

Confirmation of seven bat species for Cambodia

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មូលនិយមសង្ខេប

ផ្អែកលើការសំយោគឯកសារ កម្ពុជាមានសត្វប្រេងត្រីមតែ៥៣ប្រភេទ តួលេខនេះបង្ហាញពីកំរិតទាបខ្លាំងបើធៀបទៅនឹងប្រទេសជិតខាង។ តាមរយៈការសិក្សារូបសាស្ត្រនៃភាគសំណាកដែលបានប្រមូលក្នុងរយៈពេល១១ឆ្នាំ (២០០០ដល់២០១១) ដោយឧបករណ៍មង (mist nets) និងអន្ទាក់រ៉ាង (harp traps) នៅក្នុងនិងក្រៅតំបន់ការពារនៃជ្វាប្រទេសយើងបានរកឃើញសត្វប្រេងត្រីប្រាំពីរប្រភេទបន្ថែមទៀតរួមមាន៖ *Rhinolophus yunanensis*, *Hipposideros diadema*, *Saccolaimus saccolaimus*, *Myotis ater*, *M. horsfieldii*, *Murina cyclotis* និង *Kerivoula picta*។ ដូច្នេះចំនួនសរុបនៃប្រេងត្រីកម្ពុជាបច្ចុប្បន្នគឺ៦០ប្រភេទ កំណត់ត្រានេះបង្ហាញពីភាពខ្វះខាតក្នុងការរកតួលេខពិតដែលមាន។ តាមទស្សនវិស័យអភិរក្ស មានសត្វប្រេងត្រី៣ប្រភេទប៉ុណ្ណោះពីប្រទេសកម្ពុជាដែលបានចុះក្នុងបញ្ជីIUCN។ ពីរប្រភេទចាត់ចូលក្នុងក្រុមកង្វះទិន្នន័យ (Data Deficient) និងមួយទៀតជាប្រភេទកំពុងរងគ្រោះ (Vulnerable) ហើយប្រាកដណាស់មានពិតមានជាច្រើនទៀតស្តីពីសត្វប្រេងត្រីនៅកម្ពុជាដែលយើងមិនទាន់ដឹងនូវឡើយ។ របកគំហើញប្រភេទសត្វប្រេងត្រីថ្មីជាមួយនឹងការស្រាវជ្រាវដ៏តិចតួចនិងគ្របដណ្តប់មួយភាគតូចនៅឡើយបានឆ្លុះបញ្ចាំងពីលទ្ធភាពខ្ពស់ក្នុងការរកឃើញប្រភេទថ្មីច្រើនថែមទៀតនាពេលអនាគត។

Abstract

Relative to neighbouring countries, the Cambodian bat fauna is poorly known, with only 53 species reported in the peer-reviewed literature. Through a morphological review of specimen material collected over an 11-year period (2000-2011) with mist nets and harp traps in protected and non-protected areas, mostly in border regions, we confirm the occurrence of seven additional bat species: *Rhinolophus yunanensis*, *Hipposideros diadema*, *Saccolaimus saccolaimus*, *Myotis ater*, *M. horsfieldii*, *Murina cyclotis* and *Kerivoula picta*. These records highlight the incompleteness of existing information, and the new national total of 60 bat species undoubtedly falls short of the true figure. Only three of the bat species known to occur in Cambodia are listed by the IUCN in categories other than Least Concern. Two species are considered Data Deficient and one Vulnerable, and major gaps remain in knowledge. In view of the recent spate of bat species new to science described from Cambodia and the limited survey effort and coverage achieved to date, the likelihood of additional discoveries in future field studies would appear to be high.

Keywords

Bat taxonomy, new records.

Introduction

The bats of Cambodia are poorly known. Although research effort has intensified in recent years, a recent study found only 50 bat species documented in the peer-reviewed literature for this country (Kingsada *et al.*, 2011). Three bat species new to science were subsequently described from sites in East and Northeast Cambodia and have been added to this number: *Glischropus bucephalus* Csorba, 2011, *Murina cineracea* Csorba & Furey, 2011 and *M. walstoni* Furey, Csorba & Son, 2011 (Csorba *et al.*, 2011). This lags far behind similar figures for neighbouring Thailand, Vietnam and Laos, which include at least 126, 110 and *circa* 80 bat species respectively (Francis *et al.*, 1999; Can *et al.*, 2008; Kingsada *et al.*, 2011).

A number of additional bat species were included in range maps or reported for Cambodia by Corbet & Hill (1992), Matveev & Csorba (2007) and Francis (2008) without explanation. This paper validates the presence of six such species through a morphological review of specimens collected in the country and provides the first documented evidence of a seventh. Notes on the distribution and ecology of each species are also provided.

Methods

Study areas

Voucher specimens referred to in this paper were collected over 11 years in Cambodia. From 2000 to 2005, specimens were collected by J. Walston in several provinces of the country: Kampong Speu (February 2000), Preah Vihear (December 2000), Kandal (December 2001) and Phnom Penh (November 2005) (Fig. 1). These were deposited at the Hungarian Natural History Museum (HNHM, Budapest, Hungary) and Harrison Institute (HZM, Sevenoaks, United Kingdom, formerly Harrison Zoological Museum) and examined by the authors. From 2005 to 2011, specimens were collected during studies by the authors in several protected areas and proposed protected areas, as summarised below (Fig. 1). Four-bank harp traps and mist nets of varying sizes were employed in the surveys and selection of sampling locations largely focused on flyways within the forest understory, such as trails, watercourses and natural linear breaks in the vegetation. Specimens from these studies were deposited at the Centre for Biodiversity Conservation (CBC, Zoological Collection, Royal University of Phnom Penh), HNHM and HZM.

In July 2005 and January 2006, bat surveys were undertaken in the Seima Protection Forest by G. Csorba and S.H. Hout and by G. Csorba, L. Duval and G. Ronkay,

respectively. During these surveys, three harp traps and several mist nets were used. The Seima Protection Forest is in the low-lying eastern plains of Cambodia (Mondulki Province) and covers 303,400 ha. The site supports a high diversity of forest types, including evergreen forest, mixed deciduous formations, and dry dipterocarp forest (Pollard, 2007). In January 2006, bats were surveyed in Bokor National Park by G. Csorba, L. Duval and G. Ronkay. The same survey equipment was employed as in the Seima Protection Forest surveys. The national park is in the southern coastal province of Kampot and covers 140,000 ha. The park centres on a sandstone massif, with an extensive plateau at around 1,000 m a.s.l. (above sea level). Habitats include semi-evergreen and evergreen forest, while the plateau is dominated by dwarf evergreen forest and includes small cleared areas of grassland (Seng *et al.*, 2003).

In July 2005 and February-March 2011, bat surveys were undertaken in Preah Vihear Protected Forest by G. Csorba, B. Hayes and Hout S.H. and by Ith S., G. Csorba, N. Furey, Seng R., Chea N. and M. Csorba, respectively. During the 2005 survey, mist nets were solely employed, while in the 2011 survey several mist nets and three harp traps were used. The protected forest is located in the northern plains and abuts the Cambodia-Thailand border in Preah Vihear Province. The landscape of the area is dominated by dry dipterocarp forest and grassland, interspersed with patches of semi-evergreen forest (Walston & Bates, 2001).

In November 2009, a brief survey was undertaken in the Preah Vihear sector of the Kulen Promtep Wildlife Sanctuary by Ith S. and G. Csorba using one harp trap and three mist nets. The wildlife sanctuary lies to the west of Preah Vihear Protected Forest and encompasses parts of the Oddar Meanchey, Preah Vihear and Siem Reap provinces. The landscape and habitats of the wildlife sanctuary are similar to those of the Preah Vihear Protected Forest.

In December 2009 and 2010, surveys were undertaken by N. Furey in the Pursat sector of Phnom Samkos Wildlife Sanctuary using several mist nets. This wildlife sanctuary covers 332,566 ha and is located in the Cardamom Mountains of the Pursat, Battambang and Koh Kong provinces in Southwest Cambodia. The wildlife sanctuary has an elevation range of 100-1,717 m a.s.l. and includes large areas of dry dipterocarp forest, lowland evergreen forest and hill evergreen forest (Daltry & Momberg, 2000).

In February-March and August 2010, field studies were undertaken in the Veun Sai Proposed Protected Forest by Ith S., G. Csorba, N. Furey, Phauk S. and T.

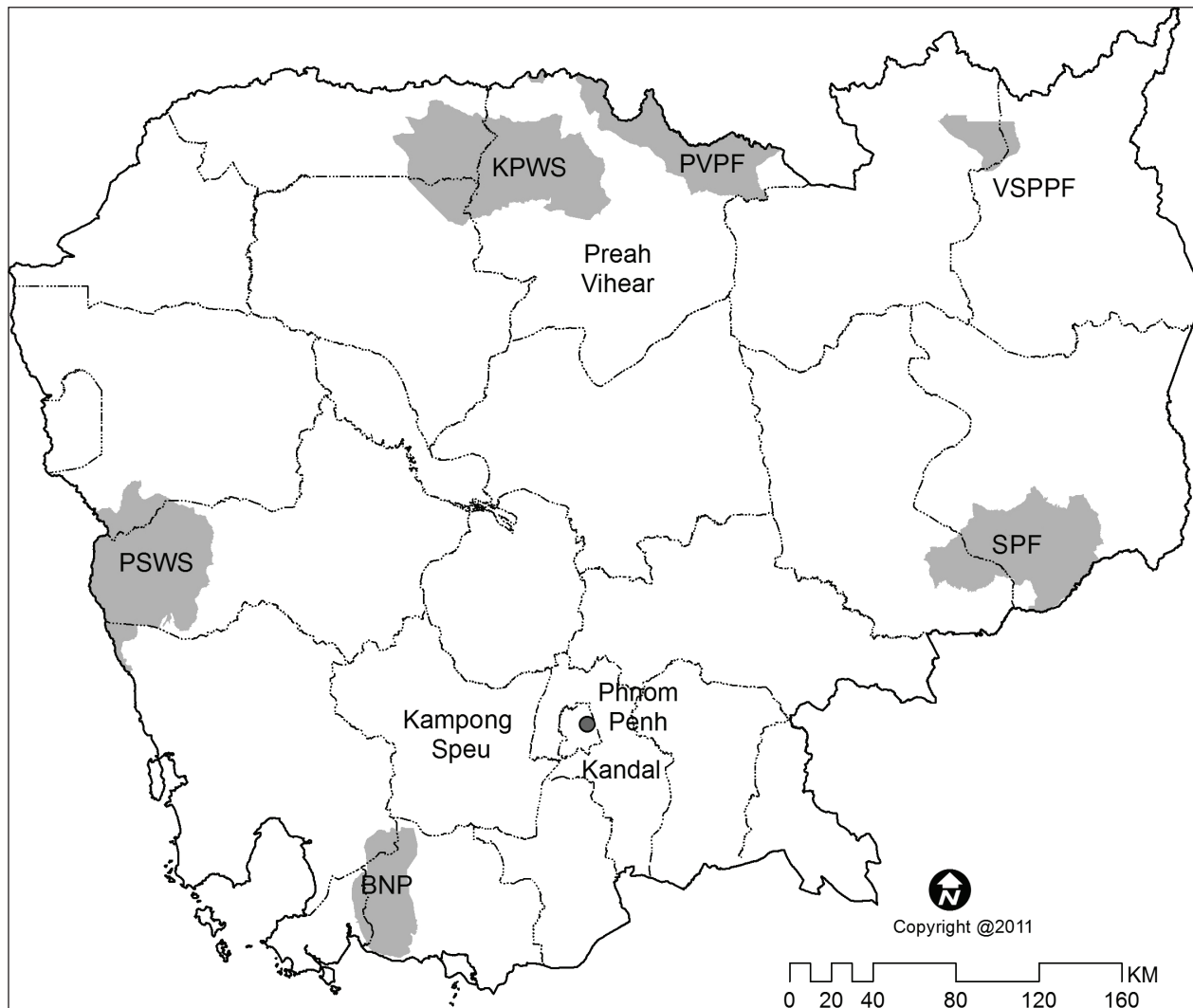


Fig. 1 Location of bat survey areas in Cambodia. BNP = Bokor National Park, KPWS = Kulen Promtep Wildlife Sanctuary, PSWS = Phnom Samkos Wildlife Sanctuary, PVPF = Preah Vihear Protected Forest, SPF = Seima Protection Forest, VSPPF = Veun Sai Proposed Protected Forest.

Gorfol using several harp traps and mist nets. Veun Sai Proposed Protected Forest covers approximately 55,000 ha in Veun Sai District, Ratanakiri Province, and Siem Pang District, Steung Treng Province of Northeast Cambodia. Habitats in the site comprise lowland evergreen and semi-evergreen forest at elevations between 100 and 400 m, with more northerly areas mountainous and southern parts characterized by grasslands (B. Rawson, pers. comm.).

Morphological assessment

Age and reproductive status were assessed following Anthony (1988) and Racey (1988). External measurements were taken from dry skins and alcohol-preserved

specimens to the nearest 0.1 mm, while craniodental measurements were taken to the nearest 0.01 mm using digital callipers under a stereo microscope. Measurements herein include only those taken from non-juvenile individuals, as indicated by fully ossified metacarpal-phalangeal joints. Definitions for external measurements were as follows: FA: forearm length - from the extremity of the elbow to the extremity of the carpus with the wings folded; HB: head and body length - from the tip of the snout to the anal opening; T: tail length - from the anal opening to the tip of the tail; E: From the lower border of the external auditory meatus to the tip of the pinna, excluding any hair; TIB: tibia length - from the knee joint to the ankle; and HF: hindfoot - from the tip of the longest digit, excluding the claw, to the extremity of the

heel, behind the os calcis. Illustrations of these measurements are provided by Bates & Harrison (1997).

Definitions for craniodental measurements were as follows: GTL: greatest length of skull - greatest antero-posterior diameter of the skull, taken from the most projecting point at each extremity along the median line of the skull (including the premaxilla); CBL: condylobasal length - from the exoccipital condyle to the anterior rim of alveolus of the first upper incisor; CCL: condylo-canine length - from the exoccipital condyle to the most anterior part of the canine; ZYW: zygomatic width - the greatest width of the skull across the zygomatic arches; MAW: mastoid width - the greatest distance across the mastoid region; CM³L: maxillary toothrow length - from the front of upper canine to the back of the crown of the third molar; C¹C¹W: width across the upper canines - greatest width, taken across the outer borders of upper canines; M³M³W: width across the upper molars - greatest width, taken across the outer crowns of the last upper molars; ML: mandible length - from the anterior rim of the alveolus of the first lower incisor to the most posterior part of the condyle; CM₃L: mandibular toothrow length - from the front of the lower canine to the back of the crown of the third lower molar; CPH: least height of the coronoid process - from the tip of the coronoid process to the apex of the indentation on the inferior surface of the ramus adjacent to the angular process.

Species sequence and nomenclature follow Simmons (2005). A full list of specimen material examined is given in Annex 1.

Results

Rhinolophus yunnanensis Dobson, 1872a (Fig. 2)

Material examined: One male from Kampong Speu Province and one female from Phnom Samkos Wildlife Sanctuary (Fig. 1, Annex 1).

Possessing a sella with a wide base and characteristic middle constriction, the two specimens were readily identified as members of the *pearsonii* group which comprises two species in the Indochinese Subregion: *R. pearsonii* Horsfield, 1851 and *R. yunnanensis*. As these taxa are strikingly similar and differ primarily in size (Csorba *et al.*, 2003), species diagnosis was based on craniodental measurements. Though some measurements were intermediate between ranges for the two species (Table 1 and 2), skull length (*sensu* Csorba *et al.*, 2003), CM³L, MAW, ML and CM₃L measurements of the two specimens exceeded upper limits for *R. pearsonii* provided by Csorba *et al.* (2003), and the specimens were therefore referred to *R. yunnanensis* (skull length = 24.72 & 25.00

mm versus 24.33 mm; CM³L= 10.08 & 10.26 mm versus 9.97 mm; MAW= 11.37 mm versus 11.33 mm; ML= 17.86 & 17.54 mm versus 17.39 mm; CM₃L= 10.75 & 11.11 mm versus 10.70 mm, respectively).

The single female from Phnom Samkos Wildlife Sanctuary was caught at 1840h in a mist net over a stream in an area of disturbed hill evergreen forest. Time-expanded (x10) echolocation calls with a frequency of maximum energy of 53.6 kHz were recorded from the animal while held motionless in the hand. *Rhinolophus yunnanensis* occurs in India, Myanmar and China, southwards almost to Peninsular Thailand (Simmons, 2005; Francis, 2008) and the above specimens represent the first records in Cambodia.

Hipposideros diadema (E. Geoffroy, 1813) (Fig. 3)

Material examined: One male from Preah Vihear Province, four males and three females from Veun Sai Proposed Protected Forest, and two males from Preah Vihear Protected Forest (Fig. 1, Annex 1).

Ten specimens were referred to *H. diadema* on the basis of the following characteristics: FA, CCL, CM³L and ZYW (Tables 1 and 2) in accordance with ranges given by Corbet & Hill (1992); presence of pale patches on dorsum (which distinguish this species from all other Asian members of the genus *Hipposideros*; Francis, 2008); posterior noseleaf wider than anterior noseleaf; absence of fleshy outgrowths behind posterior noseleaf; intermediate noseleaf with median ridge; frontal depression present; second lower incisor (I₂) not greatly enlarged.

In Veun Sai Proposed Protected Forest, seven individuals were caught on trails and streams in semi-evergreen forest at 1820h, 1845h and 2000h in mist nets and one overnight in a harp trap. In Preah Vihear Protected Forest, two individuals were collected before 2000h: one in a mist net in dry dipterocarp forest and one in a harp trap beside a pool in semi-evergreen forest. A geographically widespread species occurring in the Nicobar Islands (India), Myanmar, Thailand, south Vietnam and Laos, through Indonesia and the Philippines to Australia (Simmons, 2005), Corbet & Hill (1992) included *H. diadema* in range maps for Cambodia without explanation, although Kock (2000) concluded that its presence was uncertain. The present records therefore confirm its occurrence, as more recently suggested by Francis (2008).

Saccolaimus saccolaimus (Temminck, 1838)

Material examined: One male from Phnom Penh (Fig. 1, Annex 1).

This specimen was identified as *S. saccolaimus* based on the following characteristics: external and cranial

measurements (Tables 1 and 2) in accordance with published ranges (Bates & Harrison, 1997; Borissenko & Kruskop, 2003); dorsal pelage dark brown with irregular white markings; ventral pelage paler; radio-metacarpal pouch almost absent; well-defined gular sac present; interfemoral membrane, hind limbs and feet naked; wing membrane attached to the ankle; anterior upper premolar (P^2) large, approximately 30% of posterior premolar (P^4) in crown area.

Ranging from India and Sri Lanka through mainland Southeast Asia, the Philippines, Indonesia and Papua New Guinea to Northeast Australia, the occurrence of *S. saccolaimus* in Cambodia was mentioned by Simmons (2005), Matveev & Csorba (2007) and Francis (2008) without details. The above record therefore confirms its presence and its capture in an urban environment is consistent with the species' known habit of occasionally roosting in buildings (Bates & Harrison, 1997).

Myotis ater (Peters, 1866) (Fig. 4)

Material examined: Three males from Preah Vihear Province, two females from Kulen Promtep Wildlife Sanctuary, two males from Phnom Samkos Wildlife Sanctuary, four females from Veun Sai Proposed Protected Forest, and ten males and seven females from Preah Vihear Protected Forest (Fig. 1, Annex 1).

Though it is unclear whether bats from mainland Southeast Asia are the same as those from Maluku, the type locality of *M. ater* (Francis, 2008), the specimens from Cambodia were referred to the species and distinguished from the similar *M. muricola* (Gray, 1846) on the basis of the following characteristics: average FA slightly longer at 36.5 mm (range = 34.8-38.8 mm) (Table 1); feet small, half or less than the length of the tibia; wing membrane attached to base of toes; skull larger with CBL averaging 13.55 mm (13.15-14.20 mm) and CCL averaging 12.84 mm (12.49-13.39 mm) (Table 2); crown area of first (P^1) and particularly second upper incisor (I^3) considerably larger; upper canine (C^1) also larger, exceeding posterior premolar (P^4) in height; upper middle premolar (P^3) small and displaced inwards, such that anterior (P^2) and posterior premolar are very close or in contact; lower canine (C_1) distinctly exceeds posterior premolar (P_4) in height; lower middle premolar (P_3) small and usually intruded such that the anterior (P_2) and posterior premolars are almost in contact.

In Kulen Promtep Wildlife Sanctuary, two individuals were caught at 1840h in semi-evergreen forest. In Preah Vihear Protected Forest, two individuals were caught in harp traps and the remainder in mist nets from 1900h to 2200h in semi-evergreen forest and dry dipterocarp forest. In Phnom Samkos Wildlife Sanctuary, two

individuals were caught at 1940h and 2100h in mist nets in disturbed evergreen forest. In Veun Sai Proposed Protected Forest, two individuals were caught in mist nets at 2010h on a trail and stream in semi-evergreen forest and two individuals in harp traps at 1920h in a banana plantation and in semi-evergreen forest. As currently understood, *M. ater* occurs in Vietnam, Peninsular Thailand and Malaysia through the Indonesian islands and the Philippines to New Guinea (Simmons, 2005). The above records validate previous reports of its occurrence in Cambodia (Matveev & Csorba, 2007).

Myotis horsfieldii (Temminck, 1840) (Fig. 5)

Material examined: One male and female from Preah Vihear Province, one male from the Seima Protection Forest, and four males and two females from Veun Sai Proposed Protected Forest (Fig. 1, Annex 1).

Nine specimens were identified as *M. horsfieldii* on the basis of the following characteristics: FA, TIB, HF, CCL and CM^3L measurements (Tables 1 and 2) according with published ranges for Indochina (Bates *et al.*, 1999; Hendrichsen *et al.*, 2001; Borissenko & Kruskop, 2003); feet relatively large, slightly more than half the length of the tibia; wing membrane attached to outer metatarsal, 1-2 mm from the base of the toes; upper canine (C^1) nearly twice the height of the posterior premolar (P^4); upper anterior (P^2) and middle premolar (P^3) small, the latter slightly displaced inwards and sometimes compressed; lower canine (C_1) greatly exceeding the lower posterior premolar (P_4) in height; crown area of lower middle premolar (P_3) approximately half that of the anterior premolar (P_2).

In Veun Sai Proposed Protected Forest, *M. horsfieldii* was caught at 1900h and 1920h and overnight in harp traps on trails and in a mist net at 1920h in a dry river basin in semi-evergreen forest. The species occurs throughout Southeast Asia from India eastwards to southern China and southwards to Indonesia and the Philippines (Simmons, 2005). The present records validate previous reports of the species for Cambodia by Matveev & Csorba (2007) and Francis (2008).

Murina cyclotis Dobson, 1872b (Fig. 6)

Material examined: One female from Bokor National Park, one male from the Seima Protection Forest, two females from Veun Sai Proposed Protected Forest, and three females from Preah Vihear Protected Forest (Fig. 1, Annex 1).

Seven specimens were identified as *M. cyclotis* on the basis of the following characteristics: external and cranial measurements (Tables 1 and 2) according with published ranges (e.g. Bates & Harrison, 1997); upper canine (C^1)



Fig. 2 *Rhinolophus yunanensis*: CBC01208, Phnom Samkos Wildlife Sanctuary (© N. Furey).



Fig. 3 *Hipposideros diadema*: CBC01146, Veun Sai Proposed Protected Forest (© N. Furey).



Fig. 4 *Myotis ater*: CBC00620, Veun Sai Proposed Protected Forest (© G. Csorba).



Fig. 5 *Myotis horsfieldii*: CBC01142, Veun Sai Proposed Protected Forest (© N. Furey).



Fig. 6 *Murina cyclotis*: CSOCA266, Preah Vihear Protected Forest (© G. Csorba).



Fig. 7 *Kerivoula picta*: CSOCA272, Preah Vihear Protected Forest (© G. Csorba).

Table 1 Selected external measurements. Values are given as mean, SD (where $n \geq 5$), and (min–max) n . Acronyms and definitions for measurements are given in the text.

Taxon	FA	HB	T	E	TIB	HF
<i>Rhinolophus yunanensis</i>	56.6, - (55.0-58.2) 2	58.4, - (54.9-61.8) 2	21.1, - (20.0-22.1) 2	27.1, - (25.7-28.4) 2	26.5, - (26.3-26.7) 2	11.3, - (11.1-11.4) 2
<i>Hipposideros diadema</i>	86.8, 2.9 (83.2-93.2) 10	90.3, 2.6 (86.8-95.1) 10	50.2, 4.5 (44.3-57.2) 10	27.6, 2.0 (23.3-30.8) 10	35.0, 1.4 (33.5-37.8) 10	16.2, 1.0 (15.1-18.1) 10
<i>Saccolaimus saccolaimus</i>	69.2, - (-) 1	28.5, - (-) 1	28.5, - (-) 1	17.4, - (-) 1	28.5, - (-) 1	12.5, - (-) 1
<i>Myotis ater</i>	36.5, 1.0 (34.8-38.8) 28	41.7, 2.1 (38.0-45.7) 25	38.7, 2.1 (33.6-44.0) 25	12.8, 1.0 (10.1-14.0) 28	15.4, 0.4 (14.7-16.4) 25	7.2, 0.4 (6.0-8.0) 28
<i>Myotis horsfieldii</i>	35.3, 1.0 (34.2-37.6) 9	45.2, 2.1 (41.9-48.7) 9	37.2, 3.0 (32.9-43.1) 9	13.7, 1.3 (10.8-15.1) 9	16.3, 0.5 (15.5-16.9) 9	8.7, 0.5 (7.5-9.1) 9
<i>Murina cyclotis</i>	32.8, 0.8 (31.4-33.8) 7	42.3, 2.0 (39.1-45.1) 7	35.7, 1.4 (34.0-37.5) 7	14.4, 0.9 (13.5-15.9) 7	18.3, 0.4 (17.8-18.9) 7	7.9, 0.4 (7.2-8.5) 7
<i>Kerivoula picta</i>	34.2, 1.5 (32.3-36.8) 6	36.3, 0.8 (35.0-37.2) 5	40.3, 1.3 (38.6-42.0) 5	11.2, 1.1 (10.1-12.8) 6	15.2, 0.7 (14.3-16.0) 5	6.7, 0.7 (5.6-7.5) 6

significantly exceeding posterior premolar (P^4) in height, with an equivalent or larger basal area; basal area of the upper anterior premolar (P^2) two-thirds to nearly equal that of the posterior premolar; mesostyles absent from upper molars (M^1 , M^2); lower anterior premolar (P_2) large; area of talonids on lower molars approximately one-third of respective trigonids.

In Veun Sai Proposed Protected Forest, *M. cyclotis* was captured in a harp trap set overnight on a trail in semi-evergreen forest and at 1935h in a harp trap in a banana plantation. In Preah Vihear Protected Forest, three individuals were captured before 2000h in a harp trap set at a small pool in a dry streambed in semi-evergreen forest. *Murina cyclotis* occurs throughout Southeast Asia from India and Sri Lanka through to China, the Philippines and Indonesia (Simmons, 2005). Although included in range maps for Cambodia by Corbet & Hill (1992), its presence in Cambodia was considered unconfirmed by Kock (2000). The present records consequently affirm its occurrence, as more recently suggested by Matveev & Csorba (2007) and Francis (2008).

Kerivoula picta (Pallas, 1767) (Fig. 7)

Material examined: One female from Kandal Province, and three males and two females from Preah Vihear Protected Forest (Fig. 1, Annex 1).

Kerivoula picta is unmistakable morphologically, because no other member of the *Kerivoula* genus has

contrasting orange and black wings, including the similar-sized *K. hardwickii* (Horsfield, 1824) and *K. titania* in Cambodia (Bates *et al.*, 2007). All six specimens examined possess this feature and the distinctive pelage of *K. picta*: bright orange on the dorsal surface and buff coloured on the medial ventral surface. External and cranial measurements of the Cambodian specimens (Tables 1 and 2) accord with measurements from specimens elsewhere in this species' range (Bates & Harrison, 1997) and all exhibit the large, bicuspid first upper incisor (I^2) characteristic of *K. picta*.

In Preah Vihear Protected Forest, five individuals were captured before 2000h in harp traps set in dry dipterocarp forest and over a small pool in a dry streambed in semi-evergreen forest. Geographically widespread, *K. picta* ranges from India and Sri Lanka eastwards to China and southwards through Peninsular Thailand and West Malaysia to Indonesia (Simmons, 2005). The inclusion of the species in range maps for Cambodia by Francis (2008) is validated by these records.

Discussion

Our confirmation of seven additional bats for Cambodia raises the total number of bat species known from the country to 60. This figure undoubtedly falls short of the true total, however, because additional specimen material - including at least five previously unconfirmed species

Table 2 Selected craniodental measurements. Values are given as mean, SD (if $n \geq 5$), and (min–max) n . Acronyms and definitions for measurements are given in the text.

Taxon	GTL	CBL	CCL	ZYW	MAW	CM ³ L	C ¹ C ¹ W	M ³ M ³ W	ML	CM ₃ L	CPH
<i>Rhinolophus yunnanensis</i>	25.96, - (25.87- 26.05) 2	23.04, - (22.87- 22.31) 2	22.24, - (22.11- 22.36) 2	12.75, - (12.6- 12.89) 2	11.37, - (11.37) 2	10.17, - (10.08- 10.26) 2	6.66, - (6.65- 6.67) 2	9.62, - (9.62) 2	17.70, - (17.54- 17.86) 2	10.93, - (10.75- 11.11) 2	3.70, - (3.54- 3.86) 2
<i>Hipposideros diadema</i>	31.96, 0.66 (31.04- 33.08) 7	28.82, 0.60 (27.81- 29.74) 7	28.11, 0.49 (27.41- 28.83) 7	18.39, 0.47 (17.81- 19.17) 7	15.04, 0.21 (14.76- 15.31) 7	12.61, 0.16 (12.46- 12.96) 7	8.25, 0.16 (8.04- 8.47) 7	12.44, 0.22 (12.15- 12.83) 7	22.56, 0.48 (21.83- 23.05) 7	13.89, 0.26 (13.62- 14.38) 7	7.08, 0.29 (6.86- 7.57) 7
<i>Saccolaimus saccolaimus</i>	25.04, - (-) 1	-	22.24, - (-) 1	15.69, - (-) 1	13.41, - (-) 1	10.00, - (-) 1	5.4, - (-) 1	10.8, - (-) 1	18.09, - (-) 1	11.26, - (-) 1	7.22, - (-) 1
<i>Myotis ater</i>	14.65, 0.27 (14.30- 15.41) 28	13.55, 0.23 (13.15- 14.20) 28	12.84, 0.22 (12.49- 13.39) 28	9.40, 0.22 (8.90- 9.86) 27	7.45, 0.14 (7.10- 7.75) 28	5.55, 0.13 (5.29- 5.82) 28	3.92, 0.11 (3.72- 4.16) 28	6.03, 0.19 (5.67- 6.31) 28	10.86, 0.30 (10.32- 11.75) 28	5.88, 0.14 (5.64- 6.15) 28	3.30, 0.15 (2.99- 3.62) 28
<i>Myotis horsfieldii</i>	15.51, 0.36 (15.18- 16.16) 8	14.06, 0.29 (13.73- 14.51) 8	13.27, 0.26 (12.97- 13.72) 8	9.27, 0.23 (9.01- 9.75) 7	7.80, 0.16 (7.63- 8.14) 8	5.66, 0.15 (5.46- 5.93) 8	4.23, 0.08 (4.09- 4.32) 8	5.87, 0.13 (5.65- 6.04) 8	11.01, 0.19 (10.83- 11.43) 8	6.11, 0.42 (5.79- 7.05) 8	3.35, 0.11 (3.17- 3.50) 8
<i>Murina cyclotis</i>	16.87, 0.33 (16.58- 17.48) 6	14.97, 0.38 (14.66- 15.68) 6	14.45, 0.37 (14.12- 15.12) 6	9.54, 0.20 (9.36- 9.93) 6	7.88, 0.17 (7.64- 8.11) 6	5.42, 0.14 (5.27- 5.64) 6	4.12, 0.10 (4.00- 4.30) 6	5.39, 0.13 (5.19- 5.59) 6	11.28, 0.17 (11.08- 11.57) 6	5.81, 0.26 (5.36- 6.12) 6	4.35, 0.30 (3.82- 4.66) 6
<i>Kerivoula picta</i>	14.41, 0.21 (14.12- 14.68) 6	12.94, 0.29 (12.58- 13.38) 6	12.40, 0.22 (12.20- 12.77) 6	8.56, 0.26 (8.29- 8.99) 6	7.33, 0.12 (7.17- 7.50) 6	5.60, 0.17 (5.39- 5.85) 6	3.05, 0.11 (2.88- 3.20) 6	5.40, 0.17 (5.08- 5.55) 6	10.17, 0.21 (10.01- 10.57) 6	5.78, 0.14 (5.61- 5.99) 6	2.65, 0.19 (2.43- 2.95) 6

for Cambodia - is currently being identified (Furey *et al.*, 2011). Given the limited extent of survey effort and coverage achieved to date, the potential for additional discoveries in future field research also appears strong, particularly in understudied forests of the country's Southwest, Northeast and Northwest (Kingsada *et al.*, 2011).

At present, only three Cambodian bat species appear on the IUCN Red List (2011) in categories other than Least Concern: *Murina harrisoni* Csorba & Bates, 2005, which is listed as Data Deficient, being known only from the holotype from Kirirom National Park; *Otomops wroughtoni* (Thomas, 1913), also Data Deficient and in Cambodia known only from a single animal found in Preah Vihear (Walston & Bates, 2001); and *Pteropus lylei* Andersen, 1908, considered Vulnerable and in Cambodia known from colonies in the Phnom Penh and Siem Reap cities (Matveev, 1999; B. Hayes, pers. comm.), though seemingly also present in other areas (Francis, 2008). While the status of the three bat species recently described from Cambodia has yet to be assessed, two (*G. bucephalus* and

M. cineracea) are unlikely to qualify for a threatened category being widespread in Southeast Asia (Csorba, 2011; Csorba *et al.*, 2011), although the third (*M. walstoni*) may qualify for listing as Data Deficient, being known only from singletons from Yok Don National Park (Vietnam) and Botum-Sakor National Park, and a few records from Northeast Cambodia (Csorba *et al.*, 2011; Furey & Csorba unpublished data).

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Appendix 1

[Specimens denoted 'CSOCA' are presently held at the Centre for Biodiversity Conservation and intended for deposition at the Hungarian Museum of Natural History].

Rhinolophus yunanensis: HZM 15.36144, male, in spirit, skull removed, collected by J. Walston in February 2000, Kirirom National Park, Kampong Speu Province, 11°31' N, 104°08' E; CBC01208, parous female, in spirit, skull removed, collected by N. Furey in December 2010, Phnom Samkos Wildlife Sanctuary, 12°09.787' N, 102°59.956' E, 1,281 m a.s.l.

Hipposideros diadema: HZM 6.34184, juvenile male, in spirit, skull removed, collected by J. Walston in December 2000,

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PAUL BATES has spent much of the last 30 years researching the bats and small mammals of Southern and Southeast Asia. Initially studying the mammal fauna of India and Sri Lanka, in 1997 he began working in Vietnam and Cambodia which led to research and training projects throughout Southeast Asia. More recently, he has helped develop a network of Southeast Asian taxonomists working on mammals, birds and amphibians.

NEIL FUREY has worked in Southeast Asia since 1997, spending many years in Vietnam and completing assignments in Cambodia, China, India, Indonesia and Myanmar. He studied the ecology of Vietnamese karst bat populations for his doctorate and has a special interest in community ecology and systematics. Much of his work in Southeast Asia focuses on strengthening conservation and research capacity.

M'lou Prey, Preah Vihear Province, 13°59.081' N, 105°16.232' E; CBC00626, mature male, in spirit, skull removed, collected by Ith S. and G. Csorba in February 2010, Veun Sai Proposed Protected Forest, 14°01.654' N, 106°43.745' E; HNHM 2011.2.2, HNHM 2011.2.1, nuliparous and parous female, in spirit, collected by G. Csorba and Ith S. in February and March 2010, Veun Sai Proposed Protected Forest, 14°00.589' N, 106°44.935' E and 14°00.854' N, 106°45.001' E (approximate coordinates) respectively; CBC00644, mature male, in spirit, skull removed, collected by Ith S. and G. Csorba in March 2010, Veun Sai Proposed Protected Forest, 14°00.854' N, 106°45.001' E (approximate coordinates); CBC01145, CBC01146, parous female and mature male, in spirit, skulls removed, collected by N. Furey, Ith S. and Tamas Gorfol in

/August 2010, Veun Sai Proposed Protected Forest, 14°00.937 N, 106°45.135 E; HNHM 23637, mature male, in spirit, collected by N. Furey, Ith S. and Tamas Gorfol in August 2010, Veun Sai Proposed Protected Forest, 14°02.205 N, 106°44.269 E; CBC01276, CSOCA275, mature males, in spirit, skulls removed, collected by Ith Saveng and G. Csorba in March 2011 in the Baray Mountains and O'Cheuteal area, Preah Vihear Protected Forest, 14°01.231 N, 105°37.133 E (200 m a.s.l.) and 13°59.825 N, 105°33.862 E (100 m a.s.l.) respectively.

Saccolaimus saccolaimus: HNHM 2006.13.1, juvenile male, in spirit, skull removed, collected by J. Walston in November 2005, Phnom Penh city, 11°33' N, 104°55' E.

Myotis ater: HZM 10.34188, HZM 11.34189, HZM 8.34186, three males, in spirit, skulls removed, collected by J. Walston in December 2000, M'lou Prey, Preah Vihear Province, 13°58.907 N, 105°16.466 E; CBC00466, CBC00467, nuliparous females, in spirit, skulls removed, collected by Ith S. in November 2009, Takeung village, Kulen Promtep Wildlife Sanctuary, 13°53.255 N, 104°52.961 E, 60 m a.s.l.; CBC00579, CBC00580, mature males, in spirit, skulls removed, collected by N. Furey in December 2009, O'Peam, Phnom Samkos Wildlife Sanctuary, 12°12.240 N, 103°04.201 E, 274 m a.s.l.; CBC00620, CBC00646, parous females, in spirit, skulls removed, collected by G. Csorba and Ith S. in February and March 2010, Veun Sai Proposed Protected Forest, 14°00.937 N, 106°45.135 E; CBC01143, CBC01152, parous and nuliparous female, in spirit, skulls removed, collected by N. Furey, Ith S. and T. Gorfol in August 2010, Veun Sai Proposed Protected Forest, 14°01.818 N, 106°43.285 E and 14°00.933 N, 106°44.975 E respectively; CBC01225, CBC01227, CBC01228, CBC01229, CBC01230, CBC01231, CSOCA209, CSOCA210, CSOCA213, CSOCA216, five mature males and five nuliparous females, in spirit, skulls removed, collected by G. Csorba, N. Furey and Ith S. in February 2011, Trapaeng Pring, Preah Vihear Protected Forest, 13°53.064 N, 105°22.556 E, 120 m a.s.l.; CBC01234, CBC01241, CSOCA219, CSOCA221, CSOCA232, CSOCA233, CSOCA234, five mature males and two nuliparous females, in spirit, skulls removed, collected by G. Csorba, N. Furey and Ith S. in February 2011, Ka Kheuk, Preah Vihear Protected Forest, 14°03.556 N, 105°17.017 E, 110 m a.s.l.

Myotis horsfieldii: HNHM 2005.81.5, HNHM 2005.81.6, parous female and mature male, in spirit, skulls removed, collected by

G. Csorba, B. Hayes and Hout S.H, in July 2005, Kvay, Preah Vihear Province, 13°34.000 N, 105°00.250 E, 70 m a.s.l.; HNHM 2006.34.53, juvenile male, in spirit, skull removed, collected by G. Csorba, L. Duval and G. Ronkay in January 2006, Seima Protection Forest, 12°10.950 N, 107°01.100 E, 190 m a.s.l.; CBC00627, HNHM 2011.2.14, mature male and nuliparous female, in spirit, skulls removed, collected by Ith S., G. Csorba and Phauk S. in February 2010, Veun Sai Proposed Protected Forest, 14°01.478 N, 106°43.978 E, 110 m a.s.l.; CBC00641, HNHM 2011.2.13, mature male and nuliparous female, in spirit, male with skull removed, collected by Ith S., G. Csorba and Phauk S. in February 2010, Veun Sai Proposed Protected Forest, 14°02.210 N, 106°44.278 E, 110 m a.s.l.; CBC01128, CBC01142, juvenile and mature male, in spirit, skulls removed, collected by N. Furey, Ith S. and T. Gorfol in August 2010, Veun Sai Proposed Protected Forest, 14°02.832 N, 106°41.623 E and 14°01.818 N, 106°43.285 E respectively.

Murina cyclotis: HNHM 2006.34.2, parous female, in spirit, skull removed, collected by G. Csorba, L. Duval and G. Ronkay in January 2006, Bokor National Park, 10°36.100 N, 104°05.167 E, 270 m a.s.l.; HNHM 2006.34.38, mature male, in spirit, skull removed, collected by G. Csorba, L. Duval and G. Ronkay in January 2006, Seima Protection Forest, 12°15.733 N, 107°03.817 E, 360 m a.s.l.; HNHM 2011.2.9, HNHM 23840, nuliparous and parous females, in spirit, skull of latter removed, collected by G. Csorba, N. Furey, Ith S. and T. Gorfol in February and August 2010, Veun Sai Proposed Protected Forest, 13°59.971 N, 106°42.034 E and 14°03.413 N, 106°43.516 E (170 m a.s.l.) respectively; CBC01277, CBC01278, CSOCA266, nuliparous females, in spirit, skulls removed, collected by G. Csorba, N. Furey and Ith S. in March 2011, Baray Mountains, Preah Vihear Protected Forest, 14°01.231 N, 105°37.133 E, 200 m a.s.l.

Kerivoula picta: HZM 1.35275, female, in spirit, skull removed, collected by J. Walston in December 2001, Prek Kampues, Kandal Province, 11°27' N, 104°54' E; CBC01262, CBC01286, mature male and nuliparous female, in spirit, skulls removed, collected by N. Furey, G. Csorba and Ith S. in February and March 2011, O'Cheuteal, Preah Vihear Protected Forest, 14°00.686 N, 105°39.900 E, 130 m a.s.l.; CBC01282, CSOCA272, CSOCA273, two mature males and one female, in spirit, skulls removed, collected by G. Csorba, N. Furey and Ith S. in March 2011, Baray Mountains, Preah Vihear Protected Forest, 14°01.231 N, 105°37.133 E, 200 m a.s.l.