BIODIVERSITY SURVEY OF BATS IN AND AROUND THE PHONG NHA – KE BANG NATIONAL PARK, QUANG BINH, VIETNAM

by

VU DINH THONG[1,*], Pham Duc Tien[1], Nguyen Truong Son[1], Tran Thi Lua[2], Vu Thi Thuy[2], Nguyen Thi Thiep[3], Pham Kim Vuong[4], Dinh Hoang Tuan[4], Le Thuc Dinh[4]

[1]Institute of Ecology and Biological Resources
[2]Vietnam National University, Hanoi
[3]Hanoi National University of Education
[4]Phong Nha-Ke Bang National Park
*E-mail: thong@iebr.ac.vn

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Acronyms and Abbreviations

PNKB: Phong Nha-Ke Bang National Park

PNKBNP: Phong Nha-Ke Bang National Park and extension areas.

IUCN2011. IUCN Red List of Threatened Species. Version 2011.2

RDBVN2007: Red Data Book of Vietnam. Version 2007.

IEBR: Institute of Ecology and Biological Resources

Executive Summary/Abstract

This report describes a bat survey of Phong Nha – Ke Bang National Park and extension section, Quang Binh Province, Vietnam, conducted as part of the Nature Conservation and Sustainable Natural Resource Management in Phong Nha – Ke Bang National Park Region Project, from July 2011 to February 2012.

PNKBNP covers a total of 341,824 ha in Quang Binh Province, North Central Vietnam. The park contains the greatest cave systems of the country with over 300 caves and grottoes discovered. Particularly, PNKBNP is home to the world's longest and largest caves, and is the oldest major karst area in Asia. The findings of this survey indicate that PNKBNP is host to a remarkably high diversity bat fauna. At least, 41 bat species have been recorded over the present and previous surveys, including a new species to science, 5 species listed in the 2007 Red Data Book of Vietnam, and 1 species listed in the 2011 IUCN Red List of Threatened Species as "Vulnerable". In fact, the number of bat species recorded from the park had been rapidly increased over the surveys, and bat surveys were just carried in very narrow area in comparison with the total area of PNKBNP. These imply that PNKBNP would be an important site for both academic and conservation of bats in Vietnam and Asia. Further investigations into the bat fauna of PNKBNP are clearly required for a proper assessment of its diversity and conservation values.

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1. Introduction

1.1. Overview of the report

To date, bat research in Vietnam is at an early stage. Although Vietnamese bats has received attention from scientist in recent times, currently still very little is known regarding the status and distribution of the majority of species occurring within the country. Despite large gaps remaining in terms of survey coverage, however, recent studies have clearly demonstrated that Vietnam contains very high levels of species richness. In particular, limestone karst formations, such as those which characterise much of the landscape of Phong Nha-Ke Bang National Park, are highly significant areas for bat diversity due to their typically extensive cave networks which provide ideal roosting sites. Moreover, sites of forested limestone karst provide critical habitat for several globally threatened and near-threatened bat species occurring in Vietnam.

The purpose of the present survey was to conduct a bat survey within the strictly protected core areas and extension section of Phong Nha-Ke Bang National Park, with a special emphasis on caves, and to assess their importance for biodiversity conservation in Phong Nha-Ke Bang National Park as a whole.

1.2. Phong Nha - Ke Bang National Park and the PNKB Regional Project

PNKBNP is a UNESCO World's Natural Heritage Site. It is situated in the Bo Trach and Minh Hoa districts of Quang Binh province, north-central Vietnam. The park was created to protect one of the world's two largest karst regions with over 300 caves and grottoes, to protect the ecosystem of limestone forest of the Annamite Range region in north central of Vietnam. The cave systems of the park contain many fascinating rock formations and various forest types. Particularly, it is located in a plateau, which is evaluated as one of the finest and most distinctive examples of a karst landform complex in Southeast Asia.

The PNKB Regional Project area covers the core zone of PNKBNP with an area of 116,824 ha (including extension area of 31,070 ha) and a buffer zone of 225,000 ha, consisting of parts of 13 adjacent communes in three districts: Bo Trach, Minh Hoa, and Quang Ninh of Quang Binh Province, Vietnam. The total population of these 13 communes comprising 146 villages is 12,828 households, 61,256 people of which about 11,000 are ethnic minorities of Van Kieu and Chut and the rest belong to the majority ethnic group of Kinh.

The Nature Conservation & Sustainable Natural Resource Management in Phong Nha - Ke Bang Region, Vietnam aims to improve the management of Phong Nha – Ke Bang National Park and reduce the pressure on its natural resources.

In the context of management formulation and improvement, the project organizes biodiversity baseline surveys. These surveys have the following functions:

To inform the management plan and management implementation.

To form the basis of long term biodiversity monitoring, and/or to assess the impact of improved management.

To provide a basis to apply for World Heritage status on biodiversity grounds for the extended PNKB NP.

The subjects and topics of biodiversity baseline surveys need to be chosen and guided carefully to balance between the need to increase relevant knowledge, park management, monitoring needs, management planning, and available time. The surveys need to be scientifically adequate, relevant, and results comprehensively processed to optimize the value ad benefit to PNKB NP. The specialists to undertake the various surveys need to be chosen carefully, as many surveys need specialized knowledge and skills.

1.3. Brief history of the Phong Nha - Ke Bang National Park relevant to bat survey

In 1986, Phong Nha-Ke Bang region was first considered for protection of the extensive cave system within an area of 5,000 ha. Subsequently, it was established as a nature reserve by the Quang Binh Provincial People's Committee in 1993. Subsequently, the Forest Inventory and Planning Institute (FIPI) prepared a revised investment plan for establishment of Phong Nha-Ke Bang National Park region as a national park. In 2001, the the Prime Minister approved the revised plan by FIPI, but did not included an approximately 60,000 ha of the Ke Bang limestone section in Minh Hoa district, which was proposed for inclusion within the national park in the plan. Remarkably, Phong Nha-Ke Bang has been recognized as a UNESCO World Heritage Site since 1998. It contains over 300 grottoes and caves, including the largest and longest caves of the world. It is clear that, the outstanding cave systems and various vegetations covering large karst area are home to a highly diverse bat fauna, which would include precious species.

1.4. PNKB physical structure and climate

PNKBNP is one of the two largest limestone regions in the world. In addition, since its karsts can be traced back to Palaeozoic era, 400 million years ago, PNKBNP appears as the oldest major karst in Asia. It contains around two dozens of mountain peaks with over 1,000 metres in height. Noteworthy peaks are the Peak Co Rilata with ta height of 1,128 m and the Peak Co Preu with a height of 1,213 m.

Besides the grotto and cave systems, PNKBNP has the world’s longest underground river. The Son and Chay are the main rivers in this national park. Most of caves here have been shaped by these two rivers. These cave ecosystems together with surrounding forests provide ideal homes to bats and other animals.

Similar to other areas within North-central Vietnam, climate in PNKBNP is tropically hot and humid. The annual mean temperature is 23 to 25 °C, with a maximum of 41 °C in the summer and a minimum of 6 °C in the winter. The hottest months in this region fall from June to August, with an average temperature of 28 °C,

and the coldest months from December to February with an average temperature of 18 °C. Annual rainfall is 2,000 mm to 2,500 mm, and 88% of the rainfall is from July to December. With more than 160 rainy days per year, raining appears in every month of the year. On the other hand, the annual relative humidity averages 84%.

1.5. Previous biodiversity survey work on bats in and around the PNKBNP

Prior to the survey, very few studies incorporating bats were conducted within PNKBNP. A brief chronology of these is given below.

Nguyen Xuan Dang et al. (1998; 1999; 2000) provided reports on mammal surveys at PNKBNP, which included records of bat species

Timmins et al. (1999) produced an assessment of conservation importance and conservation priorities of the Phong Nha-Ke Bang, which included records of bat species.

Nguyen Truong Son et al. (2000) provided a list of bat species recorded from a rapid survey in PNKBNP.

Hendrichsen et al. (2001) produced a review of bat research in Vietnam, including records of bat species from PNKBNP. This is the most comprehensive document regarding previous bats of PNKBNP. It summarized all previous records of bats from the park by 2001 and truthfully referred its records to either primary materials or literatures. Therefore, only data from this document is cited in the report for discussion on bat diversity of PNKBNP.

2. Objectives of the survey

2.1. Aims and objectives of the biodiversity survey on bats

The aim of the field surveys were to evaluate the biodiversity value, and make conservation recommendations for PNKBNP.

Specific objectives of the field survey were to:

- Collect data on the bat fauna of the study areas;
- Identify important bat roosts and caves within the study area;
- Assess the conservation value of the sites surveyed; and
- Formulate recommendations for appropriate conservation management of the study area.

2.2. Scope of the survey on bats

The survey was conducted in selected sites, which represent typical habitats and are suitable for bat roosts, in the core zone and extension section of Phong Nha-Ke Bang National Park. To pursue the above aims and objectives, the survey was focused mostly on assessment of bat diversity and conservation status within the study areas.

3. Bat survey

3.1. Overview

The survey comprised two phases of fieldwork in PNKBNP. The first phase of fieldwork was carried out in the extension section between July and August 2011. The second phase of fieldwork was carried out in the core zone in February 2012. A list of survey sites and survey effort is given overleaf in Annex 1.

3.2. Methodology, sampling scheme, and survey locations

Site selection

The survey was emphasized on caves and forests, where bats had not been previously studied to determine the species composition of cave and non-cave roosts within core and extended zones of Phong Nha-Ke Bang National Park. Apart from the caves, the surveys were conducted along the courses of rivers, streams, and flight corridors under forest canopies.

In the extended zones, bat capture was conducted at four caves (DBP, Mo O, On 1, On 2), and six trapping sites under forest canopies. In the core zone, the fieldwork was also carried out at four caves and five sites under forest canopies. Selection of trapping sites was largely based on information from local guides and field observations.

Mist netting and Harp trapping

A total of ten mist nets with various sizes (6-12m [length] x 3m [height]) and five harp trap (4 bank design, Francis 1999) were employed during the field surveys. Nets were attended constantly while in active use. Harp traps were generally more effective for capturing insectivorous bats while mist nets were often more effective in wider flight corridors and for capturing fruit bats. Since harp traps were obviously helpful for capturing large numbers of bats, they were always placed at cave doors, where large aggregations of bats would fly together.

Specimen collection

Whenever possible, representative specimens were collected for each species, preferably one of each sex. For several species not easily diagnosed, additional specimens were collected encompassing the range of variation within the captured material (based on biometrics, external morphology, pelage and gender). All specimens were humanely killed using diethyl ether and subsequently soaked in 70% ethanol solution. The large specimens were injected with 10% formalin, prior to storage in 70% ethanol. Pregnant and lactating bats were released at the capture point after taking important external measurements, weight, and photos. Voucher specimens collected during the surveys are retained at the Institute of Ecology and Biological Resources (IEBR), Hanoi, in the collection of Vu Dinh Thong, and at the Phong Nha – Ke Bang National Park.

Identification

Preliminary identifications were made in the field using Lekagul & McNeely (1977), Corbet & Hill (1992), Bates & Harrison (1997), Borissenko and Kruskop (2003), Francis (2008), and Vu Dinh Thong (2011). Further examination of specimens was carried out in Hanoi using information from a variety of published literature. All specimens were determined by the first author (Vu Dinh Thong).

Data collected

All bats captured were measured for forearm length, identified, sexed and the time of capture recorded. For study specimens, additional measurements including head and body (HB), tibia (TB), ear height (EH), lengths of the third, fourth and fifth finger were also recorded to the nearest 0.1mm using two digital calipers. Weight of all live bats and study specimens were taken within one hour from capture time using a digital balance with accuracy to the nearest 0.1g. Details of pelage colors and important external characteristics were also recorded before soaking in ethanol.

Training for park and survey staff

Basic bat survey technique was given to selected staff of PNKBNP during field survey. Additionally, a short training workshop was also conducted at the headquarter of the park with involvement of many other staff of PNKBNP and students from universities in Hanoi. These activity efforts are illustrated in the Annex 2, 3.

3.3. Results

3.3.1. Bats in the PNKB National Park and the extension area

Over the two phases of the survey, a total 179 individuals belonging to 23 species, 13 genera, 6 families were captured. Of which, 24 individuals were kept as voucher specimens for taxonomic examination at IEBR. Provisionally named specimens will require further taxonomic examination to confirm identifications. A full list of species recorded during the survey period is given in Annex 3.

Results from the field survey provide 10 species new to PNKBNP (*Megaerops ecaudatus, Sphaerias blanfordi, Taphozous melanopogon, Rhinolophus macrotis, Hipposideros scutinares, Hipposideros cineraceus, Murina cyclotis, Murina eleryi, Murina tiensa, Murina cineracea*), and one horseshoe bat species (*Rhinolophus* sp.) new to science. Collating the results from the present with previous surveys conducted in PNKBNP, a total of 41 species belonging to 23 genera, 7 families are now known from the study area. A list of these species is given in Annexes 3, 4.

Of the 12 sites surveyed during the present study, four are identified as important for bat conservation because of presence of either rare or threatened species, comprising *R. paradoxolophus*,*Hipposideros scutinares, Rhinolophus* sp. [nov.], *Murina cineracea, Murina tiensa, Macroglobosus sobrinus,*and *Megaerops ecaudatus.*

Survey site accounts

The survey efforts are given below. Number of captured individuals, which partially indicates a relative abundance of each species within the trap site, is given in either the text or square brackets.

1. Trap Site #1 - Cave 11:

(17o32'.24"N; 106o16'.59"E), Cave 11 is one of the large caves of the cave system. It is located in the core zone of PNKB, covered and surrounded by less disturbed forests. A large number of bats were observed at this cave. However, estimated number is much decreased in comparison with data recorded in 2009. Remains of sticks and batteries indicate clearly that bats inhabiting this cave were illegally hunted by local people. Two mist nets and a harp trap were placed at the cave door. Seven species were recorded at this cave*: Aselliscus stoliczkanus* [1], *Hipposideros armiger* [1], *H. larvatus* [2], *H. pomona* [2], *Rhinolophus thomasi* [2], *R. pearsonii* [2], and *Myotis calticraniatus* [1].

2. Trap Site #2 - Cha Noi Cave:

(17o38'.18.1"N; 106o06.12.3"E), Cha Noi Cave is one of the most well known caves of PNKB. It is located near the Cha Noi Forestry Protection Station and a valley, and surrounded by good forests. A large stream seasonally runs beside this cave. Five mist nets and two harp traps were placed at the cave door and across the stream. Ten species were captured from this study site: *Cynopterus sphinx* [1], *Megaderma lyra* [3], *Aselliscus stoliczkanus* [1], *Hipposideros armiger* [1], *H. larvatus* [1], *H. pomona* [1], *H. scutinares* [1], *Rhinolophus thomasi* [1], *R. paradoxolophus* [1], *R. pearsonii* [1], and *Ia io* [3]. Particularly, an individual of unnamed horseshoe

bat species, which is describing by the first author and here provisionally identified as *Rhinolophus* sp. characteristics of this individual are identical to those of a series of individuals previously collected from other nature reserves and national parks in Northern Vietnam. They are clearly distinct from all known horseshoe bats et species levels, and currently classified as a new species to science. Their detailed descriptions are given in our manuscript, which was submitted to a peer-reviewed journal.

3. Trap Site #3 - Bay Tang Cave:

(17o31'33.3"N; 106o16'31.2"E), Bay Tang Cave is a very large cave located within the core zone of PNKB. Since it is a historical site, many tourists visit this cave annually. This cave is surrounded by almost primary forests, and has two adjacent doors. Three mist nets were placed at the cave doors and across a flight corridor inside the cave. Additionally, four other mist nets and two harp traps were also placed across a long footpath connecting the cave and the Legendary Road 20. In order to sample a variation of species composition in a good forest area with cave, bat captures were carried out in February and July, these months belong to the typical rainy and dry seasons, respectively. Four species were captured within this cave area: *Taphozous melanopogon* [5], *Aselliscus stoliczkanus* [1], *Rhinolophus thomasi* [1], and *Pipistrellus javanicus* [1]. Remarkably, a large number of bats were observed and captured inside the cave during the trapping nights in July, but none was seen in February. Further ecological studies within this cave area are required to determine this variation. Of the four captured species, *Taphozous melanopogon* is the most abundant while *Pipistrellus javanicus* appears very rare with only one individual captured.

4. Trap Site #4 – an unnamed forest site:

(17o40'39.8"N; 105o55'48.4E), the trapping site contains a small tributary and various vegetation types: remaining timber trees, shrubs, banana, and bamboo. Three mist nets and two harp traps were placed at this study site. However, only a single individual of *Megaderma lyra* [1] was captured during two trapping nights at this study site.

5. Trap Site #5 – an unnamed forest site:

(17o40'32.0"N; 105o56'38.7"E), the trap site is located beside a farm with various fruit trees. The farm is surrounded by degraded forests with a small stream running across. Two mist nets were placed along an edge of the farm, and a harp trap was placed across the stream. Four species were captured during three trapping at this site, comprising *Rhinolophus pusillus* [1], *Hipposideros larvatus* [2], *Murina cyclotis* [2], and *Murina cineracea* [2].

6. Trap Site #6 - Sot Cave

(17o32'02.3"N; 106o15'18.9"E), Sot Cave is located within the core zone of PNKB. Two mist nets and two harp traps were employed to capture bats within this site. Three species were collected over two trapping nights: *Rhinolophus pusillus* [1], *R. thomasi* [6], and *Pipistrellus javanicus* [2].

7. Trap Site #7 – an unnamed forest site:

(17o40.26.4'N; 105o56.26.4"E), the trap site contains various vegetation types ranging from old farms to secondary forests. Six mist nets and three harp traps were employed during three nights. Only two common species, *Hipposideros larvatus* [6] and *Rhinolophus thomasi* [1], were captured at this site.

8. Trap Site #8 – Da Lat Forest

(17o40'33.7"N; 105o56'05.4"E), Da Lat is a primary forests located in Hoa Son Cummune, Minh Hoa District. Four mist nets and two harp traps were employed over three nights. Six species were captured from this site: *Hipposideros armiger* [4], *H. larvatus* [2], *Rhinolophus thomasi* [2], *R. pearsonii* [2], *Murina cineracea* [1], and *M. tiensa* [2].

9. Trap Site #9 – an unnamed forest site:

(17o40'39.8"N; 105o55'48.4E), this site contains a range of habitats, including streams, small caves and secondary forests. Six mist nets and four harp traps were employed during seven nights. Twelve species were captured over four trapping nights: *Rhinolophus macrotis* [1], *R. thomasi* [8], *R. pearsonii* [1], *R. pusillus* [17], *Aselliscus stoliczkanus* [4], *Hipposideros cineraceus* [4], *H. larvatus* [1], *H. pomona* [2], *Macroglobosus sobrinus* [1], *Megaerops ecaudatus* [1], *Murina cyclotis* [1], and *Myotis calticraniatus* [1]. Of these, *Megaerops ecaudatus* and *Macroglobosus sobrinus* are rarely documented throughout its distribution range.

10. Trapping Site #10 – DBP585 Cave:

(17o40'44.4"N; 105o55'46.6"E), this is a small cave situated beside a large farm and near an army station. Prior to the present study, it had not been named and received no zoological survey. We here name it after the well known army station 585 (= “Don Bien Phong 585” in Vietnamese). Only one species, *Hipposideros armiger* [11], was captured from this cave over one night using two mist nets and a harp trap.

11. Trap Site #11 – Mo O Cave:

(17o40'05.3"N; 105o56'23.8"E), Mo O Cave has a small mouth opening towards an old farm. It is surrounded and covered by good forests. Prior to this study, the cave was not named and had received no zoological survey. Nine species were captured from this cave over four trapping nights: *Aselliscus stoliczkanus* [15], *Hipposideros armiger* [6], *H. larvatus* [8], *H. pomona* [6], *H. cineraceus* [3], *Rhinolophus macrotis* [2], *R. thomasi* [11], *R. pearsonii* [3], and *R. pusillus* [7].

12. Trap Site #12 – Mo O village

(17o40'38.8"N; 105o56'33.8"E), the trap site comprises various vegetation types: shrubs, banana, small timber trees, and secondary forest. Four species were captured from this site over three trapping nights: *Sphaerias blanfordi* [1], *Aselliscus stoliczkanus* [1], *Rhinolophus macrotis* [1], *Myotis calticraniatus* [1], *Murina cineracea* [1], and *M. tiensa* [2].

3.3.2. Threats to and management concerns of Bats in the PNKBNP and the extension area

Similar to several karst areas of the country, threats to bat populations in PNKBNP stem from three principal sources: habitat loss and degradation, incidental disturbance of bat roosts, over-harvesting of caves for tourism development.

To date, very little is known regarding the ecology, roosting and habitat requirements of bats in PNKB and other areas of Vietnam. However, it is clear that habitat loss and degradation can pose a serious threat to bat populations. An example study in Lao P.D.R. showed dramatic differences between sites possessing good vegetation cover compared to those with secondary cover, with much higher bat abundance and diversity recorded in the former (Hutson *et al.* 2001; Furey and Son, 2002). Without doubt, bat species are directly affected by habitat degradation. Cutting timber and large trees definitely leads to loss of roosting sites of bats. Particularly, cave visiting has been well developed in PNKB. As consequence, cave roosts of bats are seriously threatened. Results from interviews and evidence remained inside several caves indicate that bats of PNKB are hunted for local consumption. It is clear that hunting would be one of the most serious threats to cave roosts within PNKB.

Given the low reproductive potential of bats (usually one to two young per year), this activity poses a serious concern as colonies require considerable lengths of time to recover from population declines. Furthermore, given that cave roosts are inherently vulnerable sites which account for the largest proportion of bat populations in karst areas at certain times of the year, clearly these activities have the potential to cause dramatic declines in bat populations in localised areas.

3.4. Analysis and discussion of the results, observation, and data

Collating the results of previous and present researches, a total of at least 41 species are now known from PNKB, representing nearly half of the known bat fauna of Vietnam and approximate 4.0% of the world's bat species (Vu Dinh Thong, unpublished data; Simmons, 2005; Vu Dinh Thong, 2011). These figures alone demonstrate a highly important area for bat conservation in South-east Asia. A full species list is given in Annex 3. It should be noted that this list is clearly incomplete as it is based upon the results of specimen collections, which in some cases have been published prior to their examination by a professional taxonomist.

In terms of individual areas, the present data indicates that the 4 most important sites for bat conservation within PNKB are Da Lat Forest, Cha Noi Cave, Mo O Cave, and Cave 11. In fact, numbers of bat species recorded from PNKBNP had been rapidly increased over the surveys. Therefore, there are good reasons to expect that further survey works will reveal additional bat species at this area. The present survey recorded 10 new species to PNKBNP and a new species to science in just 25 days of fieldwork covering a relatively small proportion of the area. Given

that large areas of forested karst in PNKB remain essentially uninvestigated in terms of their bat fauna, particularly within both core and extended zones.

Unfortunately however, bat populations within PNKB are presently threatened by several factors. Despite the limited coverage and relatively short duration of the present survey, it is evident that incidental disturbance of cave roosts is widespread within the area and presents a serious concern. Although not conclusive, the available evidence also strongly suggests that direct persecution of bats for local consumption could also present a serious concern in localised areas. Further research to determine the scale of these activities within PNKB and identify a representative network of key sites for bat conservation should be considered a priority. Moreover, immediate measures to address these threats and to ensure adequate protection for key cave roosts identified in this study are required.

4. Conclusions and Recommendations

4.1. The status of bat diversity at PNKB National Park

* The currently known bat fauna of PNKBNP is highly diverse.

* A number of nationally and globally rare bat species are living in PNKBNP.

* The numbers of bat species recorded from PNKB have been rapidly increased over the recent surveys. This result suggests a great potentiality of bat diversity of PNKB.

4.2. Threat assessments

Within PNKB, over harvesting of caves for tourism development appears as one of the most threats to bats of the area, particularly to the cave dwelling species. On the other hand, evidence of hunting for local consumption is also a critical threat to bats within PNKB.

4.3. Recommended actions

- Additional surveys, combining all mist nets, harp traps, mobile nets with support of echolocation detector systems are required to fill current gaps in survey coverage and identify other important bat roosts in PNKBNP. These should attempt to identify a representative network of key sites for bat conservation within PNKBNP and provide a better understanding of seasonal patterns in activity and movement. Insofar as is possible, roost assessments

in caves should be conducted between December to March, the peak season for cave roosting.

- Monitoring studies of roosts at caves such as Mo O cave, should be undertaken to ascertain the safe limits of manure harvesting and least damaging means of collection, and, if deemed appropriate, a system of quotas should be introduced to maintain collection within these limits.

- In tandem with the above research, further information regarding the scale and severity of other factors threatening cave bat populations within PNKB is required to provide a basis for prioritisation of targeted conservation actions. Research is also required to determine whether current levels of tourism at PNKBNP are negatively affecting bat roosts, and to what extent there may be a need to restrict levels of access at different times of the year.

- PNKBNP represents an ideal area for more detailed studies investigating the roosting and habitat requirements and behavioural ecology of several poorly known species of special conservation concern. Opportunities to realise this potential should be sought with relevant universities and research institutes.

- A review of specimen collections made at sites within PNKBNP is required to resolve existing uncertainties concerning the species composition of these areas.

- Training courses with involvement of the managers of PNKBNP, local authorities, school teachers, and selected key people should be taken to raise public awareness of bat's importance in ecosystems. The efforts of the courses would provide fruitful results in monitoring and conservation of bats and environments within PNKBNP and surroundings.

4.4. Recommendations for the NP Management Plan

- Effective protection of the two key cave roosts, Cha Noi and Mo O, identified in this study is required to safeguard their conservation value. All these sites should be incorporated into patrol routes and visited on a regular basis, particularly during times of peak usage (December to March). Existing site patrols should also be expanded to include the Phong Nha, Thien Duong, and Son Doong caves to ensure these sites are not subjected to further unnecessary disturbance.

- In terms of forest areas, regular patrols and other appropriate measures should taken to prevent the possible occurrence of habitat loss and

degradation in the On and Mo O forest areas, in particular, as these represent especially significant sites for bat conservation.

- A conservation management strategy specifically for bats should be formulated for PNKB.

- Awareness-raising activities should be undertaken to promote understanding among local communities of the ecological importance e.g. beneficial roles in insect pest control, pollination and seed dispersal etc, conservation significance and fragility of bat populations to incidental and deliberate disturbance. In particular, training should be provided to relevant FPD staff so they can assume a key role in carrying out these and other monitoring activities e.g. roost assessments. Appropriate awareness-raising activities could include educational discussions held in relevant villages, distribution of educational materials e.g. posters., talks given in local schools and supervised visits to selected caves to witness the emergence of bat roosts.

- Specific cave management plans should be formulated to safeguard the archaeological and biological value of all caves which currently serve as tourist attractions. Relevant interpretative and educational materials should be also created to promote understanding and appropriate behaviour on the part of visitors to the site. This could include displaying codes of conduct and/or 'thoughtful tourism' style notices in appropriate locations.
- Development proposals for tourism related infrastructure involving alterations to the interior environment of caves e.g. pathway creation, cementing of floors, installation of lights etc. should be properly evaluated prior to the onset of construction, and, if necessary, revised, to eliminate negative impacts upon the biodiversity and archaeological value of these sites.
- A database should be created for all data regarding bat biodiversity within PNKB to facilitate future research and conservation management and provide accessible baseline information for future monitoring efforts.

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Annex 1. GPS reading`s for species recorded in and around the park

Survey site	Location	Habitat	Species recorded
The core zone			
Cave 11	17o32’.24.3”N 106o16’.59.2”E	Cave	*Aselliscus stoliczkanus*, *Hipposideros armiger*, *H. larvatus*, *H. pomona*, *Rhinolophus thomasi*, *R. pearsonii*, and *Myotis calticraniatus*.
Cha Noi Cave	17o38’.18.1”N 106o06.12.3”E	Cave Tream	*Cynopterus sphinx*, *Megaderma lyra*, *Aselliscus stoliczkanus*, *Hipposideros armiger*, *H. larvatus*, *H. pomona*, *H. scutinares*, *Rhinolophus thomasi*, *R. paradoxolophus*, *R. pearsonii*, and *Ia io*.
Bay Tang Cave	17o31'33.3"N 106o16'31.2"E	Forest Cave	*Taphozous melanopogon*, *Aselliscus stoliczkanus*, *Rhinolophus thomasi*, and *Pipistrellus javanicus.*
Sot Cave	17o32'02.3"N 106o15'18.9"E	Cave	*Rhinolophus pusillus*, *R. thomasi*, and *Pipistrellus javanicus*
The extension section			
Trap Site #4	17o40'39.8"N 105o55'48.4E	Forest	*Megaderma lyra*
Trap Site #5	17o40'32.0"N 105o56'38.7"E	Forest Stream	*Rhinolophus pusillus*, *Hipposideros larvatus*, *Murina cyclotis,* and *Murina cineracea*.
Trap Site #7	17o40.26.4'N 105o56.26.4"E	Forest	*Hipposideros larvatus* and *Rhinolophus thomasi*
Trap Site #8	17o40'33.7"N 105o56'05.4"E	Forest	*Hipposideros armiger*, *H. larvatus*, *Rhinolophus thomasi*, *R. pearsonii*, *Murina cineracea*, and *M. tiensa.*
Trap Site #9	17o40'39.8"N 105o55'48.4E	Forest Cave Streams	*Rhinolophus macrotis*, *R. thomasi*, *R. pearsonii*, *R. pusillus*, *Aselliscus stoliczkanus*, *Hipposideros cineraceus*, *H. larvatus*, *H. pomona*, *Macroglobosus sobrinus*, *Megaerops ecaudatus*, *Murina cyclotis*, and *Myotis calticraniatus*.
Trapping Site #10	17o40'44.4"N 105o55'46.6"E	Cave	*Hipposideros armiger*
Trap Site #11	17o40'05.3"N 105o56'23.8"E	Cave	*Aselliscus stoliczkanus*, *Hipposideros armiger*, *H. larvatus*, *H. pomona, H. cineraceus, Rhinolophus macrotis*, *R. thomasi*, *R. pearsonii*, and *R. pusillus*.
Trap Site #12	17o40'38.8"N 105o56'33.8"E	Forest	*Sphaerias blanfordi*, *Aselliscus stoliczkanus*, *Rhinolophus macrotis*, *Myotis calticraniatus, Murina cineracea*, and *M. tiensa*.

Annex 2. Report on the training for park and survey staff

Trainee	Position	Subjects	Training schedule	Methodology	Conclusions
Mr Pham Kim Vuong	Scientific staff of PNKBNP.	Bat survey techniques.	- During field surveys. - Workshop.	- Presentation & discussion over the workshop. - Practical activities during field surveys.	The trainee has learnt and applied basic tachniques during the courses.
Mr Dinh Hoang Tuan	Scientific staff of PNKBNP.	Bat survey techniques.	- During field surveys. - Workshop.	- Presentation & discussion over the workshop. - Practical activities during field surveys.	The trainee has learnt and applied basic tachniques during the courses.
Ms Vu Thi Thuy	Student of Hanoi National University.	Bat survey techniques.	- During field surveys. - Workshop.	- Presentation & discussion over the workshop. - Practical activities during field surveys.	The trainee has learnt and applied basic tachniques during the courses.
Ms Tran Thi Lua	Student of Hanoi National University.	Bat survey techniques.	- During field surveys. - Workshop.	- Presentation & discussion over the workshop. - Practical activities during field surveys.	The trainee has learnt and applied basic tachniques during the courses.
Ms Nguyen Thi Thiep	Student of Hanoi National University.	Bat survey techniques.	- During field surveys. - Workshop.	- Presentation & discussion over the workshop. - Practical activities during field surveys.	The trainee has learnt and applied basic tachniques during the courses.
Five other staff of PNKBNP	Staff of the Scientific unit of PNKBNP.	Bat survey techniques.	-Workshop	- Presentation & discussion over the workshop.	The trainee gain basic knowledge on bats of PNKBNP.

Annex 2. Report on the training for park and survey staff (continued)

Photos taken during the field and indoor workshops





Annex 3. Bat taxa recorded from PNKBNP

No.	Taxa		Data sources	Conservation status	
	Family	Species		VNRDB2007	IUCN2011
1	Pteropodidae	*Rousettus leschenaulti*	II		LC
2		*Cynopterus sphinx*	I, II		LC
3		*Eonycteris spelaea*	II		LC
4		*Megaerops ecaudatus*	I		LC
5		*Megaerops niphanae*	II		LC
6		*Macroglobosus sobrinus*	I, II		N/A
7		*Sphaerias blanfordi*	I		LC
8	Emballonuridae	*Taphozous melanopogon*	I		LC
9	Megadermatidae	*Megaderma lyra*	I, II		LC
10		*Megaderma spasma*	I, II		LC
11	Rhinolophidae	*Rhinolophus thomasi*	I, II	VU	LC
12		*Rhinolophus affinis*	II		LC
13		*Rhinolophus luctus*	II		LC
14		*Rhinolophus paradoxolophus*	I, II	VU	LC
15		*Rhinolophus macrotis*	I		LC
16		*Rhinolophus pearsoni*	I, II		LC
17		*Rhinolophus pusillus*	I, II		LC
18		*Rhinolophus* sp.	I		N/A
19	Hipposideridae	*Aselliscus stoliczkanus*	I, II, III		LC
20		*Hipposideros armiger*	I, II		LC
21		*Hipposideros scutinares*	I		VU2
22		*Hipposideros cineraceus*	I		LC
23		*Hipposideros larvatus*	I, II, III		LC
24		*Hipposideros pomona*	I, II		LC
25	Vespertilionidae	*Hypsugo pulveratus*	I		LC
26		*Ia io*	I, II	VU	LC
27		*Murina cyclotis*	I, II		LC
28		*Murina eleryi*	I		N/A
29		*Murina tiensa*	I		N/A
30		*Murina cineracea*	I		N/A
31		*Murina* sp.	I		
32		*Harpiocephalus harpia*	II	VU	LC
33		*Harpiocephalus mordax*	II		DD
34		*Myotis ater*	II		LC
35		*Myotis chinensis*	II		LC
36		*Myotis horsfieldii*	II		LC
37		*Myotis ricketti*	II	LR	N/A
38		*Myotis calticraniatus*	I, II		N/A
39		*Scotomanes ornatus*	II		LC
40		*Pipistrellus javanicus*	II		LC
41	Miniopteridae	*Miniopterus magnater*	II		LC

Note: I = The present study result; II = Hendrichsen et al. (2001); II = Vu Dinh Thong (2011).
VNRDB2007 = Red Data Book of Vietnam; IUCN2011 = IUCN Red List of Threatened Species. Version 2011.2
VU, LR = categories defined in VNRDB2007; VU2; LC, DD = categories defined in IUCN2011. N/A = not available.

Annex 4. Selected photographs of bat species captured during the survey.

Pteropodidae


Cynopterus sphinx


Megaerops ecaudatus


Macroglobossus sobrinus


Sphaeris blandfordi

Emballonuridae


Taphozous melanopogon

Megadermatidae


Megaderma lyra


M. spasma

Rhinolophidae


Rhinolophus thomasi


R. paradoxolophus


R. macrotis


R. pearsonii


R. pusillus


Rhinolophus sp. [nov.]

Hipposideridae


Aselliscus stoliczkanus


Hipposideros armiger


H. cineraceus


H. cineraceus


H. larvatus


H. pomona

Vespertilionidae


Hypsugo pulveratus


Ia io


Murina cyclotis


M. eleryi


M. tiensa


M. cineracea