

## BATS OF CAT TIEN NATIONAL PARK: DIVERSITY, ECHOLOCATION AND TAXONOMIC REMARKS

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**ABSTRACT:** Cat Tien National Park is a hotspot in Vietnam for biodiversity research and conservation. The park, with its extensive areas of primary forest, wetland habitats and large mammal populations, is known worldwide for its outstanding landscapes and biodiversity. Prior to 2007, several bat surveys were carried out in the park. However, data on the park's bats is still limited and the status of previous records of a number of species is unclear. Between 2008 and 2015, the author conducted a series of bat surveys in the park with emphases on taxonomy and echolocation. Bats were captured using mist nets and four-bank harp traps. Echolocation calls were recorded from inside a flight tent and in natural habitats. Results from the surveys and a literature review indicated that Cat Tien National Park is currently known to be home to 47 bat species belonging to 22 genera and 7 families. Of these, 19 species belonging to 10 genera and 5 families were recorded during field surveys between 2008 and 2015. This paper provides the most recent review of bat species from Cat Tien National Park. Remarks on taxonomy and echolocation frequencies of species complexes are also given in order to assist further research, training, education, management and conservation.

*Keywords:* Chiroptera, conservation, echolocation, Mammalia, training, taxonomy.

### INTRODUCTION

Cat Tien National Park (CTNP) is located in southern Vietnam. With a total area of 73,878 ha, CTNP contains one of the largest remaining natural forests in Vietnam [14]. It "supports a variety of habitat types, including primary and secondary lowland evergreen forest; primary and secondary lowland semi-evergreen forest; freshwater wetlands with open lakes and seasonally inundated grasslands; flooded forest; and a range of secondary habitat types, including grassland and areas" [14]. Prior to the present study, the bat fauna of CTNP had received attention from some scientists and lists of species were included in several publications and grey literature [2]. Of these bat species, several were rarely recorded from other localities in Vietnam and the status of many was unclear. Between 2008 and 2015, the author conducted a series of field surveys in CTNP with an emphasis on bats. Results from the surveys provided new findings with interesting data on taxonomy of bats. This paper presents the most updated review of species diversity and taxonomic remarks of bats from CTNP with recommendation for action plans in the future.

### MATERIALS AND METHODS

#### Bat capture and identification

Field surveys were conducted at various habitats of the park, including the sites where specious bat species were recorded in previous surveys. Bats were captured and handled in the field following the guidelines approved by the American Society of Mammalogists [11]. Four-bank harp traps [6] and mist nets of various sizes (2.6 m [height], 3-12 m [length], mesh size: 16 mm × 16 mm) were employed to capture bats. Each captured bat was removed carefully from the trap or net and placed individually in a cotton bag. Their external measurements were taken following Bates & Harrison (1997) [1], Csorba et al. (2003) [5], Vu Dinh Thong (2011) [15] and Vu Dinh Thong et al. (2012, 2012, 2012) [19, 20, 21]. For taxonomic assessment, external measurements were taken in the field as follows: FA, forearm length: from the extremity of the elbow to the extremity of the carpus with the wings folded; EH, ear height: length of ear conch; TIB, tibia length: from the knee joint to the ankle; HF, hind-foot length: from the extremity of the heel behind the os calcis to the extremity of the

longest digit, excluding the hairs or claws; Tail, tail length: from the tip of the tail to its base adjacent to the body. Reproductive status and age were assessed following Racey (2009) [9] and Brunet-Rossinni & Wilkinson (2009) [3], respectively. Some adult males of certain species whose identity could not be confirmed in the field, were collected for taxonomic examination at the Institute of Ecology and Biological Resources. To reduce the influence of seasonal variations in body mass, juveniles and pregnant females were excluded from analyses.

#### Echolocation recordings and analyses

Echolocation calls were obtained from recordings in three situations: handheld, inside a flight-tent (4 m [length] × 4 m [width] × 2 m [height]) and hand release using a PCTape system at a sampling rate of 480 kHz. Batman software, which displays color sonagrams of the detected echolocation signals in real time, was used to obtain high quality sound sequences. Additionally, continuous recordings were also carried out in front of caves and under forest canopies to obtain echolocation calls when bats were leaving their roosts and foraging in natural habitat. All echolocation signals from manual and continuous recordings were analysed using Selena software to measure the constant frequency of the second harmonic (CF2) of each call. The PCTape system, Batman and Selena software are custom-made by the University of Tübingen, Germany.

## RESULTS AND DISCUSSION

### Bat diversity of CTNP

A total of 19 bat species belonging to 10 genera and 5 families were captured during the field surveys between 2008 and 2015 (table 1). Of which, *Hipposideros grandis* and *H. cineraceus* were commonly recorded (during almost all trapping nights at every study site) while *Myotis rosseti* appeared as the rarest species with only one individual recorded at a trapping site within the administrative zone of the headquarters of the national park.

Results from the recent surveys and

literature review indicate that CTNP is home to a highly diverse bat fauna, which currently comprises 47 species belonging to 22 genera, 7 families (table 2). However, many species, which had been listed from CTNP in the literature, were not recorded during the surveys between 2008 and 2015.

### Taxonomic remarks

Taxonomic status of *Rhinolophus affinis* and *R. pusillus* from CTNP is still unconfirmed because their morphological features do not fit well the diagnoses of respective species from other localities in Vietnam. Concise notes and an image of each species are given below.

*Rhinolophus affinis*: Two individuals of this species were captured from CTNP. The connecting process and sella (fig. 1) of these two individuals compare favourably with *Rhinolophus affinis* (sensu Csorba et al., 2003). However, their body size and the shape of the anterior nose leaf (horseshoe) differ markedly from *Rhinolophus affinis*, which is commonly observed in Tam Dao National Park, northern Vietnam and other localities in the country. Echolocation frequency of this unusual form (83.1-83.7 kHz) is distinctly higher than that of the 'typical' *Rhinolophus affinis* (72.9-73.8 kHz) (Vu Dinh Thong 2011, 2014a, 2014b) [15, 17, 18] (table 3). Extensive studies of the taxonomy, echolocation and genetics of this apparently aberrant population to determine its taxonomic status. In the meantime, it is here treated as *Rhinolophus cf. affinis*.

*Rhinolophus pusillus*: Five individual of this species were recorded from the recent surveys. To date, morphological identification is unsatisfactory since *pusillus* is probably a species complex rather than one discrete taxon [16, 17]. Mean (min-max; sample size) of FA, EH, TIB, HF and Tail of these five individuals are 36.1 mm (35.8-36.9 mm; n=4), 14.8 mm (13.5-18.0 mm; n=5), 14 mm (n=1), 6.2 mm (n=1), 17.5 mm (n=1), respectively. Echolocation frequency values for the second harmonic of each calls of the captured individuals is 117.5 kHz (114.6-119.0 kHz; n=4).



Figure 1. *Rhinolophus* cf. *affinis* from CTNP



Figure 2. *Hipposideros armiger* (A) and *H. griffini* (B)

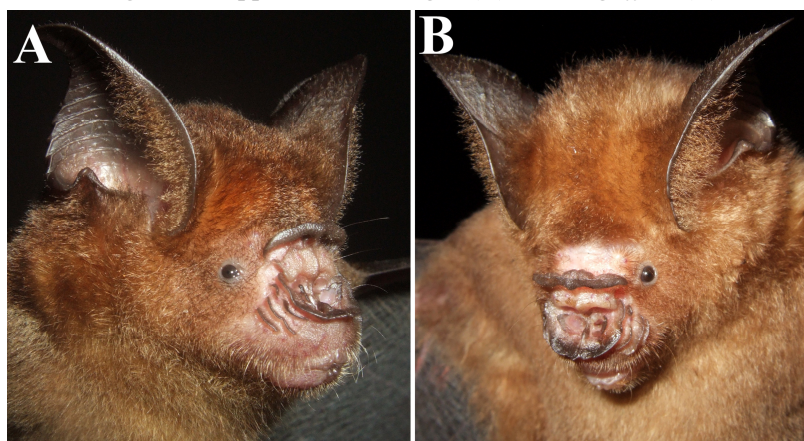


Figure 3. *Hipposideros larvatus* (A) and *H. grandis* (B)

Table 1. Bat species recorded from CTNP between 2008 and 2015

No.	Common name	Latin name	Conservation status*	Taxonomic notes
	<b>Fruit bats</b>	<b>Pteropodidae</b>		
1	Leschenault's Rousette	<i>Rousettus leschenaulti</i>	LC	Confirmed
2	Horsfield's short-nosed fruit bat	<i>Cynopterus horsfieldi</i>	LC	Confirmed
3	Ratanaworabhan's Fruit Bat	<i>Megaerops niphanae</i>	LC	Confirmed
4	Dawn Bat	<i>Eonycteris spelaea</i>	LC	Confirmed
5	Hill Long-tongued Fruit Bat	<i>Macroglossus sobrinus</i>	LC	Confirmed
	<b>False Vampire Bats</b>	<b>Megadermatidae</b>		
6	Lesser False Vampire	<i>Megaderma spasma</i>	LC	Confirmed
7	Greater False Vampire	<i>Megaderma lyra</i>	LC	Confirmed
	<b>Old World leaf-nosed bats</b>	<b>Hipposideridae</b>		
8	Griffin's Leaf-nosed Bat	<i>Hipposideros griffini</i>	N/A	Confirmed
9	Grand Leaf-nosed Bat	<i>Hipposideros grandis</i>	N/A	Confirmed
10	Cantor's Leaf-nosed Bat	<i>Hipposideros galeritus</i>	LC	Confirmed
11	Andersen's Leaf-nosed Bat	<i>Hipposideros pomona</i>	LC	Confirmed
12	Least Leaf-nosed Bat	<i>Hipposideros cineraceus</i>	LC	Confirmed
	<b>Horseshoe bats</b>	<b>Rhinolophidae</b>		
13	Indochinese Horseshoe Bat	<i>Rhinolophus chaseni</i>	N/A	Confirmed
14	Intermediate Horseshoe Bat	<i>Rhinolophus affinis</i>	N/A	Unconfirmed
15	Lesser Brown Horseshoe Bat	<i>Rhinolophus stheno</i>	LC	Confirmed
16	Accuminate Horseshoe Bat	<i>Rhinolophus acuminatus</i>	LC	Confirmed
17	Least Horseshoe Bat	<i>Rhinolophus pusillus</i>	N/A	Unconfirmed
	<b>Vesper bats</b>	<b>Vespertilionidae</b>		
18	Thick-thumbed Myotis	<i>Myotis rosseti</i>	LC	Confirmed
19	Lesser Asiatic Yellow House Bat	<i>Scotophilus kuhlii</i>	LC	Confirmed

Note: \*Conservation status was assessed following the 2015 IUCN Red List of the Threatened Species (<http://www.iucnredlist.org/>) [13]; N/A=not available; LC=Least Concern.

*Hipposideros armiger*: No individual of this species was captured during the surveys between 2008 and 2015. Borissenko & Ivanova (2003) [2] confirmed its occurrence at CTNP. It should be noted that *Hipposideros armiger* and *H. griffini* are quite similar in external morphology (fig. 2). Detailed information on the taxonomy, echolocation and distribution of *H. griffini* in Vietnam is given in Vu Dinh Thong (2012) [16] and Vu Dinh Thong et al. (2012) [20]. These two species are distinguished in echolocation frequency, craniodental characteristics and genetics. An examination of the material of '*Hipposideros armiger*' in Borissenko and Ivanova (2003) is required for a taxonomic confirmation. It is likely that both species inhabit CTNP.

*Hipposideros larvatus*: This was not recorded during the recent surveys between 2008 and 2015. However, Borissenko and Ivanova (2003) included its occurrence at CTNP. To date, *Hipposideros larvatus* is still treated as a species complex. In fact, this species is indistinguishable from *H. grandis* in morphology (fig. 3) but distinct in genetics (sensu Kruskop, 2013) [8]. *H. larvatus* is smaller than *H. grandis* with a forearm length of 51.5-58.6 mm and 57.6-64.2 mm, respectively (Kruskop 2013). It is remarkable that echolocation frequency of *H. larvatus* (85-1-95.0 kHz; n=24) is lower than that of *H. grandis* (94.9-104.6; n=109) [15]. Within CTNP, echolocation frequency of *H. grandis* is in a range of 94.1-98.2 (n=22; table 3). Further studies in systematics and echolocation of these

two species are clearly needed in coming time.

*Rhinolophus chaseni*: This species was originally described from Con Dao National Park of Vietnam by Sanborn (1939) [10]. It was subsequently treated as a either synonym or subspecies of *Rhinolophus borneensis* [2, 4, 12]. However, Francis (2008) [7] classified it as a distinct species, which was followed by Vu

Dinh Thong (2011), Kruskop (2013) [15, 8]. Without doubt, the material of *Rhinolophus borneensis* from Vietnam requires an examination for taxonomic confirmation.

Selected morphological measurements and echolocation frequencies of hipposiderids and rhinolophids recorded from CTNP are given in table 3.

Table 2. An updated species composition of bats from Cat Tien National Park based on the present study results and literature sources

No.	Common name	Latin name	Source	Taxonomic notes
<b>Fruit bats</b>		<b>Pteropodidae</b>		
1	Leschenault's Rousette	<i>Rousettus leschenaulti</i>	BI, Kr, T	Confirmed
2	Lesser Dog-faced Fruit Bat	<i>Cynopterus brachyotis</i>	BI, Kr	Confirmed
3	Horsfield's short-nosed fruit bat	<i>Cynopterus horsfieldi</i>	Kr, T14, T	Confirmed
4	Greater Shortnosed Fruit Bat	<i>Cynopterus sphinx</i>	BI	Confirmed
5	Ratanaworabhan's Fruit Bat	<i>Megaerops niphanae</i>	BI, T	Confirmed
6	Dawn Bat	<i>Eonycteris spelaea</i>	BI, T	Confirmed
7	Hill Long-tongued Fruit Bat	<i>Macroglossus sobrinus</i>	BI, Kr, T	Confirmed
<b>Emballonurids</b>		<b>Emballonuridae</b>		
8	Bare-rumped Sheath-tail-bat	<i>Saccolaimus saccolaimus</i>	BI	Unconfirmed
<b>False Vampire Bats</b>		<b>Megadermatidae</b>		
9	Lesser False Vampire	<i>Megaderma spasma</i>	BI, Kr, T	Confirmed
10	Greater False Vampire	<i>Megaderma lyra</i>	BI, Kr, T	Confirmed
<b>Old World leaf-nosed bats</b>		<b>Hipposideridae</b>		
11	Tail-less Leaf-nosed Bat	<i>Coelops frithii</i>	BI, Kr	Confirmed
12	Griffin's Leaf-nosed Bat	<i>Hipposideros griffini</i>	T12, T	Confirmed
13	Great Himalayan Leaf-nosed Bat	<i>Hipposideros armiger</i>	BI	Confirmed
14	Grand Leaf-nosed Bat	<i>Hipposideros grandis</i>	T11, Kr, T	Confirmed
15	Horsfield's Leaf-nosed Bat	<i>Hipposideros larvatus</i>	BI	Unconfirmed
16	Cantor's Leaf-nosed Bat	<i>Hipposideros galeritus</i>	BI, Kr, T	Confirmed
17	Andersen's Leaf-nosed Bat	<i>Hipposideros pomona</i>	BI, Kr, T	Confirmed
18	Least Leaf-nosed Bat	<i>Hipposideros cineraceus</i>	BI, Kr, T	Confirmed
<b>Horseshoe bats</b>		<b>Rhinolophidae</b>		
19	Indochinese Horseshoe Bat	<i>Rhinolophus chaseni</i>	T11, Kr, T	Confirmed
20	Bornean Horseshoe Bat	<i>Rhinolophus borneensis</i>	BI	Unconfirmed
21	Intermediate Horseshoe Bat	<i>Rhinolophus affinis</i>	BI, Kr, T	Unconfirmed
22	Lesser Brown Horseshoe Bat	<i>Rhinolophus stheno</i>	BI, T	Confirmed
23	Accuminate Horseshoe Bat	<i>Rhinolophus acuminatus</i>	BI, T	Confirmed
24	Blyth's Horseshoe Bat	<i>Rhinolophus lepidus</i>	BI	Unconfirmed
25	Least Horseshoe Bat	<i>Rhinolophus pusillus</i>	BI, Kr, T	Unconfirmed
26	Great Woolly Horseshoe Bat	<i>Rhinolophus luctus</i>	BI, Kr	Confirmed
<b>Vesper bats</b>		<b>Vespertilionidae</b>		
27	Hardwicke's Woolly Bat	<i>Kerivoula hardwickii</i>	BI	Confirmed
28	Papillose Woolly Bat	<i>Kerivoula papillosa</i>	BI	Confirmed
29	Himalayan Whiskered Myotis	<i>Myotis siligorensis</i>	BI, Kr	Confirmed
30	Nepalese Whiskered Myotis	<i>Myotis muricola</i>	BI, Kr	Confirmed
31	Peters's Myotis	<i>Myotis ater</i>	BI, Kr	Confirmed

32	Thick-thumbed Myotis	<i>Myotis rosseti</i>	BI, Kr, T	Confirmed
33	Myotis	<i>Myotis (Leuconoe) sp.</i>	BI	Unconfirmed
34	Disk-footed Bat	<i>Eudiscopus denticulus</i>	BI	Confirmed
35	Common Thick-thumbed Bat	<i>Glischropus tylopus</i>	BI	Confirmed
36	Kelaart's Pipistrelle	<i>Pipistrellus ceylonicus</i>	BI, Kr	Confirmed
37	Javan Pipistrelle	<i>Pipistrellus javanicus</i>	BI, Kr	Confirmed
38	Coromandel Pipistrelle	<i>Pipistrellus coromandra</i>	BI, Kr	Confirmed
39	Cadorna's pipistrelle	<i>Hypsugo cadornae</i>	Kr	Confirmed
40	Lesser Bamboo Bat	<i>Tylonycteris pachypus</i>	BI, Kr	Confirmed
41	Greater flat-haded Bat	<i>Tylonycteris robustula</i>	Kr	Confirmed
42	Peters's trumpet-eared Bat	<i>Phoniscus jagorii</i>	Kr	Confirmed
43	Walston's tube-nosed Bat	<i>Murina walstoni</i>	Kr	Confirmed
44	Lesser Asiatic Yellow House Bat	<i>Scotophilus kuhlii</i>	BI, Kr, T	Confirmed
45	Blanford's Bat	<i>Hesperoptenus blanfordi</i>	Kr	Confirmed
	<b>Bent-winged Bat</b>	<b>Miniopteridae</b>		
46	Large Bent-winged Bat	<i>Miniopterus magnater</i>	BI, Kr	Confirmed
47	Small Long-fingered Bat	<i>Miniopterus pusillus</i>	BI, Kr	Confirmed

T11=Vu Dinh Thong (2011) [15]; T12=Vu Dinh Thong (2012) [16]; Kr=Kruskop (2013) [8]; BI=Alex V. Borissenko and Natalia V. Ivanova (unpublished report) [2]; T=this study.

Table 3. External measurements (in mm) and echolocation frequency (in kHz) of hipposiderids and rhinolophids recorded from CTNP during this study. Values are given as mean  $\pm$  SD, minimum-maximum, sample size in parentheses. Abbreviations are defined in the "Material and Methods".

Species	n	Morphological measurements					Echolocation
		FA	EH	TIB	HF	Tail	
<i>H. cineraceus</i>	9	34.6 $\pm$ 0.6	15.0 $\pm$ 0.4	14.8 $\pm$ 0.3	4.9 $\pm$ 0.4	25.4 $\pm$ 1.7	153.6 $\pm$ 3.4
		33.8-35.3	14.5-15.5	14.4-15.3	4.1-5.5 (7)	23.0-28.4	147.8-159.5
<i>H. galeritus</i>	2	47.0; 49.0	14.5;	20.1; 20.5	6.6; 6.7	39.0; 43.0	110.1; 112.1
			16.0				
<i>H. grandis</i>	22	59.8 $\pm$ 1.4	21.3 $\pm$ 0.8	-	-	-	96.3 $\pm$ 1.1
		56.5-62.0	20.0-23.0	21.2; 22.1	9.4; 10.0	33.4; 34.3	94.1-98.2
<i>H. griffini</i>	5	85.4 $\pm$ 1.9	29.2 $\pm$ 0.6	36.7 $\pm$ 1.4	15.4 $\pm$ 0.4	-	77.7 $\pm$ 0.9
		83.3-87.2	28.5-30.0	35.2-38.7	14.8-15.8	-	76.6-79.2
<i>H. pomona</i>	3	41.8 $\pm$ 0.9	22.2 $\pm$ 0.8	18.8 $\pm$ 0.8	5.8 $\pm$ 1.3	33.3 $\pm$ 3.2	-
		40.8-42.6	21.5-23.0	18.4-19.1	4.3-6.9	31.0-37.0	122.5; 127.9 (2)
<i>R. accuminatus</i>	1	45.87	18.18	21.39	10.04	25.43	91.4
<i>R. cf affinis</i>	2	48.3; 48.5	18.0;	21.2; 21.5	8.9; 9.5	24.2; 25.0	83.1; 83.5
<i>R. chaseni</i>	3	46.5 $\pm$ 0.2	18.3 $\pm$ 1.3	18.4 $\pm$ 0.1	8.0 $\pm$ 0.2	22.2 $\pm$ 2.1	78.4 $\pm$ 1.8
		46.3-46.6	17.0-19.5	18.3-18.5	7.8-8.3	19.8-23.6	76.7-80.2
<i>R. pusillus</i>	5	36.1 $\pm$ 0.5	14.8 $\pm$ 1.8	-	-	-	117.5 $\pm$ 1.9
		35.8-36.9	13.5-18.0	14 (1)	6.2 (1)	17.5 (1)	114.6-119.0 (4)
<i>R. stheno</i>	3	47.0 $\pm$ 0.4	18.5 $\pm$ 0.5	20.5 $\pm$ 0.4	8.4 $\pm$ 0.2	20.9 $\pm$ 1.1	87.0 $\pm$ 0.2
		46.7-47.5	18.0-19.0	20.2-20.9	8.2-8.6	19.6-21.6	86.8-87.1

## CONCLUSION

Cat Tien National Park is currently known as a home to 47 species, 22 genera, and 7 families. Of these, 7 species are unconfirmed and at least 5 'species' probably comprise species complexes: *Rhinolophus affinis*, *R. pusillus*, *Hipposideros galeritus*, *H. larvatus* and *H. pomona*. Echolocation frequencies and morphological parameters of these five 'species' from CTNP differ considerably from other populations in Vietnam and worldwide.

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## ĐÔI CỦA VƯỜN QUỐC GIA CÁT TIÊN: TÍNH ĐA DẠNG, TIẾNG KÊU SIÊU ÂM VÀ NHỮNG NHẬN ĐỊNH VỀ PHÂN LOẠI HỌC

**Vũ Đình Thống**

Viện Sinh thái và Tài nguyên sinh vật, Viện Hàn lâm KH & CN Việt Nam

### TÓM TẮT

Vườn Quốc gia Cát Tiên là một điểm nóng của Việt Nam đối với công tác nghiên cứu và bảo tồn đa dạng sinh học. Vườn quốc gia này cũng nổi tiếng trên thế giới bởi vẻ đẹp nổi bật của cảnh quan và giá trị đa dạng sinh học với sự tồn tại diện tích rừng nguyên sinh rộng, sinh cảnh đất ngập nước và những quần thể thú lớn. Trước năm 2007, đã có một số đợt điều tra về đôi ở vườn quốc gia này. Tuy nhiên, những dẫn liệu về đôi ở đây còn rất hạn chế và nhiều ghi nhận trước đây chưa chắc chắn. Từ 2008 đến 2015, tác giả đã điều tra về đôi ở vườn quốc gia này với trọng tâm nghiên cứu về phân loại học và tiếng kêu siêu âm. Đôi được bắt bằng bẫy thụ cầm loại bốn khung dây và lưới mờ. Tiếng kêu siêu âm được ghi trong những tình huống khác nhau, bao gồm những tình huống đôi ở trong màn bay và khi đôi kiếm ăn trong sinh cảnh sống tự nhiên của chúng. Kết quả điều tra và tổng hợp từ những tài liệu đã công bố trước đây cho thấy Vườn Quốc gia Cát Tiên là nơi sinh sống của 47 loài đôi thuộc 22 giống, 7 họ. Trong đó, 19 loài thuộc 10 giống, 5 họ được ghi nhận qua các đợt điều tra thực địa từ năm 2008 đến 2015. Bài báo này cung cấp dẫn liệu cập nhật nhất về thành phần loài đôi ở Vườn Quốc gia Cát Tiên. Thêm vào đó, những nhận định về phân loại học và tần số tiếng kêu siêu âm của những tổ hợp loài cũng được bàn luận làm cơ sở cho công tác nghiên cứu, đào tạo, giáo dục, quản lý và bảo tồn.

*Từ khóa:* Chiroptera, bảo tồn, tiếng kêu siêu âm, Mammalia, đào tạo, phân loại học.

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