



**The NEF Bio-ecological Nature Conservation Project
in Mountainous Region of North Vietnam**

FINAL REPORT – MAMMAL GROUP

REPORT PERIOD: 2018-2021

Hanoi, 01/2022

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1. GENERAL INFORMATION

1.1 Group name and names of all members

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2. RESEARCH

2.1. Abstract

This project examines mammal diversity of karst-dwelling species in the northeastern limestone region of Vietnam using morphological and molecular data. Based on field survey data and results from phylogenetic analyses, recommendations for appropriate conservation measures for better protecting threatened species are provided. In addition, the project supports capacity building for two students, one master and one Ph.D. in field surveys, molecular and morphological analyses, and publishing skills, which together help them become leading scientists in the country.

In total, six field surveys were conducted in four protected areas in northeastern Vietnam, including two trips in each of the following: Bac Me Nature Reserve, Ha Giang Province, Nam Xuan Lac Habitat and Species Conservation Area, Bac Kan Province Chu Nature Reserve, Tuyen Quang Province, and Phia Oac-Phia Den National Park, Cao Bang Province. We documented 39 species of mammals in Nam Xuan Lac Habitat and Species Conservation Area, 58 in Cham Chu Nature Reserve, 51 in Bac Me Nature Reserve, and 34 in Phia Oac-Phia Den National Park.

For the training of graduate students, Ms. Nguyen Thi Tham is entering the final year of her doctoral program at the University of Science, Vietnam National University, Hanoi. Using the data collected under this project, she has published one paper in a top national journal and two others in international venues. Two additional papers under preparation using data generated under this project are aimed for publication in international journals. Mr. Ly Ngoc Tu completed his master's degree at the Institute of Ecology and Biological Resources. During this project, he also published two papers in international journals and one in a national journal. He is also involved in the two other papers under preparation. Mr. Ly Ngoc Tu is planning to enroll in a doctoral program soon.

As a result of this project, the team has published six papers, one in a national and five in international journals. Two more papers are under preparation with one describing a new species of tree shrew, genus *Tupaia*. Based on the collected data, we have made a number of recommendations for conservation related to small mammal fauna in the study area. We recognize that small mammals have received little attention from local and central government authorities as well as international communities in terms of protection although they play an important role in providing critical ecosystem services. The situation needs to be changed in the future to save this unique landscape from further adverse impact due to anthropogenic threats.

2.2. Background of the study

This project examines mammal diversity of karst-dwelling species in the northeastern limestone region of Vietnam using morphological and molecular data. Based on field survey data and taxonomic status of existing and newly described taxa, we will recommend appropriate conservation measures for better protecting threatened species.

The project has following objectives:

- To assess the morphological and molecular diversity of karst-dwelling mammals in the limestone forest of northeastern Vietnam;
- To develop a list of mammal species and their distribution in the study areas;
- To recover evolutionary processes that influence the mammal community in the region using molecular data;
- To evaluate conservation status of different threatened groups based on field survey data;
- To recommend conservation measures for better protect species of special concern.

2.3. Literature review

Vietnam is situated in Indochina Peninsula, which is home to very high diversity of forest mammals. Up to now, more than 500 mammal species have been recognized in the region. In terms of richness in species diversity and endemism, Vietnam is widely considered a biodiversity hotspot not only in Southeast Asia but also in the world (Tordoff *et al.* 2007, 2012). However, the mammal fauna in Vietnam has experienced a steep decline in recent decades. Specifically, one species went extinct in Vietnam in 2011 and more than 60 species are currently listed as Vulnerable or higher in the IUCN Red List (Brook *et al.*, 2012; IUCN, 2020), although Vietnam's forest covers moderately risen from 37% in 2006 (1970/QĐ/BNN-KL) to 41.89% in 2019 (1423/QĐ-BNN-TCLN) (Ministry of Agriculture and Rural Development decision; 2006, 2020). Overexploitation mostly by hunting and snaring has been regarded as one of the most severe threats to mammals and other vertebrates in the country.

Northeastern limestone region of Vietnam contains large karst features surrounded by soil mountain (Sterling & Hurley, 2005; Sterling *et al.*, 2006). Karst towers form an extensive but highly dissected plateau (Sterling *et al.*, 2006). The region possesses one of the highest concentrations of endemic species (Clements *et al.*, 2006). There are several remarkable mammals endemic to the northeast region, including the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*), the Daovantien's Limestone Rat (*Tonkinomys daovantieni*), and the Cao-vit Black Crested Gibbon (*Nomacus nasutus*).

Field surveys between 1998 and 2011 recorded 68 small mammal species, consisting of 1 Scandentia, 10 Eulipotyphla, 35 Chiroptera and 22 Rodentia in Tuyen Quang and Ha Giang

provinces (Nguyen Truong Son *et al.*, 2011). A number of new endemic small mammals species in the karst area of the region, such as the Daovantien's Limestone Rat *Tonkinomys daovantieni* (Musser *et al.*, 2006), *Hipposideros khaokhouayensis* (Vu Dinh Thong *et al.*, 2008), the Dong Bac's trident bat *Aselliscus dongbacana* (Vuong Tan Tu *et al.*, 2015), the Orlovi's Mole *Euroscaptor orlovi* (Zemlemerova *et al.*, 2016), has continued to be discovered. Small mammal fauna in northeastern Vietnam have also been studied in some protected areas, such as Huu Lien Nature Reserve (Lang Son Province) (Lunde *et al.*, 2007); Ba Be National Park (Bac Kan Province) (Furey *et al.*, 2007; Nguyen Truong Son & Vu Dinh Thong, 2008); Tay Con Linh Nature Reserve (Ha Giang Province) (Lunde *et al.*, 2003), Na Hang Nature Reserve (Tuyen Quang Province) (Nguyen Truong Son & Vu Dinh Thong, 2008). However, there has been little research to record small mammals in Cham Chu Nature Reserve (Tuyen Quang Province), Bac Me Nature Reserve (Ha Giang Province), Nam Xuan Lac Species and Habitat Conservation Area (Bac Kan Province), and Phia Oac-Phia Den (Cao Bang Province).

After reviewing extensive literature related to the mammal fauna of northeastern Vietnam, we propose to focus on endemic and rare groups in the region. Although the groups play an important role in elucidating the evolution as well as biogeography of this unique karst region, they are still poorly studied. We will pay special attention to the following taxa:

Rodents:

- Genus *Tonkinomys* (Musser *et al.* 2006) – This genus is endemic to northeastern Vietnam, and only known from the limestone tower in Huu Lien Nature Reserve. Additional research can shed light on the distribution of the species, e.g., whether it has a broader distribution or not, and/or on the taxonomy of the poorly known genus, e.g., it has more than one species.
- In addition, the following genera, *Typhlomys*, *Belomys*, *Petaurista*, *Euroscaptor*, which are distributed only in northeastern Vietnam, will be studied in detail.

Shrews:

- Genera *Crocidura*, *Blarinella* – The genera have a high level of diversity in limestone areas in northeastern Vietnam, listed as rare to vulnerable in the IUCN Redlist, and restricted to limestone karst.

Bats:

- *Rhinolophus macrotis* complex; *Rhinolophus pearsonii* and *Rhinolophus yunanensis*; *Rhinolophus paradoxolophus* and *Rhinolophus marshalii*: the taxonomy of this group is complicated. They are featured distribution in limestone karst.
- *Hipposideros khaokhouayensis*, *Hipposideros lylei*, *Coelops frithii*, *Barbastella darjelingensis*, *Murina chrysochaetes*: rare species and distributed in limestone karst only.

2.4. Materials and methods

Survey time

For the first year (October 2018 – September 2019), three field surveys were conducted:

- Survey 1 from 24 to 31 October 2018 in Cham Chu Nature Reserve, Nam Luong Village, Phu Luu Commune, Ham Yen District, Tuyen Quang Province.
- Survey 2 from 12 to 19 April 2019 in Cham Chu Nature Reserve, Cao Duong Village, Yen Thuan Commune, Ham Yen District, Tuyen Quang Province.
- Survey 3 from 24 to 31 May 2019 in Bac Me Nature Reserve (Minh Ngoc, Thuong Tan, Lac Nong communes), Bac Me District, Ha Giang Province.

For the second year (October 2019 – September 2020), three additional field trips were undertaken:

- Survey 1 from 14 to 21 October 2019 in Bac Me Nature Reserve, Ha Giang Province
- Survey 2 from 20 to 27 May 2020 in Phia Oac-Phia Den, Cao Bang Province
- Survey 3 from 24 to 31 August 2020 in Nam Xuan Lac Habitat and Species Conservation Area, Bac Kan Province

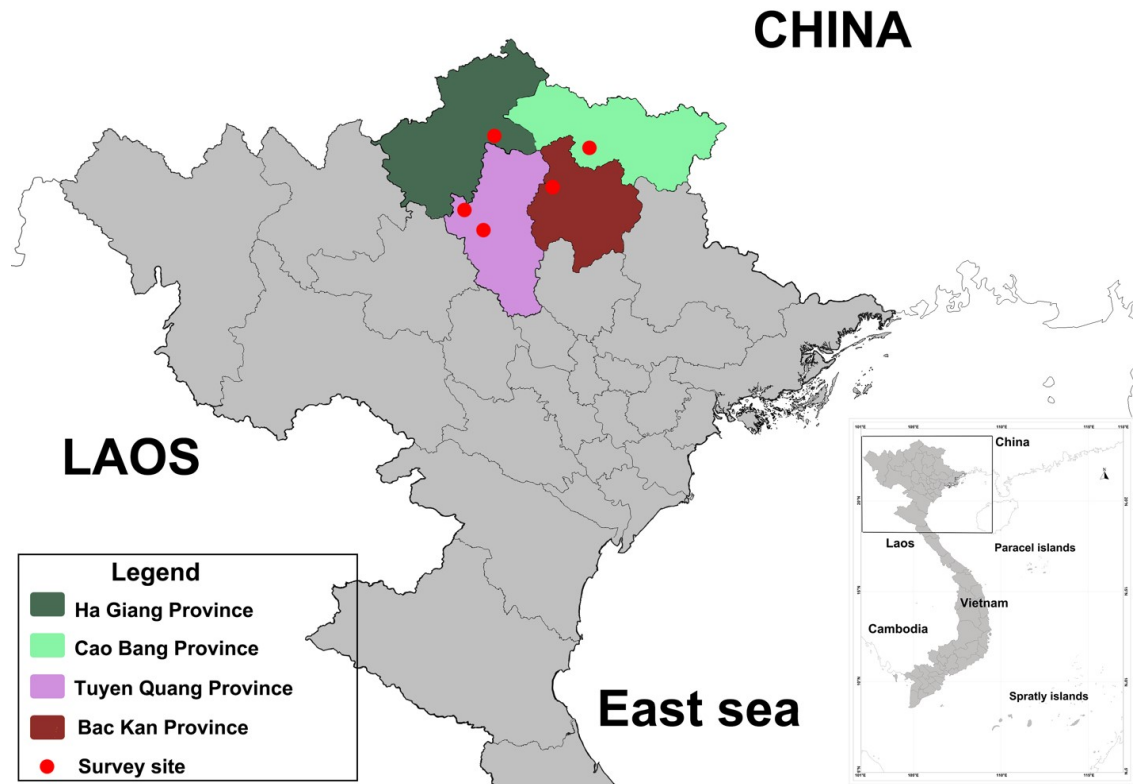
For the third year (October 2020 – November 2021), two last surveys were completed:

- Survey 1 from 03 to 10 October 2020 in Phia Oac-Phia Den National Park, Nguyen Binh District.
- Survey 2 from 5 to 12 November 2021 in Nam Xuan Lac Habitat and Species Conservation Area, Bac Kan Province

Interview to select survey sites

Interviews with local communities were undertaken to gather basic information of mammal fauna to determine suitable survey sites in the area. Interviewees include the Reserve's staff, forest rangers, and hunters. The survey areas and points are depicted in the diagram below.

Figure 1. Map of Northern Vietnam with the location of survey sites on provinces.



Specimen collection

Different types of traps were used in the survey, including box, cage, and cylinder traps and mist net. Box and cage traps are suitable for catching rodents and foxes. Sherman traps with larger size were used to capture species of *Maxomys*, *Niviventer*, *Rattus*, *Mus*, and shrews. Sherman traps with medium size were used for members of *Crociodura*, *Brarinella*, *Chodsigoa*, *Episoriculus*, *Hylomys*, and water shrews. Tomahawk traps with large size were deployed to collect taxa of *Leopoldamys*, *Bandicota*, *Berylmys* and local traps used for *Callosciurus*, *Dremomys*, *Tamiops*, *Menetes*. Depending on habitat and surrounding environment, traps were set on the ground or fallen tree trunks along streams. Pitfall traps made of cups worked well with small-sized rodents, the genus *Mus*, and shrews of *Crociodura*, *Brarinella*, *Chodsigoa*, *Episoriculus*, *Hylomys* and even larger-sized species of *Niviventer*. We used 20 traps made of plastic set up along trails or observable shrew tracks. The traps manufactured in Japan and recommended by the American Society of Mammalogists (Sikes et al. 2011). Rodents and shrews were directed to pitfall traps by a fence made of nylon with 0.5m tall and fixed to the ground by nails every 3-4m. The fence ran through the middle of each trap. Each line consisted of 10-20 traps with a total length of 50-100m.

Traps were set along suitable habitat. The distance between traps depending on the complexity of the habitat. The more complex the closer the traps were placed. Traps were set

on tree branches, climbers, and on the ground. Traps were marked by bright lines (often red) and numbered. Traps were numbered to avoid being missed during checking. Baits used in traps had smell attractive to rodents from a long distance and was sticky and slowly degraded. They consisted of a mixture of peanut butter, flour, raisin, and salted pork in a ratio of 6:2:2:1. In addition, other local baits, such as cassava, sticky rice with peanut, and dry fruit, were also used. Thin slides of copra and banana were used with Sherman traps. In most cases, baits were changed every day at dusk to lure nocturnal species. However, as some species are also active during the daytime, baits were also changed in the morning during the trap checking.

Mist nets and harp traps were deployed to collect bats (*Chiroptera*). Mist nets were set across trails in a forest, forest edge, stream, or outside a cave. Harp traps were also placed in similar sites. We set mist nets and harp traps from 17:30-18:00 đến 22:00-23:00 and checked every 20 minutes before it turned dark. After it was completely dark, mist nets and harp traps were checked more frequently to ensure that bats did not die because they were entangled in nets for too long.

Transect survey

Transects were established based on topographic and forest cover maps and existing and new trails to cover different kinds of habitat. During the transect survey, team members walked along a transect at a speed of 1-1.5km/hour. Surveyors listened to sound and observed target species or their signs/tracks as well as recorded human disturbances. We noted geographic coordinates of every encounter with target species and disturbance and took photos of any event.

Specimen processing

All collected animals were temporarily identified and such data as age, sex, and basic morphology were also recorded. Unidentified animals were prepared as specimens for further study at the laboratory. Data were collected in the following steps:

- Measurements: The following measurements were taken right after animals were captured (live or dead), including Head-body length (HB), Tail length (TL), length of hind foot (HF), ear length (E), body weight (Wt), length of forearm including wrist (FA) and lower leg (TIB) (for bats). Measurements were undertaken as recommended by Lunde and Nguyen (2001).
- External morphology: Description of external morphology, such as fur color, head, eye, ear, neck, back, belly, and tail.
- Photo: Specimens were photographed from different angles and in different positions to record external morphology, such as back, belly, head, and tail.
- DNA sampling: DNA samples were taken from representative specimens for taxonomic and phylogenetic studies.

- Species identification was based on the following references: The mammals of the Indomalayan Region (Corbet and Hill, 1992); Environment and Bioresources of Vietnam Present Situation and Solutions (Le and Cao, 1998); A photographic guide to mammals of Thailand and Southeast Asia (Francis, 2001); An identification guide to the rodents of Vietnam (Lunde and Nguyen, 2001); A guide to the mammals of Southeast Asia (Francis, 2008); Checklist of Wild mammals species of Vietnam (Dang Ngoc Can et al., 2008); Fauna and flora of Vietnam-Mammals (Dang Huy Huynh et al., 2007); Mammals species of the World (Wilson and Reeder, 2005); Squirrels of the world (Thorington et al. 2012); Bat of Vietnam (Kruskop, 2013); Mammals of Thailand (Lekagul B., McNeely 1977); Bat of Indian (Bates and Harrison 1997); Cao Văn Sung và cs (1980); Smith et al. (2008). Horseshoe bats of the World: (Chiroptera: Rhinolophidae) (Csorba, Ujhelyi, and Thomas, 2003).

Other scientific publications were also used for identification purposes, including:

Marianne et al. (2017), Zemlemerova et al. (2016), Hoàng (2017), Vuong et al. (2017a,b), Nguyen et al. (2016a,b, 2015a,b, 2013). Abramov et al. (2013); Daosavanh et al. (2013), Zenkins et al. (2013, 2010a, b, 2009, 2007); Kawada et al. (2008, 2009, 2012), Kruskop and Eger (2008), Borisenko et al. (2008), Kruskop et al. (2006), Muser et al. (2006), Vu and Tran (2005), Lunde et al. (2004), Hendrichsen et al. (2001).

Molecular Phylogenetic Methods

Tissue samples were extracted following protocols specified in Le et al. (2006) using a DNeasy blood and tissue kit (Qiagen, Valencia, CA). Extracted DNA was used for amplification of interested genes by PCR. The PCR volume consisted of 21 μ l (10 μ l mastermix (Fermentas, Burlington, ON, Canada), 5 μ l water, 2 μ l of each primer at 10 pmol/ μ l and 2 μ l DNA or higher depending on the quantity of DNA in the final extraction solution). PCR conditions will be: 95 °C for 5 min to activate the Taq; 40 cycles at 95 °C for 30 s, 45 °C for 45 s, 72 °C for 60 s; and a final extension at 72 °C for 6 min. Negative controls were used in all amplifications to check for possible contamination. PCR products will be subjected to electrophoresis through 1% agarose gel (UltraPure™, Invitrogen, La Jolla, CA). Gels were stained for 10 min in X TBE buffer with 2 pg/ml ethidium-bromide, and visualized under UV light. Successful amplifications were purified to eliminate PCR components using a GeneJET™ PCR Purification kit (Fermentas). Purified PCR products were then sent to Macrogen (Seoul, South Korea) for sequencing. All laboratory work were conducted at the Department of Genetics (Faculty of Biology, VNU University of Science, Vietnam National University, Hanoi).

We identified different levels of phylogenetic units by 1) estimating sequence divergence between hypothesized units and 2) phylogenetic tree analysis. Below the level of species, we looked at the level of Evolutionarily Significant Units (ESU), which are monophyletic groups of genetically differentiated populations within a larger monophyletic species (Ryder 1986;

Vogler and Desalle, 1994). Sequence divergence between phylogenetic units was estimated by comparing the number of fixed differences and shared mutations, and the average nucleotide substitutions and number of net substitutions per site (D_{xy} and D_a , respectively, with Jukes-Cantor correction), using DnaSP v. 5.10 (Librado and Rozas, 2009). A permutation test (10,000 randomizations without alignment gaps) of genetic differentiation was also carried out using the nearest neighbor statistic (S_{nn}) implemented in DnaSP. S_{nn} measures how often the most similar sequences in a dataset are from the same population.

For phylogenetic analyses, following tests for outlier loci, sequence data were aligned using ClustalX v1.83 (Thompson *et al.*, 1997) with default settings for complete alignment. Phylogenetic relationships among mitochondrial and nuclear sequences were inferred using Maximum Likelihood (ML) analyses implemented in PALM (Chen *et al.*, 2009). The model of sequence evolution was chosen using the Akaike Information Criterion (AIC), comparing 56 models for the PALM analysis (in PALM). Nonparametric bootstrapping was used to provide a measure of statistical confidence for internal tree branches in ML analyses (Felsenstein, 2003). Phylogenetic hypotheses were estimated using Maximum Parsimony as implemented in PAUP* v4.0b10 (Swofford, 2001) and Bayesian analysis as implemented in MrBayes v3.2 (Ronquist *et al.*, 2012).

Morphological data collection

Bats:

These were base fundamental; FA, forearm length from the extremity of the elbow to the extremity of the carpus with the wings folded; T, tail length from the tip of tail to its base fundamental; HF, hind foot from the tip of the longest digit, excluding claw, to the extremity of the heel, behind the os calcis; TIB, tibia length from the knee joint to ankle; E, ear length from the lower border of external auditory meatus where it joins with the body to the tip of pinna; TRAGUS, tragus length from the lower posterior emargination to the tip of the tragus; and body mass (in gram).

Craniodental and mandibular measurements were taken to the nearest 0.01 mm following Son *et al.* (2015): STOTL, total length of skull from the anterior rim of the alveolus of the first upper incisor to the most projecting point of the occipital region; CCL (condyle-canine length), from the exoccipital condyle to the most anterior part of the canine; C1C1W, greatest width across the outer borders of the upper canines; M3M3W, greatest width across the outer crowns of the last upper molars; ZYW (zygomatic width), greatest width of the skull across the zygomatic arches; MAW (mastoid width), greatest distance across the mastoid region; IOW (interorbital width), least width of the interorbital constriction; BCW (braincase width), greatest width of the braincase; BCH (braincase height), from the basisphenoid at the level of the hamular processes to the highest part of the skull, including the sagittal crest (if present);

CM3L (maxillary toothrow length), from the front of upper canine to the back of the crown of the third molar; CP4L (upper canine-premolar length), from the front of the upper canine to the back of the crown of the posterior premolar; 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; cp4L (lower canine-premolar length), from the front of the lower canine to the back of the crown of the posterior premolar; 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.

Rodents:

Values (in millimeters, mm) for total length, length of tail (LT), length of hind foot, including claw (LHF), and length of ear from intertragal notch to crown (LE) are those we obtained in the field and recorded in our field journals. Values for length of head and body (LHB) were determined by subtracting length of tail from total length. Weights were obtained in the field with a Pesola spring scale. Values for cranial and dental measurements were obtained by Lunde using digital calipers accurate to the nearest 0.01 mm; however, values were rounded to the nearest 0.1 mm. The following cranial and dental dimensions (listed in the sequence they appear in tables) were measured; their limits are illustrated in figure 3 and defined in Musser and Newcomb (1983). The measurement for skull: ONL occipitonasal length (5 greatest length of skull); ZB zygomatic breadth; IB interorbital breadth; LR length of rostrum; BR breadth of rostrum; BBC breadth of braincase; HBC height of braincase; BZP breadth of zygomatic plate; LD length of diastema; LIF length of incisive foramina; BIF breadth of incisive foramina; LBP length of bony palate (palatal bridge); BBP breadth across bony palate at first molars; PPL postpalatal length; BMF breadth of mesopterygoid fossa; LB length of bulla; CLM1-3 crown length of maxillary molar row; BM1 breadth of first upper molar.

Mole and Shrew:

Measurements of the external morphology included body weight (BW), head and body length (HBL), tail length (TL), forefoot length (FFL), forefoot width (FFW), and hind-foot length (HFL). The short and long diameters of the testes in the male specimens and uterine activity in the female specimens also were recorded to determine their respective reproductive condition. Dental abbreviations used include incisor (i), canine (c), premolar (p), and molar (m). This new mole was assigned to the genus *Euroscaptor* on the basis of its dental formula (i 3/3, c 1/1, p 4/4, m 3/3, total 44) as defined by Dobson (1883).

Fifteen skull characters were measured from the prepared skulls following Kawada et al.

(2007) using a Mitsutoyo (Kawasaki, Kanagawa, Japan) digital caliper with an accuracy of 0.01 mm and compared with 70 specimens of the other species in the genus. These measurements included the greatest length of the skull (GLS), palatal length from the anterior tip of the 1st incisor to the posterior lip of the palate (PL), inner length of the zygomatic arch (LZA), length of the upper toothrow (I1–M3), distance between the upper canine and 3rd molar (C–M3), length of the upper molars (M1–M3), rostral breadth of the canines (RB), breadth between the infraorbital foramina (BIOF), breadth across the upper 2nd molars (BAM), greatest interorbital breadth (IOB), mandible length (ML), mandible height at the coronoid process (MH), length of the lower toothrow (i1–m3), distance between the lower 1st premolar and 3rd molar (p1–m3), and length of the lower molars (m1–m3).

2.5. Research results

Species diversity in four protected areas

Nam Xuan Lac Habitat and Species Conservation Area

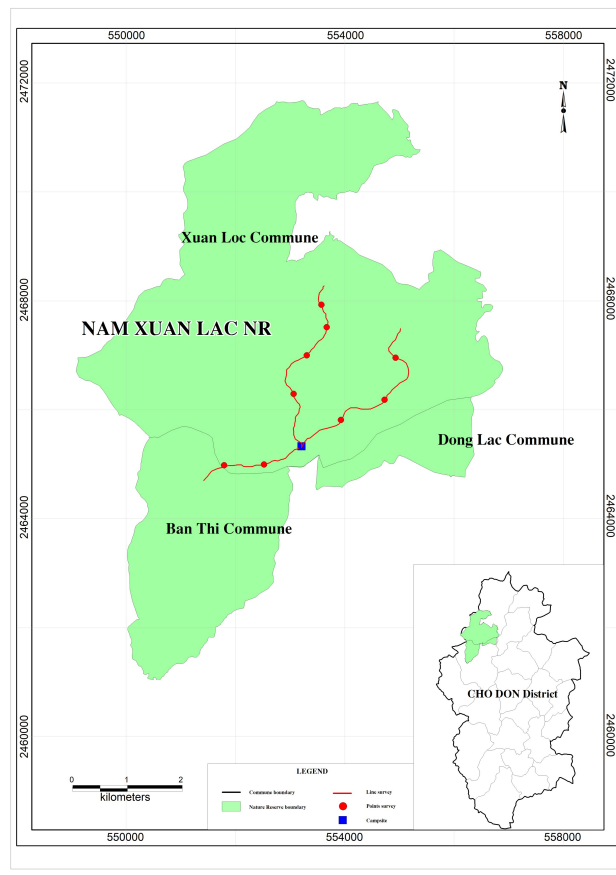


Figure 1. Survey transects in Nam Xuan Lac

Survey tracks are shown in Fig. 1. In total, 39 species were detected during our surveys in the protected area. Of these, three primates, namely the Bengal Slow Loris (*Nycticebus bengalensis*), the Pygmy Slow Loris (*Nycticebus pygmaeus*), and the Francois’ Langur

(*Trachypithecus francoisi*) are listed as Endangered in the IUCN Red List (2021). Two species, the Mainland Serow (*Capricornis milneedwardsii*) and the Stump-tailed Macaque (*Macaca arctoides*) are categorized as Vulnerable in the same List. However, all primates are very rare and were recorded either in previous study and through interviews or specimens kept at local households. We were unable to observe any of the species during the surveys. On the other hand, the Mainland Serow was encountered during the study (Table 1).

Table 1. Species recorded in Nam Xuan Lac Habitat and Species Conservation Area

No.	Vietnamese name	Latin name	Source	Vietnam's Red Data Book 2007	IUCN Red List 2020
	I. BỘ NHIỀU RĂNG	SCANDENTIA Wagner, 1855			
	1. Họ Đồi	Tupaiaidae Gray, 1825			
1.	Đồi	<i>Tupaia belangeri</i> (Wagner, 1841)	L		LC
	II. BỘ LINH TRƯỞNG	PRIMATES Linnaeus, 1758			
	2. Họ Cu li	Lorisidae Gray, 1821			
2.	Cu li nhỏ	<i>Nycticebus pygmaeus</i> Bonhote, 1907	M	VU	EN
3.	Cu li lớn	<i>Nycticebus bengalensis</i> (Lacépède, 1800)	L	VU	EN
	3. Họ Khỉ	Cercopithecidae Gray, 1821			
4.	Khỉ vàng	<i>Macaca mulatta</i> (Zimmermann, 1870)	L	LR	LC
5.	Khỉ mặt đỏ	<i>Macaca arctoides</i> (I. Geoffroy, 1831)	PV		VU
6.	Voọc đen má trắng	<i>Trachypithecus francoisi</i> (Pousargues, 1898)	PV, L	EN	EN
	III. BỘ ĂN SÂU BỌ	EULIPOTYPHLA Gregory, 1910			
	4. Họ Chuột chũi	Talpidae G. Fischer, 1814			
7.	Chuột chũi	<i>Euroscaptor</i> sp.	PV,M		
	IV. BỘ DƠI	CHIROPTERA Blumbach, 1779			
	5. Họ Dơi quạ	Pteropodidae Gray, 1821			
8.	Dơi chó cánh ngắn	<i>Cynopterus brachyotis</i> (Muller, 1838)	L		LC
9.	Dơi chó cánh dài	<i>Cynopterus sphinx</i> (Vahl, 1797)	L		LC

	6. Họ Dơi lá mũi	Rhinolophidae Gray, 1825			
10.	Dơi lá đuôi	<i>Rhinolophus affinis</i> Horsfield, 1823	L		LC
11.	Dơi lá mũi péc xông	<i>Rhinolophus pearsonii</i> Horsfield, 1851	L,M		LC
12.	Dơi lá tô ma	<i>Rhinolophus thomasi</i> Andersen, 1905	M		LC
13.	Dơi lá nam á	<i>Rhinolophus microglobosus</i> Csorba and Jenkins, 1998	M		LC
	7. Họ Dơi lá mũi	Hipposideridae Lydekker, 1891			
14.	Dơi nếp mũi quạ	<i>Hipposideros armiger</i> (Hodgson, 1835)	L, M		LC
15.	Dơi nếp mũi vương miện	<i>Hipposideros diadema</i> (Geoffroy, 1813)	L		LC
16.	Dơi nếp mũi xám	<i>Hipposideros larvatus</i> (Horsfield, 1823)	M		LC
	8. Họ Dơi muỗi	Vespertilionidae Gray, 1821			
17.	Dơi muỗi xám	<i>Pipistrellus javanicus</i> (Gray, 1838)	L		LC
18.	Dơi ống tai tròn	<i>Murina cyclotis</i> Dobson, 1872	M		LC
	VI. BỘ ĂN THỊT	CARNIVORA Bowdich, 1821			
	9. Họ Cầy	Viverridae Gray, 1821			
19.	Cầy vòi hương	<i>Paradoxurus hermaphroditus</i> (Pallas, 1777)			LC
20.	Cầy vòi mốc	<i>Paguma larvata</i> (C. E. H. Smith, 1827)	L		LC
21.	Cầy hương	<i>Viverricula indica</i> (Geoffroy Saint-Hilaire, 1803)	PV		LC
22.	Cầy gấm	<i>Prionodon pardicolor</i> Hodgson, 1841	L	VU	LC
	10. Họ Cầy lớn	Herpestidae Bonaparte, 1845			
23.	Cầy lớn tranh	<i>Urva javanica</i> (Geoffroy Saint-Hilaire, 1818)	QS		LC
24.	Cầy mốc cua	<i>Herpestes urva</i> (Hodgson, 1836)	L		LC
	12. Họ chó	Canidae Gray Fischer, 1817			
25.	Lửng chó	<i>Nyctereutes procyonoides</i> (Gray, 1834)	PV		LC
	V. BỘ MÓNG GUỐC NGÓN CHẤM	ARTIODACTYLA Owen, 1848			

	13. Họ Lợn rừng	Suidae Gray, 1821			
26.	Lợn rừng	<i>Sus scrofa</i> Linnaeus, 1758	QS		LC
	14. Họ Hươu nai	Cervidae Goldfuss, 1820			
27.	Mang thường	<i>Muntiacus vaginalis</i> (Boddaert, 1785)	L		LC
	15. Họ Trâu bò	Bovidae Gray, 1821			
28.	Sơn dương	<i>Capricornis milneedwardsii</i> David, 1869	QS	NT	VU
	VI. BỘ Gặm nhấm	RODENTIA Bowdich, 1821			
	16. Họ Sóc bay	Pteromyidae Brand, 1855			
29.	Sóc bay lớn	<i>Petaurista philippensis</i> (Elloit, 1839)	PV		LC
	17. Họ Sóc cây	Sciuridae Fischer de Waldheim, 1817			
30.	Sóc đen	<i>Ratufa bicolor</i> (Sparrman, 1778)	L, PV		NT
31.	Sóc bụng đỏ	<i>Callosciurus erythraeus</i> (Pallas, 1779)	L,M		LC
32.	Sóc mõm hung	<i>Dremomys rufigenis</i> (Blanford, 1878)	L,M		LC
33.	Sóc chuột hải nam	<i>Tamiops maritimus</i> (Bonhote, 1900)	L,PV		LC
	18. Họ Dúi	Spalacidae Gray, 1821			
34.	Dúi mốc lớn	<i>Rhizomys pruinosus</i> Blyth, 1851	L,M,PV		LC
	19. Họ Chuột	Muridae Illiger, 1811			
35.	Chuột nhắt nhà	<i>Mus musculus</i> Linnaeus, 1758	L		LC
36.	Chuột núi	<i>Leopoldamys edwardsi</i> (Thomas, 1882)	M		LC
37.	Chuột hươu bé	<i>Niviventer fulvescens</i> (Gray, 1847)	M		LC
38.	Chuột mốc lớn	<i>Berylmys bowersi</i> (Anderson, 1879)	L,M		LC
	20. Họ Nhím	Hystricidae G. Fischer, 1817			
39.	Đon	<i>Atherurus macrourus</i> (Linnaeus, 1758)	L		LC

Note: L – Literature; QS – Direct observation; PV – Interview; M – Specimen
IUCN Red List: EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern

Bac Me Nature Reserve

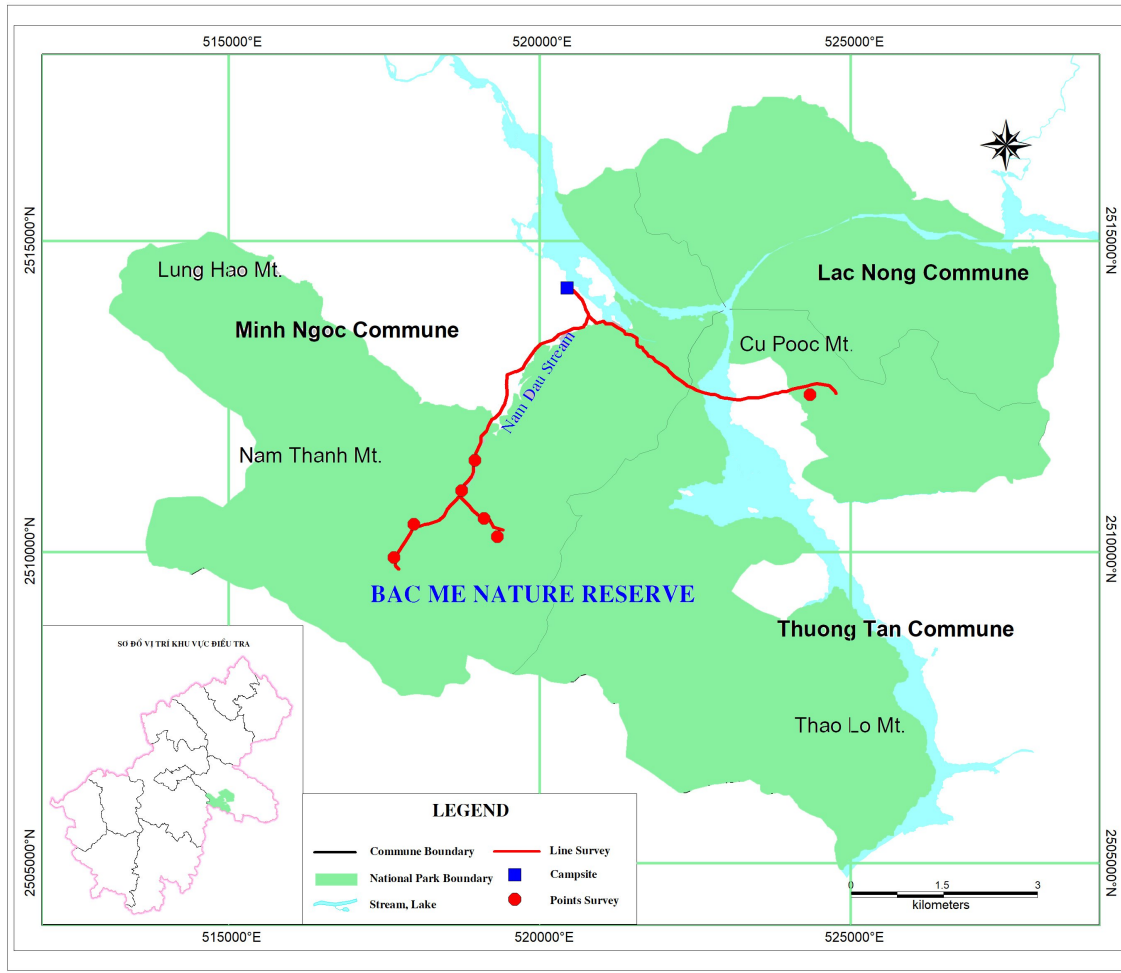


Figure 2. Survey transects in Bac Me

Survey tracks are shown in Fig. 2. In total, 51 species were identified during our surveys in the protected area. Among them, two species are considered Critically Endangered, i.e., the Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) and the Sunda Pangolin (*Manis javanica*), and four are listed as Endangered in the IUCN Red List (2021), including the Bengal Slow Loris (*Nycticebus bengalensis*), the Pygmy Slow Loris (*Nycticebus pygmaeus*), Andersen’s Roundleaf Bat (*Hipposideros pomona*), and the Large-spotted Civet (*Viverra megaspila*). Six others, namely the Northern Pig-tailed Macaque (*Macaca leonina*), the Clouded Leopard (*Neofelis nebulosa*), the Leopard (*Panthera pardus*), the Binturong (*Arctictis binturong*), the Asiatic Black Bear (*Ursus thibetanus*), and the Mainland Serow (*Capricornis milneedwardsii*), are categorized as Vulnerable. All of the above species were extremely very rare and documented only through our interviews with local people, except for the Andersen’s Roundleaf Bat, whose specimens were collected. It is noted that a population of tree shrew, genus *Tupaia*, a population of mole, genus *Euroscaptor*, a population of

white-toothed shrew, genus *Crocidura*, a population of pipistrelle microbat, genus *Pipitrellus*, are distinctly different from their congeners (Table 2). Their taxonomic status is currently being investigated by our group.

Table 2. Species recorded in Bac Me Nature Reserve

No.	Vietnamese name	Latin name	Source	IUCN Red List
	I. BỘ NHIỀU RĂNG	SCANDENTIA Wagner, 1855		
	1. Họ Đồi	Tupaiaidae Gray, 1825		
1.	Đồi	<i>Tupaia</i> sp.	M	
	III BỘ LINH TRƯỞNG	PRIMATES Linnaeus, 1758		
	3. Họ Cu li	Lorisidae Gray, 1821		
2.	Cu li lớn	<i>Nycticebus bengalensis</i> (Lacépède, 1800)	PV	EN
3.	Cu li nhỏ	<i>Nycticebus pygmaeus</i> (Bonhote, 1907)	PV	EN
	4. Họ Khỉ	Cercopithecidae Gray, 1821		
4.	Khỉ đuôi lợn	<i>Macaca leonina</i> (Blyth, 1863)	PV	VU
5.	Khỉ vàng	<i>Macaca mulatta</i> (Zimmermann, 1780)	PV	LC
6.	Voọc mũi hếch	<i>Rhinopithecus avunculus</i> (Dollman, 1912)	PV	CR
	IV. BỘ ĂN SÂU BỌ	EULIPOTYPHIA Gregory, 1910		
	5. Họ Chuột chù	Soricidae G. Fischer, 1814		
7.	Chuột chù	<i>Crocidura</i> sp.	M	
8.	Chuột chù nhà	<i>Suncus murinus</i> (Linnaeus, 1766)	K, QS	LC
	6. Họ Chuột chũi	Talpidae G. Fischer, 1814		

9.	Chuột chũi	<i>Euroscaptor</i> sp.	M	
	V. BỘ DỜI	CHIROPTERA Blumbach, 1779		
	7. Họ Dơi quả	Pteropodidae Gray, 1821		
10.	Dơi chó cánh dài	<i>Cynopterus sphinx</i> (Vahl, 1797)	M	LC
	8. Họ Dơi lá mũi	Rhinolophidae Gray, 1825		
11.	Dơi lá nam á	<i>Rhinolophus microglobosus</i> Csorba and Jenkins, 1998	M	LC
12.	Dơi lá mũi nhỏ	<i>Rhinolophus pusillus</i> Temminck, 1834	M	LC
	9. Họ Dơi nếp mũi	Hipposideridae Lydekker, 1891		
13.	Dơi nếp mũi quạ	<i>Hipposideros armiger</i> (Hodgson, 1835)	M	LC
14.	Dơi nếp mũi xám	<i>Hipposideros larvatus</i> (Horsfield, 1823)	M	LC
15.	Dơi nếp mũi xinh	<i>Hipposideros pomona</i>	M	EN
16.	Dơi nếp mũi ba lá	<i>Aselliscus stoliczkanus</i> (Dobson, 1871)	M	LC
17.	Dơi muỗi sọ dẹt	<i>Pipitrellus</i> sp.	PV	
18.	Dơi lá pec-xon	<i>Rhinolophus pearsoni</i> (Horsfield, 1851)	M	LC
	VI. BỘ ĂN THỊT	CARNIVORA Bowdich, 1821		
	10. Họ Mèo	Felidae Fischer de Waldheim, 1817		
19.	Mèo rừng	<i>Prionailurus bengalensis</i> (Kerr, 1792)	PV	LC
20.	Báo gấm	<i>Neofelis nebulosa</i> (Griffith, 1821)	PV	VU
21.	Báo hoa mai	<i>Panthera pardus</i> (Linnaeus, 1758)	PV	VU
	11. Họ Cầy	Viverridae Gray, 1821		
22.	Cầy mực	<i>Arctictis binturong</i> (Raffles, 1821)	PV	VU
23.	Cầy vòi mốc	<i>Paguma larvata</i> (C. E. H. Smith, 1827)	PV	LC

24.	Cây giông sọc	<i>Viverra megaspila</i> (Blyth, 1862)	PV	EN
25.	Cây giông	<i>Viverra zibetha</i> Linnaeus, 1758	PV	LC
26.	Cây hương	<i>Viverricula indica</i> (É. Geoffroy Saint-Hilaire, 1803)	PV	LC
	12. Họ Gấu	Ursidae Fischer de Waldheim, 1817		
27.	Gấu ngựa	<i>Ursus thibetanus</i> G. Cuvier, 1823	PV	VU
	13. Họ Chồn	Mustelidae Fischer, 1817		
28.	Chồn bạc má bắc	<i>Melogale moschata</i> (Gray, 1831)	PV	LC
29.	Triết bụng vàng	<i>Mustela kathiah</i> Hodgson, 1835	PV	LC
	VII. BỘ MÓNG GUỐC NGÓN CHẶN	ARTIODACTYLA Owen, 1848		
	14. Họ Lợn rừng	Suidae Gray, 1821		
30.	Lợn rừng	<i>Sus scrofa</i> Linnaeus, 1758	PV	LC
	15. Họ Trâu bò	Bovidae Gray, 1821		
31.	Sơn dương	<i>Capricornis sumatraensis</i> (Bechstein, 1799)	PV	VU
	VIII. BỘ GẶM NHẮM	RODENTIA Bowdich, 1821		
	16. Họ Sóc	Sciuridae Fischer de Waldheim, 1817		
32.	Sóc bay lông tai	<i>Belomys pearsonii</i>	M	DD
33.	Sóc đen	<i>Ratufa bicolor</i> (Sparman, 1778)	PV	NT
34.	Sóc bay trâu	<i>Petaurista philippensis</i> (Elliot, 1839)	PV	LC
35.	Sóc bụng đỏ	<i>Callosciurus erythraeus</i> (Pallas, 1779)	PV,M,QS	LC
36.	Sóc bụng xám	<i>Callosciurus inornatus</i> (Gray, 1867)	M	LC
37.	Sóc mõm hung	<i>Dremomys rufigenis</i> (Blanford, 1878)	PV	LC
38.	Sóc chuột hải nam	<i>Tamiops maritimus</i> (Milne-Edwards, 1867)	PV,M,QS	LC

	17. Họ Dúi	Spalacidae Gray, 1821		
39.	Dúi mốc lớn	<i>Rhizomys pruinosus</i> Blyth, 1851	PV	LC
	18. Họ Chuột	Muridae Illiger, 1811		
40.	Chuột núi đuôi dài	<i>Leopodamys sabanus</i> (Thomas, 1887)	PV	
41.	Chuột nhắt nương	<i>Mus pahari</i> Thomas, 1916	M	LC
42.	Chuột đồng Nam Trung Quốc	<i>Apodemus draco</i> (Barrett – Hamilton, 1900)	M	LC
43.	Chuột hươu lớn	<i>Leopoldamys edwardsi</i> (Thomas, 1882)	PV	LC
44.	Chuột mốc lớn	<i>Berylmys bowersi</i> (Anderson, 1879)	PV	LC
45.	Chuột khổng tử	<i>Niviventer</i> cf. <i>confucianus</i> (Milne-Edwards, 1871)	M	
46.	Chuột hươu	<i>Niviventer</i> sp.	PV	
47.	Chuột thường	<i>Rattus rattus</i> (Linnaeus, 1758)	QS	LC
48.	Chuột bóng	<i>Rattus nitidus</i> (Hodgson, 1845)	M	LC
	19. Họ Nhím	Hystricidae G. Fischer, 1817		
49.	Đon	<i>Atherurus macrourus</i> (Linnaeus, 1758)	PV	LC
50.	Nhím đuôi ngắn	<i>Hystrix brachyura</i> (Linnaeus, 1758)	PV	LC
	IX. BỘ TÊ TÊ	PHOLIDOTA Weber, 1904		
	20. Họ Tê tê	Manidae Gray, 1821		
51.	Tê tê gia va	<i>Manis javanica</i> (Desmarest, 1822)	PV	CR

Note: L – Literature; QS – Direct observation; PV – Interview; M – Specimen
IUCN Red List: EN – Endangered; VU – Vulnerable; NT – Near Threatened; DD – Data deficient

Cham Chu Nature Reserve

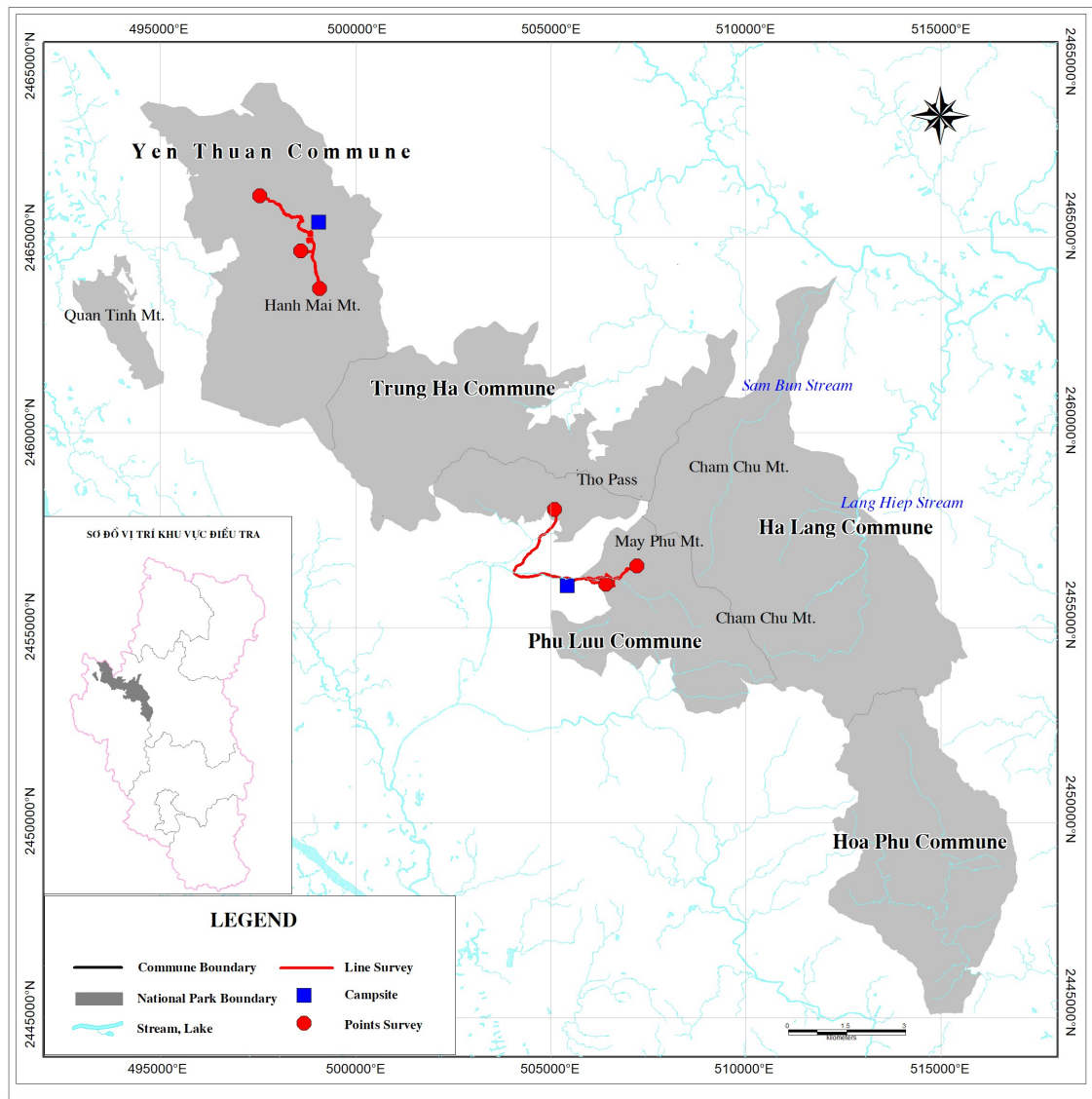


Figure 3. Survey transects in Cham Chu

Survey tracks are shown in Fig. 3. In total, 58 species were identified during our surveys in the protected area. Among them, two species are considered Critically Endangered, i.e., the Tonkin Snub-nosed Monkey (*Rhinopithecus avunculus*) and the Caovit Gibbon (*Nomascus nasutus*), and four are listed as Endangered in the IUCN Red List (2021), including the Bengal Slow Loris (*Nycticebus bengalensis*), the Pygmy Slow Loris (*Nycticebus pygmaeus*), Andersen’s Roundleaf Bat (*Hipposideros pomona*), and the Francois’ Langur (*Trachypithecus francoisi*). Four other others, namely the Stump-tailed Macaque (*Macaca arctoides*), the Asiatic Black Bear (*Ursus thibetanus*), the Greater Hog Badger (*Arctonyx collaris*), and the Mainland Serow (*Capricornis milneedwardsii*), are categorized as Vulnerable. All of the above species were directly observed during our surveys and documented only through our

interviews with local people, except for the Andersen's Roundleaf Bat, whose specimens were collected. It is noted that a population of mole, genus *Euroscaptor*, a population of Asiatic water shrew, genus *Chimarogale*, a population of the Old-World leaf-nosed bat, genus *Aseliscus*, and two populations of white-bellied rats, genus *Niviventer*, are morphologically distinct from other members of their genera (Table 3). Their taxonomic status is currently under investigation.

Table 3. Species recorded in Cham Chu Nature Reserve

No.	Vietnamese name	Latin name	Source of information	Conservation status (IUCN)
	I. BỘ NHIỀU RĂNG	I. SCANDENTIA Wagner, 1855		
	1. Họ Đồi	1. Tupaiidae Gray, 1825		
1.	Đồi	<i>Tupaia belangeri</i> (Wagner, 1841)	M	LC
	II. BỘ LINH TRƯỞNG	II. PRIMATES Linnaeus, 1758		
	2. Họ Cu li	2. Lorisidae Gray, 1821		
2.	Cu li lớn	<i>Nycticebus bengalensis</i> (Lacépède, 1800)	PV	EN
3.	Cu li nhỏ	<i>Nycticebus pygmaeus</i> Bonhote, 1907	PV	EN
	3. Họ Khỉ	3. Cercopithecidae Gray, 1821		
4.	Khỉ mặt đỏ	<i>Macaca arctoides</i> (Geoffroy, 1831)	PV	VU
5.	Khỉ vàng	<i>Macaca mulatta</i> (Zimmermann, 1780)	QS	LC
6.	Voọc mũi hếch	<i>Rhinopithecus avunculus</i> (Dollman, 1912)	PV	CR
7.	Voọc đen má trắng	<i>Trachypithecus francoisi</i> (Pousargues, 1898)	PV	EN
	4. Họ Vượn	4. Hylobatidae, Gray, 1871		
8.	Vượn cao vit	<i>Nomascus nasutus</i> Ogiby, 1840	PV	CR
	III. BỘ ĂN SÂU BỌ	III. EULIPOTYPHILA Gregory, 1910		
	5. Họ Chuột voi	5. Erinaceidae G. Fischer, 1814		

9.	Chuột voi đồi	<i>Hylomys suillus</i> Müller, 1840	M	LC
	6. Họ Chuột chù	6. Soricidae G. Fischer, 1814		
10.	Chuột chù nước	<i>Chimarogale</i> sp.	M	
11.	Chuột chù đuôi đen	<i>Crocidura attenuata</i> Milne-Edwards, 1872	M	LC
12.	Chuột chù nhà	<i>Suncus murinus</i> (Linnaeus, 1766)	M	LC
	7. Họ Chuột chũi	7. Talpidae G. Fischer, 1814		
13.	Chuột chũi miền bắc	<i>Euroscaptor</i> sp.	M	
	IV. BỘ DƠI	IV. CHIROPTERA Blumbach, 1779		
	8. Họ Dơi quả	8. Pteropodidae Gray, 1821		
14.	Dơi chó cánh dài	<i>Cynopterus sphinx</i> (Vahl, 1797)	M	LC
15.	Dơi quả lưỡi dài	<i>Eonycteris spelaea</i> (Dobson, 1871)	M	LC
16.	Dơi ăn mật hoa lớn	<i>Macroglossus sobrinus</i> Andersen, 1911	M	LC
17.	Dơi quả núi cao	<i>Sphaerias blanfordi</i>	M	LC
	9. Họ Dơi lá mũi	9. Rhinolophidae Gray, 1825		
18.	Dơi lá đuôi	<i>Rhinolophus affinis</i> Horsfield, 1823	M	LC
19.	Dơi lá nam á	<i>Rhinolophus microglobosus</i> Csorba and Jenkins, 1998	M	LC
20.	Dơi lá quạt	<i>Rhinolophus paradoxolophus</i> Bourret, 1951	M	LC
21.	Dơi lá mũi péc-xôn	<i>Rhinolophus pearsonii</i> Horsfield, 1851	M	LC
22.	Dơi lá mũi nhỏ	<i>Rhinolophus pusillus</i> Temminck, 1834	M	LC
23.	Dơi lá tô-ma	<i>Rhinolophus thomasi</i> Andersen, 1905	M	LC
	10. Họ Dơi nếp mũi	10. Hipposideridae Lydekker, 1891		

24.	Dơi nếp mũi ba lá	<i>Aseliscus</i> sp.	M	
25.	Dơi nếp mũi quạ	<i>Hipposideros armiger</i> (Hodgson, 1835)	M	LC
26.	Dơi nếp mũi xám	<i>Hipposideros larvatus</i> (Horsfield, 1823)	M	LC
27.	Dơi nếp mũi xinh	<i>Hipposideros pomona</i> K. Andersen, 1918	M	EN
	11. Họ Dơi Muỗi	Vespertilionidae Gray, 1821		
28.	Dơi tai nam á	<i>Myotis chinensis</i> (Tomes, 1857)	M	LC
	11. Họ Dơi ma	11. Megadermatidae H. Allen, 1864		
29.	Dơi ma bắc	<i>Megaderma lyra</i> E. Geoffroy, 1810	M	LC
	X. BỘ ĂN THỊT	V. CARNIVORA Bowdich, 1821		
	12. Họ Mèo	12. Felidae Fischer de Waldheim, 1817		
30.	Mèo rừng	<i>Prionailurus bengalensis</i> (Kerr, 1792)	PV	LC
	13. Họ Cầy	13. Viverridae Gray, 1821		
31.	Cầy vòi mốc	<i>Paguma larvata</i> (Smith, 1827)	QS	LC
32.	Cầy vòi đốm	<i>Paradoxurus hermaphroditus</i> (Pallas, 1777)	QS	LC
33.	Cầy gấm	<i>Prionodon pardicolor</i> Hodgson, 1842	PV	LC
34.	Cầy hương	<i>Viverricula indica</i> (Geoffroy Saint-Hilaire, 1803)	QS	LC
	14. Họ Cầy lỏn	14. Herpestidae Bonaparte, 1845		
35.	Cầy lỏn tranh	<i>Herpestes javanicus</i> (Geoffroy Saint-Hilaire, 1818)	QS	LC
36.	Cầy móc cua	<i>Herpestes urva</i> (Hodgson, 1836)	QS	LC
	15. Họ Gấu	15. Ursidae Fischer de Waldheim, 1817		

37.	Gấu ngựa	<i>Ursus thibetanus</i> Cuvier, 1823	PV	VU
	16. Họ Chồn	16. Mustelidae Fischer, 1817		
38.	Lửng lợn	<i>Arctonyx collaris</i> Cuvier, 1825	PV	VU
39.	Chồn vàng	<i>Martes flavigula</i> (Boddaert, 1785)	QS	LC
40.	Chồn bạc má bắc	<i>Melogale moschata</i> (Gray, 1831)	M	LC
41.	Triết bụng vàng	<i>Mustela kathiah</i> Hodgson, 1835	QS	LC
	VI. BỘ MÓNG GUỐC NGÓN CHẤM	VI. ARTIODACTYLA Owen, 1848		
	17. Họ Lợn rừng	17. Suidae Gray, 1821		
42.	Lợn rừng	<i>Sus scrofa</i> Linnaeus, 1758	PV	LC
	18. Họ Hươu nai	18. Cervidae Goldfuss, 1820		
43.	Mang thường	<i>Muntiacus vaginalis</i> (Zimmermann, 1780)		LC
	19. Họ Trâu bò	19. Bovidae Gray, 1821		
44.	Sơn dương	<i>Capricornis milneedwardsii</i> David, 1869	PV	VU
	VII. BỘ Gặm nhấm	VII. RODENTIA Bowdich, 1821		
	20. Họ Sóc	20. Sciuridae Fischer de Waldheim, 1817		
45.	Sóc đen	<i>Ratufa bicolor</i> (Sparman, 1778)	QS	NT
46.	Sóc bay lông chân	<i>Belomys pearsonii</i> (Gray, 1842)	QS	DD
47.	Sóc bụng đỏ	<i>Callosciurus erythraeus</i> (Pallas, 1779)	QS	LC
48.	Sóc bụng xám	<i>Callosciurus inornatus</i> (Gray, 1867)	QS	LC
49.	Sóc mõm hung	<i>Dremomys rufigenis</i> (Blanford, 1878)	QS	LC

50.	Sóc chuột hải nam	<i>Tamiops maritimus</i> (Bonhote, 1900)	QS	LC
	21. Họ Dúi	21. Spalacidae Gray, 1821		
51.	Dúi mốc lớn	<i>Rhizomys pruinosus</i> Blyth, 1851	PV	LC
	22. Họ Chuột	22. Muridae Illiger, 1811		
52.	Chuột nhắt cây	<i>Chiropodomys gliroides</i> (Blyth, 1856)	M	LC
53.	Chuột su-ri	<i>Maxomys surifer</i> (Miller, 1900)	M	LC
54.	Chuột hươu bé	<i>Niviventer fulvescens</i> (Gray, 1847)	M	LC
55.	Chuột lang-bi-an	<i>Niviventer langbianis</i> (Robinson et Kloss, 1922)	M	LC
56.	Chuột	<i>Niviventer</i> sp1.	M	
57.	Chuột	<i>Niviventer</i> sp2.	M	
	23. Họ Nhím	23. Hystricidae G. Fischer, 1817		
58.	Đon	<i>Atherurus macrourus</i> (Linnaeus, 1758)	PV	LC

Note: L – Literature; QS – Direct observation; PV – Interview; M – Specimen
IUCN Red List: EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern

Phia Oac-Phia Den National Park

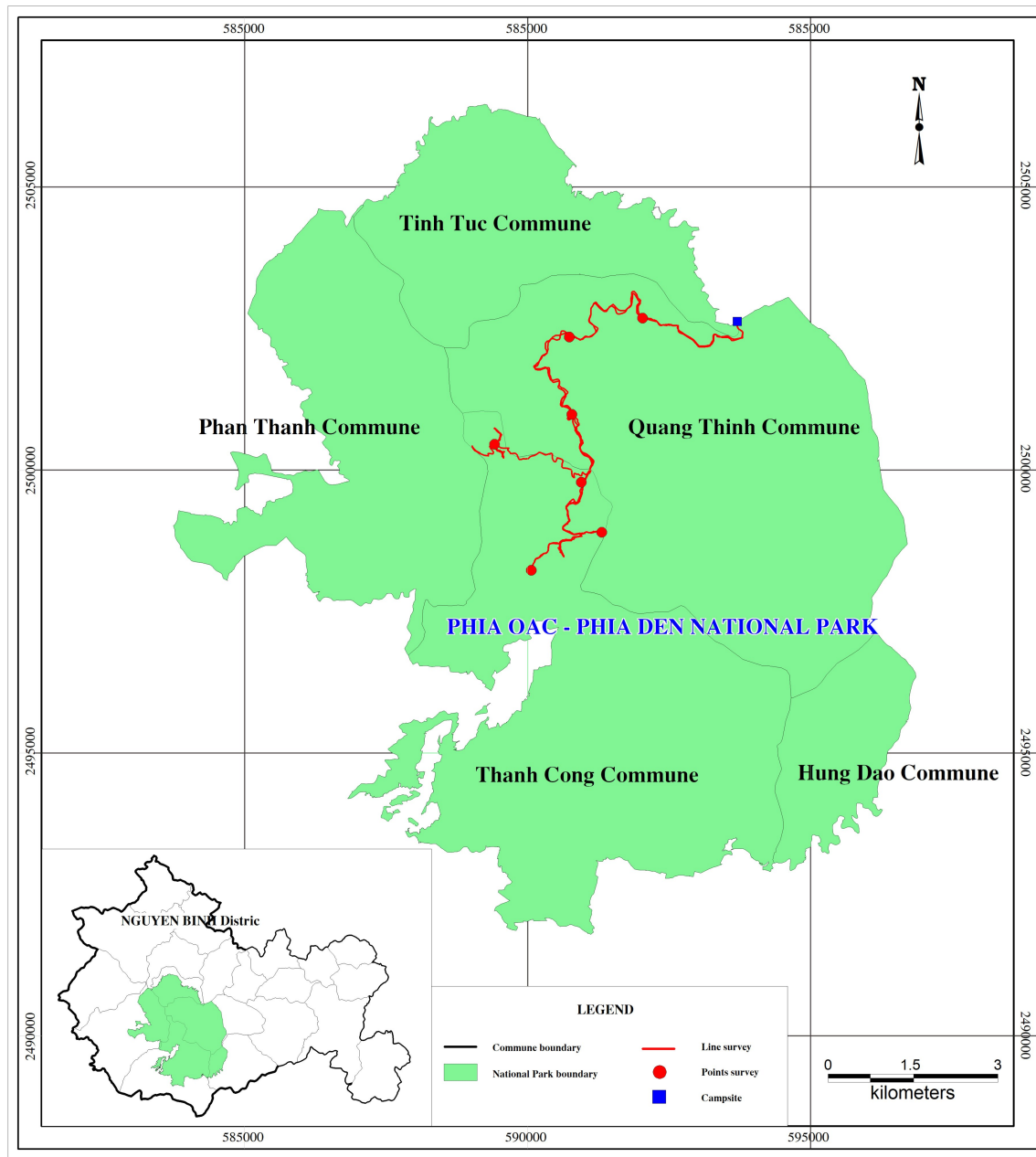


Figure 4. Survey transects in Phia Oac-Phia Den

Survey tracks are shown in Fig. 4. In total, we detected 57 species in the survey area. Of the species identified, two are considered Endangered in the IUCN Red List (2021), namely the Bengal Slow Loris (*Nycticebus bengalensis*) and the Andersen’s Roundleaf Bat (*Hipposideros pomona*). Five others, namely the Stump-tailed Macaque (*Macaca arctoides*), the Schreiber’s Bent-winged Bat (*Miniopterus schreibersi*), the Sambar (*Rusa unicolor*), the Asiatic Black Bear (*Ursus thibetanus*), and the Mainland Serow (*Capricornis milneedwardsii*), are categorized as Vulnerable. All of the species were documented through

literature review, except for the Asiatic Black Bear recorded through interviews with local people (Table 4).

Table 4. Species recorded in Phia Oac-Phia Den National Park

N _o	Vietnamese name	Latin name	Source	IUCN Red List
	I. BỘ NHIỀU RĂNG	SCANDENTIA Wagner, 1855		
	1. Họ Đồi	Tupaiaidae Gray, 1825		
1.	Đồi	<i>Tupaia belangeri</i> (Wagner, 1841)	L	LC
	II. BỘ LINH TRƯỞNG	PRIMATES Linnaeus, 1758		
	2. Họ Cu li	Lorisidae Gray, 1821		
2.	Cu li lớn	<i>Nycticebus bengalensis</i> (Boddaert, 1758)	L	EN
	3. Họ Khỉ	Cercopithecidae Gray, 1821		
3.	Khỉ mặt đỏ	<i>Macaca arctoides</i> (I.Geoffroy, 1831)	L	VU
4.	Khỉ vàng	<i>Macaca mulatta</i> (Zimmermann, 1870)	L	LC
	III. BỘ ĂN SÂU BỌ	EULIPOTYPHILA Gregory, 1910		
	4. Họ Chuột chũi	Talpidae G. Fischer, 1814		
5.	Chuột chũi	<i>Euroscaptor</i> sp.	M	
	IV. BỘ DƠI	CHIROPTERA Blumbach, 1779		
	5. Họ Dơi quạ	Pteropodidae Gray, 1821		
6.	Dơi ngựa nâu	<i>Rousettus leschenaultii</i> (Desmarest, 1820)	L	LC
	6. Họ Dơi lá mũi	Rhinolophidae Gray, 1825		
7.	Dơi lá đuôi	<i>Rhinolophus affinis</i> Horsfield, 1823	L	LC
8.	Dơi lá tai dài	<i>Rhinolophus macrotis</i> Blyth, 1844	L	LC
9.	Dơi lá mũi péc xôn	<i>Rhinolophus pearsonii</i> Horsfield, 1851	M	LC
10.	Dơi lá mũi nhỏ	<i>Rhinolophus pusillus</i> Temminck, 1834	L	LC
11.	Dơi lá tô ma	<i>Rhinolophus thomasi</i> Andersen, 1905	L	LC
12.	Dơi	Rhinolophus cf. microglobosus		
	7. Họ Dơi lá mũi	Hipposideridae Lydekker, 1891		
13.	Dơi mũi ba lá đồng	<i>Aselliscus dongbacanus</i> Tu, Csorba,	L	

	bắc	Gorfol, Arai, Son, Thanh & Hassanin, 2015		
14.	Dơi nếp mũi quạ	<i>Hipposideros armiger</i> (Hodgson, 1835)	L	LC
15.	Dơi mũi hai màu	<i>Hipposideros bicolor</i> (Temminck, 1834)	L	LC
16.	Dơi nếp mũi xám	<i>Hipposideros larvatus</i> (Horsfield, 1823)	L	LC
17.	Dơi nếp mũi xinh	<i>Hipposideros pomona</i> K. Andersen, 1918	L	EN
	8. Họ Dơi muỗi	Vespertilionidae Gray, 1821		
18.	Dơi muỗi nâu	<i>Pipistrellus coromandra</i> (Gray, 1838)	L	LC
19.	Dơi muỗi mắt	<i>Pipistrellus tenuis</i> (Temminck, 1840)	L	LC
20.	Dơi muỗi Ca-do-ra	<i>Hypsugo cadornae</i> Thomas, 1916	L	LC
21.	Dơi tai sọ cao	<i>Myotis cf. siligorensis</i> (Horsfield, 1855)	L	
22.	Dơi tai bắc việt	<i>Myotis lanige</i> (Peters, 1870)	L	LC
23.	Dơi mũi ống cánh lông	<i>Harpiocephalus harpia</i> (Temminck, 1840)	L	LC
24.	Dơi ống tai tròn	<i>Murina cyclotis</i> Dobson, 1872	L	LC
25.	Dơi mũi ống	<i>Murina huttoni</i> (Peters, 1872)	L	LC
26.	Dơi mũi ống nhỏ	<i>Murina eleryi</i> Furey, Thong, Bates, Csorba, 2009	L	
27.	Dơi mũi ống lông vàng	<i>Murina chrysochaetes</i> Eger, Lim 2011	L	
28.	Dơi mũi nhẵn	<i>Kerivoula hardwickii</i> (Horsfield, 1824)	M	LC
29.	Dơi mũi nhẵn Mi-an-ma	<i>Kerivoula kachinensi</i> Bates et al., 2004	L	LC
30.	Dơi mũi nhẵn lớn	<i>Kerivoula titania</i> Bates et al., 2007	L	LC
	9. Họ Dơi cánh	Miniopteridae Dobson, 1875		
31.	Dơi gập cánh dài	<i>Miniopterus schreibersi</i> (Kuhl, 1819)	L	VU
	VI. BỘ ĂN THỊT	CARNIVORA Bowdich, 1821		
	10. Họ Mèo	Felidae Fischer de Waldheim, 1817		

32.	Báo lửa	<i>Catopuma temminckii</i> (Vigors and Horsfield, 1827)	L	NT
33.	Mèo rừng	<i>Prionailurus bengalensis</i> (Kerr, 1792)	L	LC
	11. Họ Cây	Viverridae Gray, 1821		
34.	Cầy vòi mốc	<i>Paguma larvata</i> (C. E. H. Smith, 1827)	L	LC
35.	Cầy vòi đốm	<i>Paradoxurus hermaphroditus</i> (Pallas, 1777)	L	LC
36.	Cầy hương	<i>Viverricula indica</i> (É. Geoffroy Saint-Hilaire, 1803)	L	LC
37.	Cầy gấm	<i>Prionodon pardicolor</i> Hodgson, 1841	L	LC
	12. Họ Cây lớn	Herpestidae Bonaparte, 1845		
38.	Cầy lớn tranh	<i>Herpestes javanicus</i> (É. Geoffroy Saint-Hilaire, 1818)	L	LC
39.	Cầy mốc cua	<i>Herpestes urva</i> (Hogdson, 1836)	L	LC
	13. Họ Chồn	Mustelidae Fischer, 1817		
40.	Rái cá thường	<i>Lutra lutra</i> (Linnaeus, 1758)	L	NT
	14. Họ Gấu	Ursidae Fischer de Waldheim, 1817		
41.	Gấu ngựa	<i>Ursus thibetanus</i> Cuvier, 1823	PV	VU
	V. BỘ MÓNG GUỐC NGÓN CHẤM	ARTIODACTYLA Owen, 1848		
	15. Họ Lợn rừng	Suidae Gray, 1821		
42.	Lợn rừng	<i>Sus scrofa</i> Linnaeus, 1758	L	LC
	16. Họ Hươu nai	Cervidae Goldfuss, 1820		
43.	Mang thường	<i>Muntiacus vaginalis</i> (Zimmermann, 1780)	L	LC
44.	Nai	<i>Rusa unicolor</i> (Kerr, 1792)	L	VU
	17. Họ Trâu bò	Bovidae Gray, 1821		
45.	Sơn dương	<i>Capricornis milneedwardsii</i> David, 1869	L	VU
	VI. BỘ Gặm nhấm	RODENTIA Bowdich, 1821		
	18. Họ Sóc bay	Pteromyidae Brand, 1855		
46.	Sóc bay trâu	<i>Petaurista philippensis</i> (Elloit, 1839)	L	LC
47.	Sóc bay lông tai	<i>Belomys pearsonii</i> (Gray, 1842)	L	DD

48.	Sóc bay sao	<i>Petaurista elegans</i> (Müller, 1840)	L	LC
	19. Họ Sóc cây	Sciuridae Fischer de Waldheim, 1817		
49.	Sóc đen	<i>Ratufa bicolor</i> (Sparrman, 1778)	L	NT
50.	Sóc bụng đỏ	<i>Callosciurus erythraeus</i> (Pallas, 1779)	M	LC
51.	Sóc mõm hung	<i>Dremomys rufigenis</i> (Blanford, 1878)	M	LC
52.	Sóc chuột hải nam	<i>Tamios maritimus</i> (Bonhote, 1900)	PV	LC
	20. Họ Dúi	Spalacidae Gray, 1821		
53.	Dúi mốc lớn	<i>Rhizomys pruinosus</i> Blyth, 1851	M,PV	LC
	21. Họ Chuột	Muridae Illiger, 1811		
54.	Chuột nhắt nhà	<i>Mus musculus</i> Linnaeus, 1758	L	LC
55.	Chuột hươu bé	<i>Niviventer fulvescens</i> (Gray, 1847)	M	LC
56.	Chuột mốc lớn	<i>Berylmys bowersi</i> (Anderson, 1879)	L,M	LC
	22. Họ Nhím	Hystricidae G. Fischer, 1817		
57.	Đon	<i>Atherurus macrourus</i> (Linnaeus, 1758)	L	LC

Note: L – Literature; QS – Direct observation; PV – Interview; M – Specimen
IUCN Red List: EN – Endangered; VU – Vulnerable; NT – Near Threatened; LC – Least Concern

Molecular phylogenetic analysis

Our analyses using three different methods, maximum parsimony, maximum likelihood, and Bayesian inference, and based on three genetic markers, two mitochondrial 12S, cytochrome b, and one nuclear Rag1, show that the mole population from Cham Chu Nature Reserve is distinctly different from all other congeners in the genus *Euroscaptor*. Three samples collected from the Reserve were also reciprocally monophyletic and most closely related to *E. orlovi*, a species described in 2016. In addition, a population from Tay Con Linh Nature Reserve (highlighted in bold) was also distinct from other members of the genus (Fig. 1). Our results show that the diversity of the genus is currently underestimated and northern Vietnam might harbor a high-level cryptic diversity of the genus.

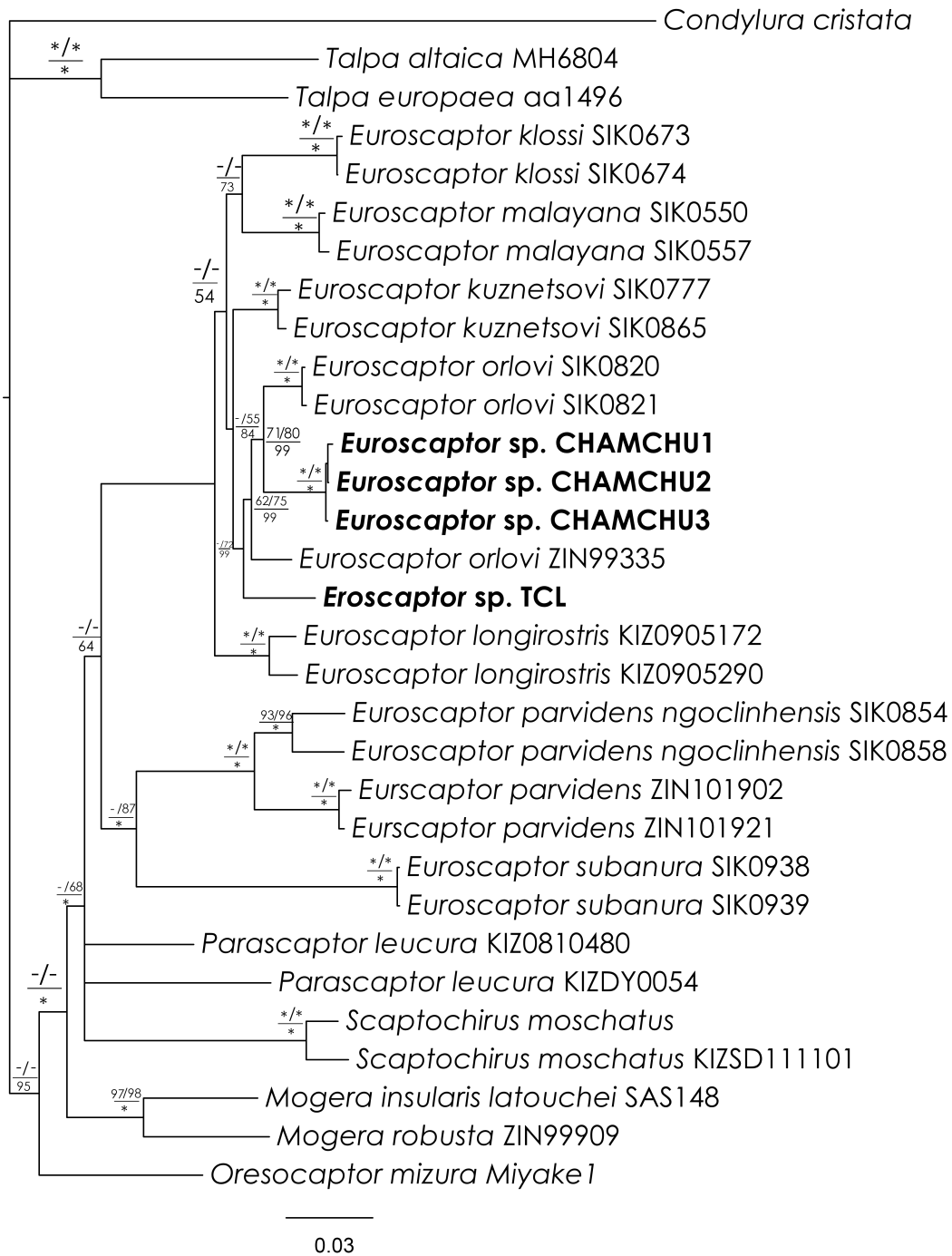


Figure 5. Bayesian phylogram based on three genes, 12s, cytochrome b and Rag1. Three specimens collected from Cham Chu Nature Reserve and one from Tay Con Linh Nature Reserve (highlighted in bold) are included. Other sequences are obtained from GenBank. In addition, our molecular analyses also discover a new population of the tree shrew, genus *Tupaia*, with samples collected from several sites across northern Vietnam, including Bac Me Nature Reserve in Ha Giang Province. This population is morphologically similar to *T.*

belangeri. Genetically, the new population is most closely related to others from China and Malaysia, but distinctly different from them.

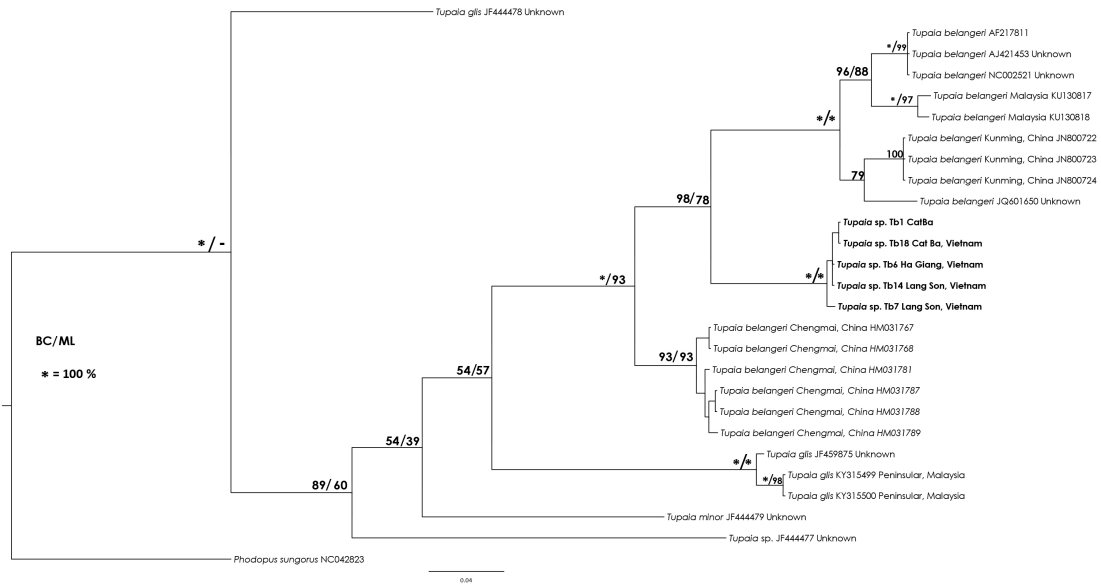


Figure 6. Bayesian phylogram based on the mitochondrial cytochrome b gene. Samples collected from Cat Ba, Lang Son, and Ha Giang (Bac Me Nature Reserve) are highlighted in bold. Other sequences are obtained from GenBank.

2.6. Discussion

The results of our study show that Nam Xuan Lac Habitat and Species Conservation Area has the lowest species richness with 39 species followed by Bac Me Nature Reserve with 51 species. Cham Chu Nature Reserve and Phia Oac-Phia Den National Park harbor 58 and 57 species, respectively. In terms of cryptic diversity, Cham Chu and Bac me have the greatest potential. The former is home to several distinct populations of different genera, including one of genus *Euroscaptor*, one of Asiatic water shrew, genus *Chimarogale*, one of the Old-World leaf-nosed bat, genus *Aseliscus*, and two of white-bellied rats, genus *Niviventer*. On the other hand Bac Me potentially possesses the cryptic diversity of tree shrew, genus *Tupaia*, mole, genus *Euroscaptor*, white-toothed shrew, genus *Crocidura*, and pipistrelle microbat, genus *Pipitrellus*. More research should be conducted in both protected areas to uncover additional diversity.

Previous studies on small mammal fauna in the northeastern limestone region primarily focused on documenting species composition and assessing population status through interviews, observation. As a result, the taxonomy status of most mole populations in the region remains poorly understood. The combination of different scientific methods including

semi-structured interviews, internal and external morphological analysis, and molecular approaches is necessary to provide more accurate and useful information on mole diversity and for the development of appropriate conservation measures for the species.

Our research group is currently examining these taxonomic issues and at least local populations of two genera, *Euroscaptors* and *Tupaia*, are shown to be genetically and morphologically distinct. Two papers are under preparation to describe the cryptic diversity in the groups. Moreover, other distinct populations are also being studied by our group and the results will be published in the near future.

Our surveys also raise several conservation issues. Large mammal fauna in the protected area have severely declined and hardly detected during our surveys, except the Mainland Serow on one occasion in Nam Xuan Lac Habitat and Species Conservation Area. In addition, all Critically Endangered, Endangered, and Vulnerable were virtually only recorded through interviews and literature review. We only observed the Vulnerable Mainland Serow and the Endangered Andersen's Roundleaf Bat. The latter was captured in Bac Me and Cham Chu nature reserves. It is therefore important to establish conservation programs for the Mainland Serow in Nam Xuan Lac and for the Andersen's Roundleaf Bat in Bac Me and Cham Chu. If urgent conservation measures are not implemented, the species will soon be extirpated from the area due to heavy pressures from human activities.

Our surveys did not yield many specimens of several common species – *Callosciurus inornatus* (two specimens collected in Bac Me NR), *Rhizomys pruinosus* (only one specimen in Cao Duong, Cham Chu NR). We had not recorded any information on the occurrence in areas close to human inhabited places, rice lands, and oranges. However, we observed many individuals of these species in the local houses of local people. The situation suggests the survey sites have been heavily impacted by human activities, such as orange production, agricultural expansion, forest loss, mining, and especially the high level of hunting. The species considered area in this study warrant further investigation to verify their conservation status and assess anthropogenic threats.

On the other hand, small mammal faunas have received little attention from government authorities and conservation communities. For example, conservation status of several newly described species, such as the Daovantien's Limestone Rat (*Tonkinomys daovantieni*) and the Orlov's Mole (*Euroscaptor orlovi*), have not been evaluated. Particularly, moles have been neglected although they play a critical role in maintaining vital ecological services. The species are especially threatened because of the lack of data on their conservation status and their vulnerability to human impacts. It is therefore essential to conduct an in-depth study to better understand diversity, distribution, and anthropogenic threats to the taxa using robust scientific methods to better protect the species from further decline.

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2.8. Publications

1. Bui, H.T., Ly T.N., Vu D.T., Le M.D., Nguyen T.T., Nguyen S.T. 2019. Supplementary data of insectivores (Mammalia, Eulipotyphla) in Vietnam. *Journal of Biology* 41: 393-407.
2. Bui, H.T., Motokawa M., Kawada S., Abramov A.V., Nguyen S.T. 2020. Skull variation in Asian moles of the genus Euroscaptor (Eulipotyphla: Talpidae) in Vietnam. *Mammal Study* 45: 265-280.
3. Gorföl, T., Kruskop S.V., Vuong T.T., Estók P., Nguyen S.T., Csorba G. 2020. A new genus of vespertilionid bat: the end of a long journey for Joffre's Pipistrelle (Chiroptera: Vespertilionidae). *Journal of Mammalogy* 101: 331-348
4. Nguyen, T.T., Ly T.N., Vu D.T., Bui H.T., Nguyen D.D., Abramov A.V., Kruskop S.V., Le M.D., Nguyen S.T. 2020. First study of small mammals of Cham Chu and Bac Me NRs, northeastern Vietnam. *Russian Journal of Theriology* 19: 193-209.
5. Endo, H., Nguyen T.S., Nguyen D.D., Sasaki M., Kimura J., Oshida T., Yago M., Ly N.T., Nguyen T.T., Motokawa, M. 2021. Zoogeographical barriers causing discontinuous osteometrical variations in the northern treeshrew skulls. *Journal of Veterinary Medical Science* 83: 1534-1544.

Two additional manuscripts on the taxonomic status of the new populations of genera *Tupaia*

and *Euroscaptor* are under preparation.

3. PROGRESS OF YOUNG SCIENTISTS

Ms. Nguyen Thi Tham is a Ph.D. student at Vietnam National University. She has a background in genetics, but now has participated in all the field trips in northeastern Vietnam. She has improved her field skills substantially. Ms. Tham has also learned a great deal of small mammal morphology during the course of the project. Her writing skill has also been strengthened through writing scientific reports and papers. During the project, Ms. Tham has published three papers, one in a top national journal as a co-author, and two in international journals, one as the first author and one as co-author under the supervision the group leader and the key researcher. She is now leading a new study of the genus *Tupaia* in Vietnam with Mr. Ly Ngoc Tu, another student of the project, and another study on the genus *Euroscaptor*. The studies review morphological and molecular data of all species of the genera in Vietnam and proposes a new taxonomic status for new populations in northern Vietnam. The data collected under the scope of the project play a crucial role in this work. The manuscript will be submitted to an international journal in the first quarter of 2022. Ms. Tham is planning to submit and defend her doctoral dissertation by the end this year.

Mr. Ly Ngoc Tu is a post-master student at IEBR. Before this project, Mr. Tu has been doing a lot of field work and has an extensive knowledge of small mammal morphology. Since taking part in this project, his writing skill has also been strengthened through writing scientific reports and papers. He has also learned more about molecular analyses and molecular evolution. This year, during this project he published three papers in prestigious international and national journals based on the results of the project. Mr. Ly Ngoc Tu is planning to continue his academic study by pursuing a doctoral degree in the near future.