A checklist of bats from Cambodia, including the first record of the intermediate horseshoe bat *Rhinolophus affinis* (Chiroptera: Rhinolophidae), with additional information from Thailand and Vietnam

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មូលន័យសង្ខេប

នៅចន្លោះឆ្នាំ១៩៩៩និង២០១១ ប្រភេទ *Rhinolophus affinis* ត្រូវបានគេប្រមូលនៅទីតាំងបួនកន្លែងនៃភាគខាងជើងប្រទេសកម្ពុជា។ នេះគឺជាឯកសារកំណត់ត្រាដំបូងនៃសត្វប្រចៀវក្រចកជើងសេះពីប្រទេសកម្ពុជា និងធ្វើឲ្យចំនួនប្រភេទសត្វប្រចៀវរកឃើញនៅប្រទេសកម្ពុជាកើនឡើងរហូតដល់៥០ប្រភេទ ដែលបញ្ជីឈ្មោះប្រភេទត្រូវបានផ្តល់ជូន។ ទិន្នន័យថ្មីៗត្រូវបានគេផ្តល់ជូនអំពីលក្ខណៈសំលេង និងអេកូឡូស៊ីរបស់ *R. affinis* នៅក្នុងប្រទេសកម្ពុជា ថៃ និងវៀតណាម និងអំពីរបាយរបស់វាក្នុងតំបន់ដីគោកនៃអាស៊ីអគ្នេយ៍។

Abstract

Between 1999 and 2011, *Rhinolophus affinis* was collected from four localities in northern Cambodia. These are the first documented records of the intermediate horseshoe bat from this country and increase the number of bat species known from Cambodia to 50, a list of which is provided. New data are provided on the acoustic characteristics and ecology of *R. affinis* in Cambodia, Thailand and Vietnam, and on its distribution in mainland Southeast Asia.

Keywords

Acoustics, Cambodia, distribution, ecology, *Rhinolophus affinis*, species list.

Introduction

Until recently there had been little bat research in Cambodia. A preliminary checklist was published by Kock (2000) and this was updated by Hendrichsen *et al*. (2001) who included 10 new country records resulting from a field survey conducted by Fauna & Flora International in Phnom Samkos Wildlife Sanctuary (Daltry & Momberg, 2000a,b). Further records were added by Matveev (2005) who collected specimens between 2000 and 2002 in a variety of locations, mostly in the north-eastern and south-western parts of the country. Other *ad hoc* field studies led to some additions to the bat fauna including: two species new to science, *Murina harrisoni* Csorba & Bates, 2005 and *Kerivoula titania* Bates *et al*., 2007; others that were rare and/or little known such as *Otomops wroughtoni* (Walston & Bates, 2001) and *Kerivoula kachinensis* (Soisook *et al*., 2007); and one that resulted from a taxonomic revision, *Rhinolophus microglobosus* (Soisook *et al*., 2008). Ith *et al*. (2011) clarified the status of *R. shameli*. Today, based on the literature cited above and including the current paper, the known bat fauna of Cambodia has reached 50 species, of which eight are *Rhinolophus* species (horseshoe bats): *Rhinolophus acuminatus*; *R. affinis, R. chaseni, R. luctus, R. malayanus, R. microglobosus, R. pusillus* and *R. shameli* (Table 1).

In contrast, there have been 190 years of bat research in Thailand and 126 species have been recorded from that country (Bumrungsri *et al*., 2006; Thong *et al*., 2006; Bates *et al*., 2007; Soisook *et al*., 2007, 2008, 2010; Wu *et al*., 2009; Douangboupha *et al*., 2010), including 21 species of *Rhinolophus*: *R. acuminatus, R. affinis, R. beddomei, R. coelophyllus, R. lepidus, R. luctus, R. macrotis, R. malayanus, R. microglobosus, R. marshalli, R. megaphyllus, R. paradoxolophus, R. pearsonii, R. pusillus, R. shameli, R. siamensis, R. stheno, R. thailandensis, R. thomasi, R. trifoliatus* and *R. yunanensis*.

In Vietnam, Hendrichsen *et al*. (2001) recognised 85 species of bats for which there were confirmed records. However, with as many as 110 species subsequently listed by Can *et al*. (2008), the total number reliably recorded is not clear and needs further revision, particularly in relation to taxa that have been misidentified (Thong, 2011). On the basis of Csorba *et al*. (2003), Thong *et al*. (2006), Soisook *et al*. (2008), Francis (2008) and Furey *et al*. (2009), 16 species of *Rhinolophus* are known from Vietnam: *R. affinis, R. chaseni, R. luctus, R. malayanus, R. megaphyllus, R. macrotis, R. marshalli, R. microglobosus, R. paradoxolophus, R. pearsonii, R. pusillus, R. shameli, R. sinicus, R. stheno, R. thomasi* and *R. yunanensis*. A further three, *R. rouxii, R. siamensis* and *R. subbadius*, were included for Vietnam by Simmons (2005), but their status remains unclear. Following Francis (2008), specimens previously referred to *R. borneensis* by Csorba *et al*. (2003) are here included in *R. chaseni*.

In Thailand and Vietnam, the intermediate horseshoe bat, *Rhinolophus affinis* Horsfield, 1823, is a common and widespread species (Fig. 1), but its status in Cambodia has been unclear. Some authors, such as Corbet & Hill (1992) and Francis (2008), included the species throughout the country on distribution maps without explanation. Others, such as Kock (2000) and Hendrichsen *et al*. (2001), specifically rejected its inclusion because of the lack of supporting evidence; a view followed by Csorba *et al*. (2003) and Simmons (2005).

This paper presents the first documented evidence for the presence of *R. affinis* in Cambodia, summarises the diagnostic characters of this species in Cambodia, provides new information on its echolocation and ecology in Cambodia, Thailand and Vietnam and maps its distribution in mainland Southeast Asia.

Methods

The new data from Cambodia result from a series of short surveys. These were conducted by Joe Walston of the Wildlife Conservation Society in Preah Vihear Province, northern Cambodia (March, 1999; August and December, 2000); by Annette Olsson in Virachey National Park, Northeast Cambodia (June, 2006); by Ben Hayes, Phauk Sophany and Phen Sarith in Phnom Kulen National Park, Northwest Cambodia (November, 2009; April, June and July, 2010); and by Neil Furey, Ith Saveng and Gabor Csorba in Preah Vihear Protected Forest, northern Cambodia (February, 2011). New data on the distribution and ecology of this species in Thailand are based on field research carried out primarily between 2003 and 2007 by the bat team of the Prince of Songkla University, Thailand, in conjunction with colleagues from the National University of Laos, Lao PDR, and the Royal University of Phnom Penh, Cambodia. New data from Vietnam were collected on a series of field surveys between 2005 and 2010 by Vu Dinh Thong.

For the field surveys undertaken in Cambodia, Thailand and Vietnam, bats were captured from caves and forests using a combination of hand nets, four bank harp

Table 1 Bat species currently recognised in the peer-reviewed literature for Cambodia. Status follows IUCN (2011) for species that have been evaluated: LC = Least Concern; NT = Near Threatened; DD = Data Deficient.

Family/ Species	IUCN status	First record
Pteropodidae		
Cynopterus brachyotis	LC	Matveev (1999)
Cynopterus sphinx	LC	Kock ((2000))
Eonycteris spelaea	LC	Kock (2000)
Macroglossus sobrinus	LC	Kock (2000)
Megaerops niphanae	LC	Klein (1971)
Pteropus hypomelanus	LC	Kock (2000)
Pteropus lylei	LC	Dobson (1880)
Rousettus amplexicaudatus	LC	Kock (2000)
Rousettus leschenaultii	LC	Kock (2000)
Emballonuridae		
Taphozous longimanus	LC	Kock (2000)
Taphozous melanopogon	LC	Kock (2000)
Taphozous theobaldi	LC	Matveev (2005)
Megadermatidae		
Megaderma lyra	LC	Kock (2000)
Megaderma spasma	LC	Kock (2000)
Rhinolophidae		
Rhinolophus acuminatus	LC	Kock (2000)
Rhinolophus affinis	LC	This paper
*Rhinolophus chaseni**	LC	Hill & Thonglongya (1972)
Rhinolophus luctus	LC	Hendrichsen *et al*. (2001)
Rhinolophus malayanus	LC	Kock (2000)
Rhinolophus microglobosus	LC	Soisook *et al*. (2008)
Rhinolophus pusillus	LC	Matveev (2005)
Rhinolophus shameli	LC	Kock (2000)
Molossidae		
Chaerephon plicata	LC	Yoshiyuki (1966)
Otomops wroughtoni	DD	Walston & Bates (2001)
Hipposideridae		
Hipposideros armiger	LC	Kock (2000)
Hipposideros cineraceus	LC	Matveev (2005)
Hipposideros galeritus	LC	Matveev (2005)
Hipposideros larvatus	LC	Klein (1969)
Hipposideros pomona	LC	Kock (2000)
Vespertilionidae		
Arielulus circumdatus	LC	Hendrichsen *et al*. (2001)
Harpiocephalus harpia	LC	Matveev (2005)
Hesperoptenus blanfordi	LC	Hendrichsen *et al*. (2001)
Hesperoptenus tickelli	LC	Hendrichsen *et al*. (2001)
Kerivoula hardwickii	LC	Kock (2000)
Kerivoula kachinensis	LC	Soisook *et al*. (2007)
Kerivoula papillosa	LC	Kock (2000)
Kerivoula titania	LC	Bates *et al*. (2007)
Murina harrisoni	DD	Csorba & Bates (2005)
Myotis annectans	LC	Hendrichsen *et al*. (2001)
Myotis hasseltii	LC	Kock (2000)
Myotis muricola	LC	Matveev (1999)
Myotis rosseti	LC	Oey (1951)
Pipistrellus coromandra	LC	Hendrichsen *et al*. (2001)
Pipistrellus tenuis	LC	Kock (2000)
Scotophilus heathii	LC	Hendrichsen *et al*. (2001)
Scotophilus kuhlii	LC	Kock (2000)
Tylonycteris pachypus	LC	Hendrichsen *et al*. (2001)
Tylonycteris robustula	LC	Hendrichsen *et al*. (2001)
Miniopteridae		
Miniopterus schreibersii	NT	Matveev (2005)
Miniopterus sp.	n/a	Matveev (2005)

* As *R. borneensis*.

traps (Francis, 1989) and mist nets. Voucher specimens were preserved in 70% ethanol.

In Cambodia and Thailand, time-expanded (x10) echolocation calls were recorded from hand-held bats using D 240x utrasound detectors (Pettersson Elektronik, Sweden), stored using digital recorders and analysed with Batsound software (version 3.31, Pettersson Elektronik, Sweden). In Vietnam, real time recordings of calls were collected from hand-held bats with custom-made equipment (PC Tape, University of Tübingen, Germany) at a sampling rate of 480 kHz. For every bat, the selected sound sequence was analysed and displayed using Selena software (University of Tübingen, Germany). Acoustic data reported in this paper refer to the frequency of maximum energy (FMAXE). In Cam-

bodia and Thailand, FMAXE was extracted from spectograms using 1024 samples Fast Fourier Transform (FFT) with a Hanning window. The Constant Frequency (CF) portions of at least five calls from each individual were analysed.

Morphological measurements were taken with a digital calliper. They included: FA: forearm length from the extremity of the elbow to the extremity of the carpus with the wings folded; TAIL: tail length from the tip of the tail to its base adjacent to the anus; TIBIA: tibia length from the knee joint to the extremity of the heel behind the os calcis; FOOT: foot length from the extremity of the heel behind the os calcis to the extremity of the longest digit, not including the hairs or claws; EAR: ear length from the lower border of the external auditory meatus to the tip of the pinna; 3MT, 4MT, 5MT: third, fourth and fifth metacarpal lengths, respectively, from the extremity of the carpus to the distal extremity of the third, fourth and fifth metacarpals, respectively; 3D1P, 3D2P: lengths of the first and second phalanges, respectively, of the third digit; 3D1P/33D2P: length of the second phalanx of the third digit divided by the length of the first phalanx, relative to its metacarpal; SL: skull length from the projecting posterior part of the skull to the anterior alveolus of the canine; CCL: condylo-canine length from the exoccipital condyle to the anterior alveolus of the canine; ZB: zygomatic breadth – the greatest width of the skull across the zygomata; MW: mastoid width – the greatest distance across the mastoid region; PC: postorbital constriction – the narrowest width across the constriction posterior to the orbits; C-M^3: upper toothrow length from the front of the upper canine to the back of the crown of the third upper molar; M^3-M^3: posterior palatal width taken across the outer borders of the third upper molar; C^1-C^1: anterior palatal width taken across the outer borders of the upper canine; PL: length of the bony palate; PL/C-M^3x 100: palatal length divided by upper toothrow length multiplied by 100; C-M_3: lower toothrow length– from the front of the lower canine to the back of the crown of the third lower molar; ML: mandible length from the most posterior part of the condyle to the most anterior part of the mandible, including the lower incisors.

Results

Systematics

Rhinolophus affinis

Intermediate horseshoe bat

Rhinolophus affinis Horsfield, 1823 [1821-1824]: (6), pl.; figs a,b; Java; (lectotype [BMNH 79.11.21.70] designated by Csorba *et al*., 2002, deposited in the Natural History Museum, London).

Rhinolophus a. macrurus Andersen, 1905: 103; Taho, 'Karennee', SE Myanmar.

Rhinolophus a. superans Andersen, 1905: 104; Pahang, Malaysia.

Diagnostic characters: *Rhinolophus affinis* is a medium-sized horseshoe bat (FA= 45.1-51.3 mm, Table 2; all observations and measurements based on material from Cambodia). The ears are not greatly enlarged. In the noseleaf, the lancet is straight-sided with a pointed tip; the connecting process, in lateral view, is rounded and typical of the *megaphyllus* group (*sensu* Csorba *et al*., 2003); and the sella is slightly concave (Fig. 2). In the wing, the second phalanx of the third digit is long, usually more than x1.7 the length of the first phalanx. The fifth metacarpal is longer than the third and fourth. The tibia, on average, slightly exceeds the length of the tail. Pelage colour is variable, ranging from mid- to orange-brown; the belly is slightly paler than the back. In the single baculum we examined from Cambodia, the shaft was thin and curved ventrally, the base had a deep notch and was expanded, and the total length was 2.3 mm (Fig. 3). This is slightly longer than for three specimens from India included in Thomas (1997) which averaged 1.8 mm in length, with a range of 1.5 to 2.1 mm.

The skull is robust (SL= 21.5-23.7 mm, Table 2); the zygomata exceed the mastoids in width. In the rostrum, the anterior median compartments are not greatly inflated and are only slightly superior to the posterior ones when viewed in lateral profile (Fig. 4). The sagittal crest is variably developed. The frontal depression is bordered by well-defined ridges. The bony palate is short, averaging about one quarter of the upper toothrow length (PL/C-M^3x100 = 22.4-26.3). In the dentition, the upper canine is usually well developed. In contrast, the first upper premolar (P^2) is minute, situated in the toothrow or slightly displaced internally. The canine and the second (large) premolar (P^4) are not in contact. In the

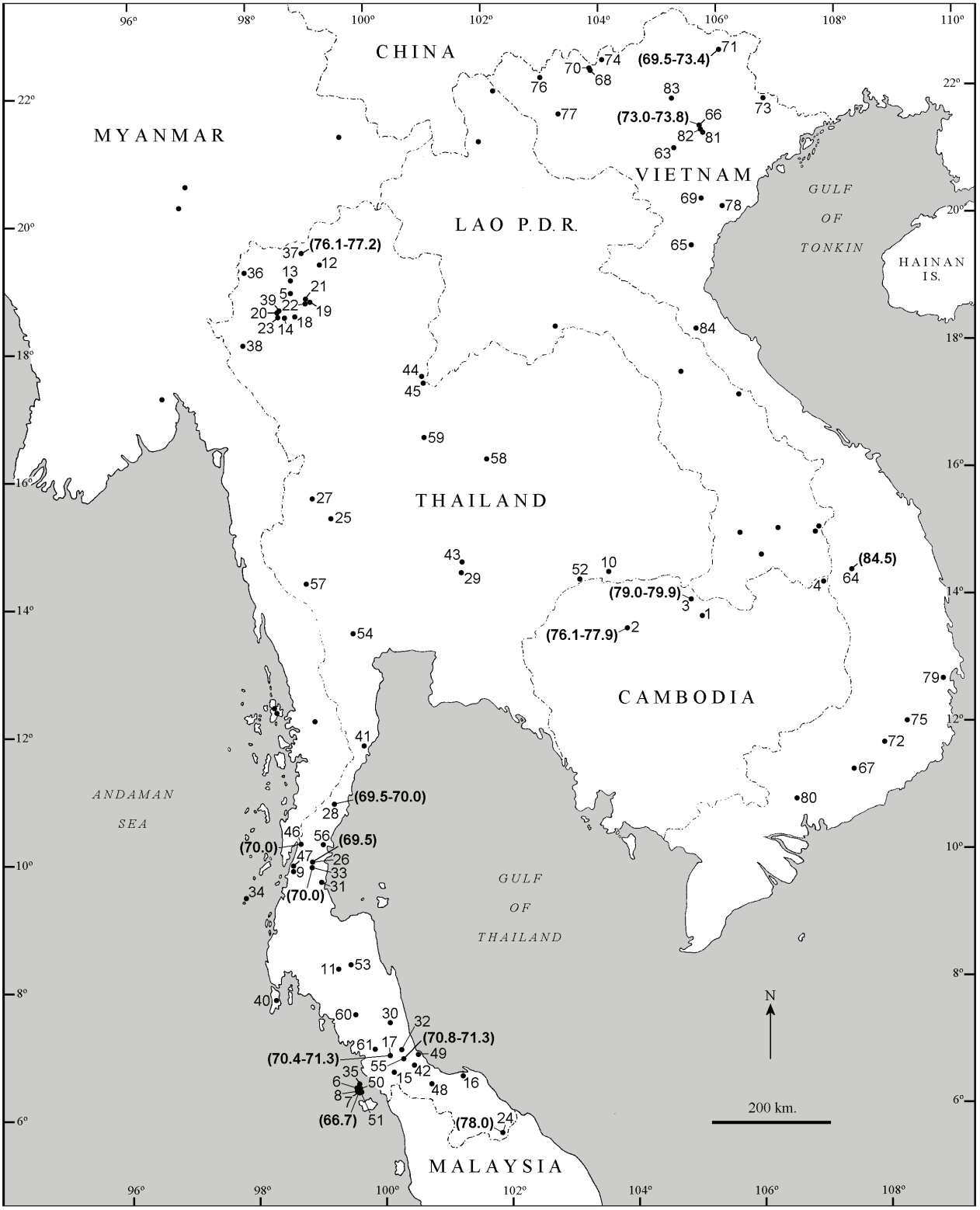

Fig. 1 Distribution of *Rhinolophus affinis* in mainland Southeast Asia, excluding Malaysia. Localities for Cambodia, Thailand, and Vietnam are based on data in Appendix 1; for Myanmar and Laos are based on references listed in 'Conservation status and distribution'. Figures in bold (in parentheses) are FMAXE readings in kHz for specimen(s) from the particular locality

Table 2 External, cranial, and dental measurements (in mm) and echolocation frequency (in kHz) of *Rhinolophus affinis* from Cambodia, for the definitions see the Methods section. Measurements are presented as mean, standard deviation, minimum-maximum, and number of specimens. Sample sizes are in parentheses when different to *n*.

External measurements													
n	sex	FMAXE	FA	TAIL	TIBIA	FOOT	EAR	3MT	4MT	5MT	3D1P	3D2P	3D2P/ 3D1P
11	♂	77.2, 1.0	48.0, 1.5	22.7, 1.1	22.9, 0.5	9.4, 0.6	18.4, 1.3	37.0, 0.9	37.8, 1.0	38.8, 1.2	13.8, 0.8	24.7, 0.9	1.79, 0.10
		76.1-79.0 (7)	45.1-50.0	20.2-24.1	22.1-23.9	8.5-10.7	16.7-20.9	35.9-39.0	36.3-40.0	37.0-41.0	12.5-15.1	23.0-26.1	1.68-2.00
3	♀	79.9	48.2, 2.8	21.6, 3.1	22.6, 2.5	9.2, 1.1	19.9, 2.9	37.3, 0.8	38.3, 1.3	38.9, 2.5	14.5, 0.6	25.2, 2.2	1.74, 0.09
		(1)	46.1-51.3	18.8-25.0	21.8-23.8	8.0-10.0	17.0-22.8	36.5-38.0	37.0-39.7	37.3-41.8	13.9-15.2	22.7-26.9	1.63-1.80
Cranial and dental measurements													
n	sex	SL	CCL	ZB	MW	PC	C-M^3	M^3-M^3	C^1-C^1	PL	PL/C-M^3x100	C-M_3	ML
11	♂	22.9, 0.7	19.4, 0.5	11.1, 0.3	10.4, 0.2	2.2, 0.1	9.0, 0.1	8.5, 0.3	6.0, 0.3	2.2, 0.1	24.3, 1.5	9.5, 0.3	15.8, 0.3
		21.8-23.7	18.4-20.0	10.8-11.6 (10)	10.2-10.8 (10)	2.0-2.5	8.7-9.2	8.2-8.9	5.5-6.4	2.0-2.5	22.4-26.3	8.9-9.9	15.2-16.1
3	♀	22.0, 0.5	19.2, 0.3	10.7, 0.0	10.2, 0.3	9.5, 0.4	8.8, 0.2	8.4, 0.3	5.9, 0.3	2.2, 0.1	24.8, 1.2	9.2, 0.3	15.3, 0.5
		21.5-22.5	18.9-19.6	10.7-10.8	10.0-10.5	9.1-9.8	8.6-9.0	8.1-8.7	5.6-6.1	2.1-2.3	23.8-26.2	9.0-9.5	14.8-15.9

lower toothrow, the second premolar (P_3) is minute; in all the material examined from Cambodia, it is extruded or partially displaced externally.

Echolocation

Every call of *Rhinolophus affinis* comprises an initial upward Frequency Modulated (FM) component, followed by a CF component, and ending with a downwards FM component. In Cambodia, FMAXE ranged from 76.1 to 79.9 kHz (Table 2). This is essentially similar to calls of *R. affinis* from northern Thailand and Laos (70.0 to 76.1 kHz) (Fig. 1) (Francis, 2008). It is in contrast to individuals from Peninsular Thailand to the north of 7°00'N which have a lower frequency, ranging from 66.7 to 71.3 kHz. However, one record from Hala-Bala Wildlife Sanctuary, Narathiwat, to the south of this latitude, is 78.0 kHz, which is comparable to those obtained in Peninsular Malaysia (77.0 to 78.0 kHz) (Francis, 2008). In Vietnam, FMAXE ranged between 69.5 and 73.8 kHz for *R. affinis* collected in the north of the country (Furey *et al*., 2009; Thong, 2011). One further individual provisionally assigned to this species from central Vietnam had a higher frequency of 84.5 kHz (Thong, 2011).

Taxonomic variation

Based on current understanding, specimens from Thailand north of the peninsula, Cambodia and Vietnam are provisionally referred to *R. a. macrurus* Andersen, 1905, which was described from eastern Myanmar. Those from Peninsular Thailand, on account of their average larger size, are referable to *R. a. superans* Andersen, 1905, which was described from Pahang in Malaysia.

Ecology

In Cambodia, *R. affinis* was collected in February, 2011 in dry dipterocarp and semi-evergreen forest at an elevation of 110 metres in Preah Vihear Protected Forest. It was also found in forest areas in Phnom Kulen National Park in April, June, July and November at elevations ranging from 80 to 177 metres. Of the four specimens collected from Virachey National Park in June, two were

Fig. 2 *Rhinolophus affinis.* PSUZC-MM2006.117, ♂, Khao Kram, Pathiew, Chumphon Province, Thailand (not to scale). (© Pipat Soisook).

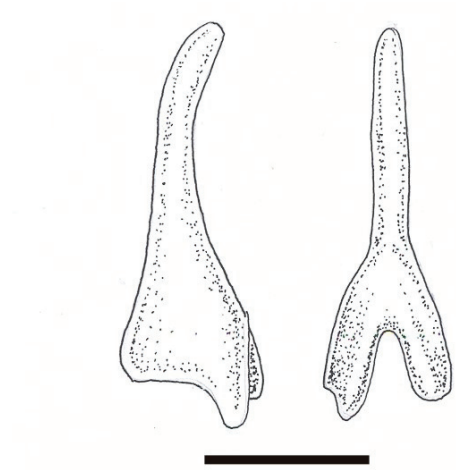

Fig. 3 Baculum of *Rhinolophus affinis.* HZM.76.39872, ♂, Virachey National Park, Cambodia. Scale = 1 mm

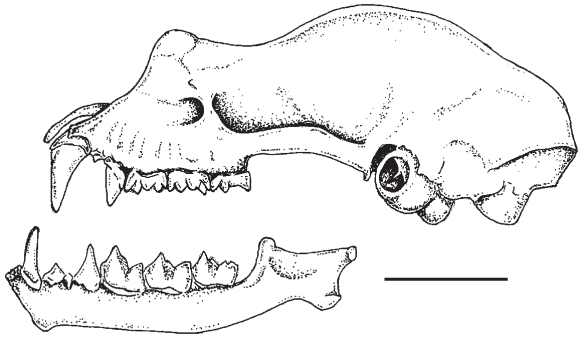

Fig. 4 Lateral view of the skull of *Rhinolophus affinis*. HZM.77.39873, ♀, Virachey National Park, Cambodia. Scale = 5 mm.

subadults, based on the unfused epiphyses of their wing bones. In Thailand, *R. affinis* is an adaptable species that has been found in the following forest types: deciduous, bamboo, dry evergreen, mixed deciduous, hill evergreen and dipterocarp. It is also frequently found in agricultural areas, including orchards and rubber plantations, and is often observed roosting in limestone caves. In Vietnam, *R. affinis* is found almost throughout the country, including mountainous areas. It frequently roosts in limestone caves and inhabits tunnels, and has been recorded foraging within various vegetation types ranging from degraded to primary forests. The species is commonly found in medium-sized colonies of up to approximately 400 individuals (Vu Dinh Thong, pers. obs.). In a detailed study in Kim Hy Nature Reserve, northern Vietnam, it was most

commonly found in disturbed forest, which according to Furey *et al*. (2010), it frequents more often than primary forest, agricultural land or degraded forest.

Distribution and conservation status

Rhinolophus affinis is currently known from India (including the Andaman Islands), Nepal to southern China, mainland Southeast Asia, Borneo and the Lesser Sunda Islands (Simmons, 2005). Its distribution in Cambodia (Fig. 1) is based on the new material listed in Appendix 1. Localities in Thailand and Vietnam are based on new material and literature records (Appendix 1), localities in Myanmar are from Bates *et al*. (2004) and the collections of the Harrison Institute, UK, and those in Laos are from Francis *et al*. (1996); Francis *et al*. (1997); Francis & Khoonmy (1998); Francis *et al*. (1999), Ruedi & Kirsch (2005) and the collections of Muséum National d'Histoire Naturelle, Paris, France.

This species is currently listed by IUCN as Least Concern (Walston *et al*., 2008), although Francis *et al*., (1999) suggested this species could be potentially at risk in Laos because of human hunting pressure.

Discussion

Rhinolophus affinis is currently considered to be a common and widespread species, albeit one that exhibits considerable variation in size. The taxonomic significance of this intraspecific variation is not clearly understood (Andersen, 1907; Bergmans & van Bree, 1986; Csorba *et al*., 2003). The echolocation data presented in this study also show considerable intraspecific variation and, again, the significance of this is not clear.

Perhaps, as Soisook *et al*. (2008) observed in their study of *R. stheno*, this variation is indicative of the presence of cryptic species. However, as Soisook *et al*. (2008) also observed for *R. malayanus* and Thabah *et al*. (2006) for the intermediate leaf-nosed bat *Hipposideros larvatus*, acoustic differences are not always good indicators of speciation or evolutionary history. It is clear that further research evaluating geographical variation in echolocation, morphometrics and genetics within *R. affinis* in mainland Southeast Asia would be of considerable interest, especially in the light of recent studies by Francis *et al*. (2010) which show that widespread taxa display considerable geographic variation in their DNA barcode sequences.

In terms of bat species diversity, data from Thailand and Vietnam suggest that there is still considerable scope for discovering new country records and possibly undescribed taxa in Cambodia. In particular, detailed surveys in the Southern Annamite montane rainforests of Northeast Cambodia, the Central Indochina dry forests of north-western Cambodia and the Cardamom Mountains rainforests of south-western Cambodia would be of interest.

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Appendix 1

Numbers in [ ] refer to localities on Fig. 1. Collection codes: HZM = Harrison Institute; CSO, CBC = Zoological Museum, Royal University of Phnom Penh; PSU, MM = Zoological Collections, Prince of Songkla University.

Material: Cambodia: Preah Vihear Province: M'Lou Prey (13°48'N 105°17E) [1]; 2♂, 1♀ (HZM.25. 34147; HZM26.34175; HZM.27.34176); Preah Vihear Protected Forest (14°04'N 105°17'E) [3]; 1♂, 1♀ (CSOCA220; CBC01233); Ratanakiri Province: Virachey National Park (14°21'N 107°22'E) [4]; 1♂, 3♀ (HZM.75.39871; HZM.76.39872; HZM.77.39873; HZM.78.39874); Siem Reap Province: Phnom Kbal Spean, Banteay Srei District, Phnom Kulen National Park (13°40'N 104°01'E) [2]; 7♂ (CBC00587; CBC00927; CBC00942; CBC00943; CBC00947-949).

Material: Thailand: Chiang Mai Province: Mae Ja cave, Chiang Dao Wildlife Sanctuary, Chiang Dao District (19°31'55" N 98°50'26"E; 864 m a.s.l) [37]; 3♂, 3♀ (PSUZC-MM2005.105; 111; 119; 120; 121; 122); Tak Province: Kavackee, East Thung Yai Naresuan Wildlife Sanctuary (15°42'26''N 98°59'28''E) [27]; 1♂ (PSUZC-MM2005.85); Loei Province: Phu Suan Sai National Park, Na Haeo District (17°30'19"N 100°56'18"E, 620 m, 975 m a.s.l) [44, 45]; 3♂ (PSUZC-MM2006.108-110); Thung Sa Lang Luang National Park, Nhong Mae Na (16.34'17''N 100.52'35''E) [59]; 1♀ (PSU-M05.107); Chaiyapum Province: Thung Kamang, Phukieo Wildlife Sanctuary, Khon San District (16°18'N 101°52'E) [58]; 1♀ (PSUZC-MM2005.86); Surin Province: Ta Muen Thom, Huai Thap Than-Huay Sumran Wildlife Sanctuary (14°21'08''N 103°15'54''E) [52]; 1♂(PSU-M05.82); Chumphon Province: Khao Kram cave, Patiew District (10°55'08"N 99°22'26"E, 67 m a.s.l) [28]; 3♂, 3♀ (PSUZC-MM2006.113-118); Huay Wang Cave, T. Khao Talu, Sawi District (10°10'00''N 98°55'11''E) [26]; 1♂ (PSU-SB070110.4); Klao Plu Cave, Lamae District (09°43'36''N 99°06'30''E) [31]; 1♂ 1♀ (PSU-SB070109.4); Pra Kayang Cave, T. Lum Lieng, A. Kraburi (10°19'34''N 98°45'55''E) [46]; 1♀ (PSU-SB070113.6); Ranong Province: Knad Dai Cave, A. La-Aun (10°01'55''N 98°55'11''E) [33]; 1♀ (PSU-SB070112.13); Satun Province: Wang Saithong waterfall, Manang District (07°05'25"N 99°54'35"E) [61]; 1♀ (PSUZC-MM2006.84); Boripatr Waterfall, Ton Nga-chang Wildlife Sanctuary (07°00'03''N 100°08'32''E) [17]; 4♂, 2♀ (PSU-M05.100-104; PSU-M05.106); Songkhla Province: Tham Khao Tieb cave, Ratthaphum District (06°59'59"N 100°17'52"E, 18 m a.s.l) [55]; 3♂, 3♀ (PSUZC-MM2006.94-99); Klao Rak Kiet, Rattaphum District (07°04'16''N 100°15'59''E) [32]; 1♂ (PSU-SB061216.18); Narathiwat Province: Hala-Bala Wildlife Sanctuary (05°47'54''N 101°49'30''E) [24]; 2♂, 1♀ (PSU-CP1, CP2, CP4); Tarutao Islands: Ao Son-Ao Chak Road (06°39'38''N 99°38'2''E) [6, 7]; 3♂, 1♀ (PSU-M07.128; PSU-M07.129; PSU-M05.83; PSU-M05.91); Ou Rang Road, Tarow (06°36'16''N 99.40'31''E) [51]; 1♀ (PSU-M07.130); Ao Son Road, Tarutao NP (06°39'32"N 99°37'58"E) [8]; 1♂ (PSU-M07.12).

Literature records for Thailand: Chiang Rai Province: Doi Chang Kieng [19] (Sawada & Harada, 1985); Chiangmai Province: Mount Angka (Doi Intanon) [39] (Allen & Coolidge, 1940); Doi Chang Khien, Muang District [19]; Doi Pui, Muang District [21]; Doi Suthep, Muang District [22]; Doi Inthanon, Chom Tong District [20]; Ban Sop Hat, Chom Thong District [14]; Dong Tak Ten, Chom Tong District [23]; Ban Prong Yang Nok, Huai Nam-Un, Mae Taeng District [13]; Ban Pa Hin, Phrao District [12] (Yenbutra & Felton, 1986); Amphoe Mae Rim [5] (Sawada & Harada, 1985); Chom Thong (BMNH) [18]; Mae Hong Son Province: Mae Hong Son [36]; Mae Sariang [38] (Lekagul & McNeely, 1977); Phetchabun Province: Thung Salang Luang, Lom Kao District [59] (Yenbutra & Felton, 1986); Nakhon Ratchasima Province: Khao Yai National Park, Pak Chong District [29]; Pak Chong Station, Pak Chong District [43] (Yenbutra & Felton, 1986); Surin Province: Ban Dan, Ban Huai Sing, Kap Choeng District [10] (Yenbutra & Felton, 1986); Kanchanaburi Province: Tham Wang Phra, Sai Yok District [57] (Yenbutra & Felton, 1986); Huai Kha Khang [25] (Hood *et al*., 1988); Ratchaburi Province: Tham Khao Bin, Chom Bung District [54] (Yenbutra & Felton, 1986); Prachap Khiri Khan Province: Muang District [41] (Yenbutra & Felton, 1986); Chumphon District: Tham Khuan Muang, Na Pho, Sawi District [56] (Yenbutra & Felton, 1986); Ranong Province: Ban Bang Non, Muang District [9] (Yenbutra & Felton, 1986); Surat Thani Province: Pak Chalue, Ban Ao Ko, Tha Chang District (Yenbutra & Felton, 1986); Ranong (BMNH) [47]; Phang Nga Province: Koh Surin Nua [34] (Yenbutra & Felton, 1986); Phuket Province: Muang District [40] (Yenbutra & Felton, 1986); Nakhon Si Thammarat Province: Tham Jom, Chawang District [53]; Ban Khuan Chang, Thung Yai District [11] (Yenbutra & Felton, 1986); Trang Province: Trang [60] (Miller, 1898; Andersen, 1905); Phatthalung Province: Khuan Kut, Muang District [30] (Yenbutra & Felton, 1986); Satun Province: Ban Wang Bla Chan, Muang District [15]; Koh Tarutao [35] (Yenbutra & Felton, 1986); Songkhla Province: Nam Tok Ton Nga Chang, Hat Yai District [42]; Saba Yoi District [48] (Yenbutra & Felton, 1986); Songkhla [49] (Sawada & Harada, 1985); Pattani Province: Biserat, Jalor [16] (Bonhote, 1903).

Material: Vietnam: Bac Kan Province: Kim Hy Nature Reserve [71]; 2♂, 3♀ Vinh Phuc Province: Road to Rung Rinh Mountain Peak, Tam Dao National Park [66]; 8♂, 1♀ Tam Dao Town, Tam Dao National Park [82]; 1♂, 1 unsexed Kon Tum Province: Bar Gok Ranger Station Raea, Chu Mom Ray National Park [64].

Literature records for Vietnam: Lai Chau Province: Muong Boum [76]; Lao Cai Province: Chapa [68]; Houang Lien Nature Reserve [70]; Lao Cai [74]; Dien Bien Province: Muong Boum [76]; Tuyen Quang Province: Tuyen Quang [83]; Lang Son Province: Lang Son [73]; Vinh Phuc Province: Tam Dao [81]; Ha Tay Province: Ba Vi National Park [63]; Ninh Binh Province: Cuc Phuong [69]; Ninh Binh [78]; Thanh Hoa Province: Ben En National Park [65] (Csorba *et al*, 2003); Ha Tinh Province: Vu Quang National Park [84] (Borissenko & Kruskop, 2003); Bak Kan Province: Quang Chu [79]; Lam Dong Province: Mt. Lang Bian, Da Lat Plateau [75]; Lam Dong [72]; Caryu Danar [67]; Ho Chi Minh Province: Saigon [80] (Csorba *et al*., 2003).