found roosting in two caves, Tam Phu Kim and Tam Nang Keo Hi Louang, and single individuals were found roosting in a large hollow *L. calyculata* tree at Camp 1 and in a hollow log lying on the forest floor at Camp 4. Individuals were caught in mist-nets (10 adults; 9 males, one female and one immature female) at Camps 2 and 4, while flying at heights of 0.3–1.5 m along dry river beds. Weights and measurements: forearm 45.2–50.1; tail 22.3–27.7; tibia 21.7–23.3; ear 17.1–21.2; noseleaf 7.8–8.8; weight 6.5–9.0.

***Rhinolophus malayanus* Bonhote, 1903.**— A single adult male (forearm 43.8; tail 22.0; tibia 20.0; ear 20.1; noseleaf width 8.4; weight 9.0) was caught at Camp 2 while flying at a height of 1 m in semi-evergreen forest.

## HIPPOSIDERIDAE

***Hipposideros pomona* Andersen, 1918.**— Approximately 150 individuals were found roosting in a small cave, Tam Hong Ewen. Seven adults were caught; 3 males and 4 females. Weights and measurements of 7 individuals except where indicated: forearm 40.2–42.6; tail 28.0–35.4; tibia 17.2–18.9; ear 21.7–24.4; noseleaf width (4) 4.8–4.9; weight 7.0–6.5).

***Hipposideros cineraceus* Blyth, 1853.**— Forty to 50 individuals were found roosting in a small cave, Tam Hong Ewen. Weights and measurements of 2 adult males, except where indicated: forearm 34.8, 34.4; tail 22.9, 24.5; tibia 15.0, 15.0; ear 17.5, 17.7; noseleaf width (1) 4.1; weight 4.5, 5.0.

***Hipposideros larvatus* (Horsfield, 1823).**— A single individual (forearm 63.5; tail 34.6; tibia 26.0; ear 23.7; noseleaf width 7.2; weight 18.0) was caught at dusk as it emerged from the cave, Tam Nang Keo Hi Louang.

#### VESPERTILIONIDAE

***Myotis muricola* (Temminck, 1840).**— Four adult males were caught, 2 each at Camps 1 and 4 (forearm 36.3–38.1; tail 36.0–37.5; tibia 15.5–16.8; ear 9.9–11.5; weight 6.0–10.5). At Camp 1 the bats were caught flying at heights of 2.5–3.5 m, in mixed deciduous forest dominated by *L. calyculata*. At Camp 4 they were caught as they flew along the Houay Kaliang, surrounded on one side by dry dipterocarp forest and on the other by semi-evergreen forest.

***Myotis* sp. Kaup, 1829.**— At Camp 2 an immature female of the genus *Myotis* was caught while it flew along a dry river bed with scattered small pools, in semi-evergreen forest. The bat, which was collected as a voucher specimen (BM(NH)97.279), is in the subgenus *Selysius* (CORBET & HILL, 1992) and is similar to the species *montivagus*; however, some of the measurements do not fit well and the anteorbital foramen is not widely separated from the anterior rim of the orbit as stated by CORBET & HILL, (1992) and HILL & FRANCIS (1984). Measurements: forearm 39.6; tail 40.1; tibia 16.8; ear 11.5; weight 6.0; greatest length of skull 14.5; condylobasal length 13.8; least interorbital width 3.5; zygomatic width 9.7; braincase width 6.9; mastoid width 7.6; c–c (alveoli) 3.9; m<sup>3</sup>–m<sup>3</sup> 6.2; c–m<sup>3</sup> 5.6; complete mandible length from condyle 10.4; ramus length from condyle 10.7; c–m<sub>3</sub> 6.0.

***Pipistrellus tenuis* (Temminck, 1840).**— At Camp 1 an adult male was caught while flying at a height of 2 m, in mixed deciduous forest and at Camp 4, 2 males and a female were caught as they flew along the Houay Kaliang. Weights and measurements: forearm 28.0–28.9; tail 29.8–33.2; tibia 10.3–12.1; ear 8.5–11.1; weight 3.5. One of the adult males was collected as a voucher specimen (BM(NH)97.278). Measurements: forearm 28.6; tail 33.2; tibia 12.1; ear 11.0; greatest length of skull 11.9; condylobasal length 11.3; least interorbital width 3.5; zygomatic width 7.7; braincase width 6.4; mastoid width 6.7; c–c (alveoli) 3.9; m<sup>3</sup>–m<sup>3</sup> 5.2; c–m<sup>3</sup> 4.3; complete mandible length from condyle 7.6; ramus length from condyle 7.8; c–m<sub>3</sub> 4.5.

***Hesperoptenus tickelli* (Blyth, 1851).**— Two adults, a male and female, were caught as they flew along the Houay Kaliang river bed, an area bordered on one side by dry dipterocarp forest and on the other by semi-evergreen forest. Weights and measurements: forearm 50.2, 53.1; tail 44.7, 45.4; tibia 21.2, 22.4; ear 12.4, 17.2; weight 15.0, 18.0. The adult male (BM(NH)97.277) was collected as a voucher specimen. Measurements: greatest length of skull 17.1; condylobasal length 17.1; least interorbital width 4.8; zygomatic width 13.5; braincase width 9.1; mastoid width 10.6; c–c (alveoli) 6.0; m<sup>3</sup>–m<sup>3</sup> 9.2; c–m<sup>3</sup>

7.2; complete mandible length from condyle 13.3; ramus length from condyle 13.9; c-m<sub>3</sub> 8.1.

***Hesperoptenus blanfordi* (Dobson, 1877).**— Four adults, 3 males and a female, were caught as they flew at heights of 2–3 m along dry river beds. At Camp 2 the river was in an area of semi-evergreen forest, whereas at Camp 4 the river was bordered by dry dipterocarp and semi-evergreen forest. Both rivers had small pools scattered along their lengths. Weights and measurements: forearm 26.9–27.8; tail 26.4–32.1; tibia 11.1–11.5; ear 9.3–11.4; weight 6.0–7.5. An adult male (BM(NH) 97.276) caught at Camp 1 was collected as a voucher specimen. Measurements: greatest length of skull 12.2; condylobasal length 11.6; least interorbital width 4.5; zygomatic width 9.0; braincase width 7.2; mastoid width 7.4; c-c (alveoli) 4.3; m<sup>3</sup>–m<sup>3</sup> 6.0; c–m<sup>3</sup> 4.4; complete mandible length from condyle 8.5; ramus length from condyle 8.7; c–m<sub>3</sub> 4.8.

***Murina cyclotis* Dobson, 1872.**— A single individual (forearm 29.7; tail 35.0; tibia 16.5; ear 14.4; weight 5.0) was caught at Camp 1 while flying at a height of 0.5 m, in the understorey of dense mixed deciduous forest.

### Evidence of Hunting

Villagers from Ban Nong Kae, Ban Taong and Ban Phon Visai said that they frequently ate rats and squirrels caught in traps, shot with catapults, or killed by hitting with sticks. In Ban Taong, between 1–12 February 1997, 5 rats and 2 squirrels were caught for food. However, bats were never caught, mainly because villagers did not have the means to catch them.

At none of the three cave sites visited, Tam Hong Ewen, Tam Phu Kim and Tam Nang Keo Hi Louang, was there any evidence of bats being caught or guano being collected, although realistically there were not enough bats to make guano collection worthwhile. There were no trails leading to the caves, although local people knew of the caves and the bats' presence. Villagers from Ban Phon Visai were very superstitious, disliked the dark and were afraid to enter the caves.

## DISCUSSION

### Species Distribution and Status

A total of 19 species of bat were recorded from the Xe Piane NBCA: 5 species of Megachiroptera; *Rousettus leschenaulti*, *R. amplexicaudatus*, *Cynopterus sphinx*, *Megaerops niphanae* and *Eonycteris spelaea* and 14 species of Microchiroptera; *Taphozous theobaldi*, *Megaderma spasma*, *M. lyra*, *Rhinolophus acuminatus*, *R. malayanus*, *Hipposideros pomona*, *H. cineraceus*, *H. larvatus*, *Myotis muricola*, *Myotis* sp., *Pipistrellus tenuis*, *Hesperoptenus tickelli*, *H. blanfordi* and *Murina cyclotis*.

The species *R. leschenaulti*, *C. sphinx*, *M. niphanae* and *E. spelaea* have been recorded from Lao PDR (PHILLIPS, 1967; DEUVE, 1972; CORBET & HILL, 1992; FRANCIS *ET AL.*, 1996). The occurrence of *R. amplexicaudatus* in Lao PDR is not unexpected, as it has

previously been recorded from West, Central (ROOKMAAKER & BERGMANS, 1981) and Northeast Thailand (ROBINSON & SMITH, 1997).

The insectivorous bats, *M. spasma*, *R. acuminatus*, *R. malayanus*, *H. pomona*, *H. larvatus*, *M. muricola*, *P. tenuis* and *M. cyclotis* recorded in the present study are all species previously recorded from Lao PDR (CORBET & HILL, 1992; FRANCIS *ET AL.*, 1996), and in most cases are found across much of the Indomalayan region. Also, *Megaderma lyra* and *H. cineraceus*, which were found roosting in caves at Ban Taong, have been previously recorded from Lao PDR, but only from the northern and central regions, northern Vietnam and, where their distribution is widespread, in Thailand (LEKAGUL & MCNEELY, 1977; YENBUTRA & FELTEN, 1987; CORBET & HILL, 1992).

A cave containing approximately 600 *T. theobaldi* was found at Camp 4. This species has not been previously recorded in Lao PDR, although it has been found in Northeast Thailand and southern Vietnam (CORBET & HILL, 1992). Also, two species of the genus *Hesperoptenus* were recorded, *H. blandfordi* from Camp 2 and *H. blandfordi* and *H. tickelli* from Camp 4. Both species are known from only a handful of records within the region. There are no previous records of *H. blandfordi* from Lao PDR, Cambodia or Vietnam, the nearest record being over 700 km to the west of Xe Pian, from Huai Kha Khaeng Wildlife Sanctuary, western Thailand (MCBEE *ET AL.*, 1986), although it has since been found in Dong Amphan (FRANCIS *ET AL.*, 1997a) and Hua Sao NBCAs (FRANCIS *ET AL.*, 1997b). Also, in Thailand the species is known from two sites in Chiang Mai (YENBUTRA & FELTEN, 1987) and from Peninsular Thailand (ROBINSON & KLOSS, 1915; HILL & THONGLONGYA, 1972). *Hesperoptenus tickelli* has previously been recorded from Nakai-Nam Theun in the central region of Lao PDR (Francis, pers comm.) and from Chiang Mai (YENBUTRA & FELTEN, 1987), Huai Kha Khaeng Wildlife Sanctuary (MCBEE *ET AL.*, 1986) and Nakhon Ratchasima (HILL & THONGLONGYA, 1972) in Thailand.

A systematic search for bat roosts around each study site resulted in the discovery of 15 roosts of 7 species: *T. theobaldi*, *M. lyra*, *M. spasma*, *R. acuminatus*, *H. pomona*, *H. cineraceus* and *H. larvatus*. Eleven of these were in hollow tree trunks, with the remainder in caves/rock shelters and a hollow log on the forest floor. The most frequently found was that of *M. spasma*. Nine were in the trunks of hollow trees, 7 of which were *L. calyculata*. *Megaderma spasma* is known to use a wide variety of roost sites including overhangs in earth banks (ROBINSON, 1990), caves (ROBINSON *ET AL.*, 1995) and culverts (ROBINSON & SMITH, 1997). *Rhinolophus acuminatus* was also found roosting in a hollow *L. calyculata* tree, as well as in a hollow log on the forest floor.

Hollow trees provide an important roosting resource for bats, particularly *L. calyculata*, which frequently become hollow with age. This species of tree is often found in areas of mixed deciduous forest in the Xe Pian NBCA. Cave roosts are a rare resource in Xe Pian, mainly due to its geology, being composed of Mesozoic sedimentary and intrusive igneous rocks (DUCKWORTH *ET AL.*, 1993). Three cave roosts were found, although these were only small, shallow structures which each contained up to approximately 700 bats of between 2 and 3 species. At Ban Nong Kae, *E. spelaea*, and at Ban Taong, *R. leschenaulti* and *R. amplexicaudatus* were caught in mist-nets. These are all species of bats which are known to roost only in caves, however, none of these species was present in the caves found. Also found living in the cave at Ban Taong were porcupines, *Atherurus macrourus*.

## Hunting

The hunting of bats for food, their supposed medicinal properties, or as curios, is widespread throughout much of Southeast Asia (LEKAGUL, & MCNEELY, 1977; DUANGKHAE, 1990; MARTIN, 1992; ROBINSON, 1994; ROBINSON, 1995; FRANCIS *ET AL.*, 1997a). A wide variety of catching techniques are used. Bats can be shot, knocked down with long flexible sticks, or caught by fishing hooks tied between trees or flown from kites. However, by far the most effective technique is the use of mist-nets. Unlike many areas of Southeast Asia, mist-nets are not widely available in Lao PDR, although they can be obtained in some of the larger cities.

There was no evidence of villagers from within the protected area hunting bats, and interviews with villagers revealed that bats were seldom caught for any reason. The villagers from Ban Taong said that they did not have the means to catch them, whereas at Ban Phon Visai, villagers said that bats did not taste good.

Despite bats not being directly hunted, they are affected indirectly by other practices such as the hunting of monitor lizards with dogs. The impact this has on bats depends upon the technique used to finally capture the lizard. When a lizard is chased by dogs, it often seeks refuge in a large hollow tree, which in areas of mixed deciduous forest is often *L. calyculata*. The lizard can be removed by one of three ways. The tree may be cut down; a fire may be lit in the base of the hollow trunk and the lizard is either killed by asphyxiation or is forced to leave the tree; or alternatively, a hole may be cut in the trunk with an axe to enable the lizard to be pulled out (Figure 6).

The cutting down of hollow trees is of obvious detriment, not only to bats currently roosting in the tree, but also by the resulting loss of a roost site. Although bats will roost in hollow logs lying on the forest floor, they are probably more vulnerable to predators there. Species that roost in hollow trees will not necessarily use logs lying on the ground. In a strip of forest dominated by *L. calyculata*, 200 m wide and 1 km long, along the Xe Khampho north of Camp 1, six of the largest (> 1 m diameter) hollow trees had been cut down in pursuit of monitor lizards.

The lighting of fires in hollow trees is just as likely to kill bats as monitor lizards, unless there is a hole higher up through which they can escape. Also, the fire will probably reduce the life expectancy of the tree and hence the availability of the roost site.

The least detrimental way villagers can retrieve a monitor lizard is by cutting a hole in the side of the trunk to grab the lizard and pull it out. This practice will probably have little effect on existing roost sites, although it will disturb any bats roosting within the tree at the time. Indeed, the hole may improve the site for bats. At Camp 1 a large (1.7 m diameter) *L. calyculata*, hollow from the base upwards, was found to be used as a roost by *R. acuminatus*. The bat had entered the hollow trunk through a hole that had been cut with an axe.

The types of hunting methods used to capture monitor lizards varied depending on the village. Villagers from Ban Nong Kae generally cut the tree down, whereas villagers from Ban Taong and Ban Phon Visai preferred to cut a hole in the tree or light a fire inside it.



## RECOMMENDATIONS

To formulate comprehensive and effective management plans for the conservation of Xe Pian's biodiversity, as well as that of other NBCAs in Lao PDR, it is vital that baseline data are obtained on the species present and their ecological requirements. In general, these requirements are poorly understood for bats over the whole of Southeast Asia.

Prior to this work little was known of the bats in Xe Pian; indeed, this is the first study of bats in the area. The present work not only provided information on the bats in the NBCA, but also recorded three species not previously found in Lao PDR.

In a non-limestone region such as Xe Pian, cave roosts are a limited resource, and so many species of bat will depend on trees with hollow cavities and fissures for roost sites. Also, quality forest will be important for foraging, not only for bats, but also many other animals. Xe Pian contains large areas of mature, relatively undisturbed, forest within its boundary. However, there are places where timber has been removed by local people or commercial companies. The removal of any timber by commercial companies within the NBCA should be prohibited, and the clearance of forest areas by local people for agriculture, and cutting of large trees for timber, should be controlled.

Most of the villagers living in Xe Pian grow crops and hunt at a subsistence level. There appears to be little hunting of bats, although rodents and larger mammals are caught for food. It would be unrealistic to try and prevent local people from hunting; as it probably provides an important source of protein to the diet. However, only people living within the NBCA should be allowed to hunt and the use of certain techniques such as guns and mist-nets, and the killing of certain species, should be prohibited or controlled. For example, people should be dissuaded from cutting down or burning trees to hunt monitor lizards. If hunters are encouraged instead to cut holes in hollow trees, then this practice would have little impact on roost sites. Also, wildlife caught in the protected area should be for local consumption only.

The introduction of wildlife protection regulations/laws would be useless without a large scale education program. This would need to be targeted at all levels of the community, from young school children to the elders of the villages.

Although the present survey provided valuable information on the distribution and ecology of many species of bat in the NBCA, there is clearly a need for further work, particularly to investigate in more detail their ecological requirements, so that suitable habitats can be maintained to ensure their continued survival within the protected area.

## ACKNOWLEDGMENTS

This project was funded by the Global Environment Facility (GEF) through the World Bank to the Government of Lao PDR, and from the Lao government through a contract with Burapha Development Consultants sub-contracted to WWF-Thailand.

A vital aspect of the project was the support received from the staff of the Lao PDR Department of Forestry. In particular I would like to thank Bouahong Phanthanousy, National Project Director of the Forest Management and Conservation Project (FOMACOP),

for permission to work in Lao PDR and for organising the Lao PDR component of the project; Bouaphanh Phantavong (FOMACOP, Deputy National Project Director); and Wesoot (Chief of Xe Piane NBCA). Also, I would like to thank the staff of the World Wide Fund for Nature–Thailand, in particular Robert Mather (Lao PDR Biodiversity Project, Team Leader) and Robert Steinmetz (Field Co-ordinator), and Bruce Jefferies (FOMACOP) for organising and ensuring the smooth running of the project. Assistance in the field was gratefully received from fellow field workers Budsabong Kanchanasaka (Royal Forest Department–Thailand), Tanya Chan-Ard (RFD-T), Siripong Thonongto (WWF-T), Golam Monowar Kamal (WWF-T), Bruce Jefferies (FOMACOP) who oversaw the export of specimens collected during the project, and Jens Klackenbergh (Natur Historiska Riksmuseet, Sweden) who identified bat-associated trees.

Villagers from Ban Nong Kae, Ban Taong and Ban Phon Visai provided excellent field support, for which I am very grateful. In particular I would like to thank the headman of Ban Nong Kae, Souk Geohongsa (Ban Taong headman), Sem and Song Geohongsa and Bin Bontan from Ban Taong, and Ki Vongvilath, Kho and Souk from Ban Phon Visai for their help and companionship.

I am very grateful for the help of Ian Baird and Robert Steinmetz who, through their translation of Lao to English, allowed villagers to be questioned about their hunting practices and knowledge of bats. Golam Monowar Kamal kindly provided me with co-ordinates of the study areas.

I would like to thank Angela L. Smith for assistance with identification of rodent skulls and for comments on the manuscript.

#### REFERENCES

- BERKMULLER, K., S. SOUTHAMMAKOTH AND VENE VONGPHET. 1995. *Protected area system planning and management in Lao PDR: Status report to mid 1995*. unpublished report to Lao-Swedish Forestry Co-operation Programme, Vientiane.
- CORBET, G.B. AND J.E. HILL. 1992. *The Mammals of the Indomalayan Region*. Natural History Museum Publications, Oxford Univ.
- COX, R., S. SIVANNAVING AND L. KHAMPHAY. 1991. Report of a survey for kouprey and other wild cattle in the southern Lao P.D.R. provinces of Champassak and Attapeu. Unpublished report to the Kouprey Conservation Trust.
- DEUVE, D. 1972. *Les Mammifères Du Laos*. Ministère De L'Éducation Nationale, Vientiane.
- DUANGKHAE, S. 1990. Ecology and behaviour of Kitti's hog-nosed bat (*Craseonycteris thonglongyai*) in western Thailand. *Nat. Hist. Bull. Siam Soc.* 38: 135–161.
- DUCKWORTH, W., T. EVANS AND R. TIMMINS. 1993. *A wildlife and habitat survey of Xe Piane National Biodiversity Conservation Area*. Unpublished draft report for the Lao-Swedish Forestry Cooperation Programme.
- DUCKWORTH, J.W., R.J. TIMMINS, R.C.M. THEWLIS, T.D. EVANS AND G.Q.A. ANDERSON. 1994. Field observations of mammals in Laos, 1992–1993. *Nat. Hist. Bull. Siam Soc.* 42: 177–205.
- DUCKWORTH, J.W., R.J. TIMMINS, G.Q.A. ANDERSON, R.M. THEWLIS, E. NEMETH, T.D. EVANS, M. DVORAK AND K.E.A. COZZA. 1995. Notes on the status and conservation of the gibbon *Hylobates (nomascus) gabriellae* in Laos. *Tropical Biodiversity* 3: 15–27.
- FRANCIS, C.M., K. KHOUNBOLINE AND N. ASPEY. 1996. *Report on 1996 survey of bats and small mammals in the Nakai-Nam Theun NBCA and nearby areas*. Unpublished report, Wildlife Conservation Society, New York.
- FRANCIS, C.M., A. GUILLEN AND C. VONGKHAMHENG. 1997a. *Survey of bats and small mammals in Dong Amphan NBCA and nearby areas*. Unpublished report, Wildlife Conservation Society, New York.

- FRANCIS, C.M., A. GUILLEN AND C. VONGKHAMHENG. 1997b *Preliminary survey of bats in Dong Hua Sao NBCA*. Unpublished report, Wildlife Conservation Society, New York.
- HILL, J.E. AND K. THONGLONGYA. 1972. Bats from Thailand and Cambodia. *Bull. British Mus. Nat. Hist. (Zool.)* 22: 171–196.
- LEKAGUL, B. AND J.A. MCNEELY. 1977. *Mammals of Thailand*. Association for the Conservation of Wildlife, Bangkok.
- MARTIN, E.B. 1992. The trade and use of wildlife products in Laos. *Traffic Bulletin* 13: 23–28.
- MCBEE, K., J.W. BICKHAM, S. YENBUTRA, J. NABHITABHATA AND D.A. SCHLITTER. 1986. Standard karyology of nine species of vespertilionid bats (Chiroptera: Vespertilionidae) from Thailand. *Annals of Carnegie Museum* 55: 95–116.
- PHILLIPS, C.J. 1967. A collection of bats from Laos. *J. Mammal.* 48: 633–636.
- ROBINSON, H.C. AND KLOSS, C.B. (1914). On a collection of mammals from the Siamese province of Bandon, N.E. Malay Peninsula. *Journal Fed. Malay St. Mus.* 5: 111–127.
- ROBINSON, M.F. (1990). Project Barito Ulu Chiroptera survey, February–April 1989. *Bat Research News*, 31: 21–23.
- ROBINSON, M.F. (1994). Observations on the wildlife trade at the daily market in Chiang Khan, Northeast Thailand. *Nat. Hist. Bull. Siam Soc.* 42: 117–120.
- ROBINSON, M.F. (1995). The sale of bats as souvenirs in Thailand. *Bat News* 38: 5.
- ROBINSON, M.F. A.L. SMITH AND S. BUMRINGSRI. 1995. Small mammals of Thung Yai Naresuan and Huai Kha Khaeng Wildlife Sanctuaries, in western Thailand. *Nat. Hist. Bull. Siam Soc.* 43: 27–54.
- ROBINSON, M.F. AND A.L. SMITH. 1997. Chiroptera from Loei Province North-East Thailand. *Nat. Hist. Bull. Siam Soc.* 45: 1–16.
- ROOKMAAKER, L.C. AND W. BERGMANS. 1981. Taxonomy and geography of *Rousettus amplexicaudatus* (Geoffroy, 1810) with comparative notes on sympatric congeners (Mammalia, Megachiroptera). *Beaufortia* 31: 1–29.
- STEINMETZ, R. AND I. BAIRD. 1996. *Field notes from a participatory biodiversity assessment of Xe Pian National Biodiversity Conservation Area, Champassak, Lao PDR*. Unpublished report.
- YENBUTRA, S. AND H. FELTEN. 1987. Bat species and their distribution in Thailand according to the collections in TISTR and SMF. Pages 9–45 in H. Felten (Ed.) *Contributions to the Knowledge of the Bats of Thailand*. Cour. Forsch.-inst. Senckenberg, 87.