

RESEARCH REPORT



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



Prepared by
REPTILE AND AMPHIBIAN GROUP

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ACRONYMS AND ABBREVIATIONS

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CREC	Central Institute For Natural Resources and Environmental Studies, Vietnam National University, Hanoi
DARD	Department of Agriculture and Rural Development
FPD	Forest Protection Department
GIS	Geographic Information System
HSCA	Habitat and Species Conservation Area
IEBR	Institute of Ecology and Biological Resources
IUCN	International Union for Conservation of Nature
MARD	Ministry of Agriculture and Rural Development
NEF	Nagao Natural Environment Foundation
NP	National Park
NR	Nature Reserve
PC	People's Committee
VNMN	Vietnam National Museum of Nature

Photo credits: Photographs used on the cover page of this report: Evergreen forest in Phia Oac-Phia Den National Park, Cao Bang Province (above); *Rhacophorus kio*, *Tylototriton ziegleri*, *Dopasia harti*, and *Oreocryptophis porphyraceus* (below). Photos: Pham The Cuong, 2020

1. GENERAL INFORMATION

1.1 Authors of the report

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2. RESEARCH

2.1 Abstract

This is the final report of a herpetological research, which was commissioned by the Nagao Natural Environment Foundation, Japan. This project aims to explore the diversity and community structure of the herpetofauna in the karst forests of northeastern Vietnam. This report not only provides updated data about herpetofaunal diversity of four study sites but also mentions conservation concerns that are essential to conservation planning for protected areas as well as for the biodiversity protection in northern Vietnam. In addition, the project also help to strengthen the professional capacity for young researchers in herpetology in Vietnam.

Eight field surveys were conducted by the between October 2018 and September 2021 in northern Vietnam: two field trips in Cham Chu NR of Tuyen Quang Province, two field trips Bac Me NR of Ha Giang Province, two field trips in Phia Oac-Phia Den NP of Cao Bang Province, and two field trips Nam Xuan Lac HSCA of Bac Kan Province.

Taxonomic identification was based on morphological and molecular analyses. Conservation concerns were evaluated based on direct observation in the field and interview with local authorities and people.

Herpetofaunal exploration: Based on the specimen identification and direct observation in the wild, a total of 126 species, comprising 65 species of reptiles and 61 species of amphibians were recorded from four study sites in northeastern Vietnam. Remarkably, two new species were discovered from Phia Oac-Phia Den NP, viz. *Lycodon pictus* and *Megophrys caobangensis*, and new provincial records were reported from northern Vietnam.

- In Cham Chu NR, a total of 61 species (22 species of reptiles and 39 species of amphibians) were documented and 17 species were recorded for the first time from Tuyen Quang Province.
- In Bac Me NR, a total of 66 species (33 species of reptiles and 33 species of amphibians) were documented and 20 of them were recorded for the first time from Ha Giang Province. The species composition of the herpetofauna of Bac Me NR is similar to that of Cham Chu NR in Tuyen Quang Province.
- In Phia Oac-Phia Den NP, a total of 72 species (37 species of reptiles and 35 species of amphibians) was documented and 13 new provincial records for Cao Bang

Province.

- In Nam Xuan Lac HSCA, a total of 53 species (22 species of reptiles and 31 species of amphibians) was documented and eight new provincial records for Bac Kan Province.
- Species of conservation concern: 28 species are globally or nationally threatened at different levels, including 12 species listed in Red Data Book of Vietnam (2007), nine species listed in the IUCN Red List (2021), four species listed in the Vietnam Governmental Decree No. 06/2019/ND-CP (2019), four species listed in CITES appendices (2019), and 11 species are currently known only from Vietnam.

Education and training:

- Luong Mai Anh, a PhD student of the Hanoi National University of Education, used the amphibian collection from northern Vietnam for doctoral research. She successfully defended her dissertation in June and will obtain the doctoral degree in the end of 2021.
- Phan Quang Tien, a master student of the Hanoi National University of Education, used the collection of snakes from Tuyen Quang Province for his master thesis. He obtained the master degree in December 2018.
- Do Hanh Quyen, a master student of the University of Science, Vietnam National University, Hanoi, has used the collection of gecko specimens from northeastern Vietnam for her master thesis. Her master course is expected to be complete in the end of 2021.

Conservation concern: Data about species richness, new findings and conservation value of reptile and amphibian species from Cham Chu NR, Bac Me NR, Phia Oac-Phia Den NP and Nam Xuan Lac HSCA underline the important role limestone karst forests in biodiversity conservation in northern Vietnam. Based on this data, local authorities and decision makers can develop a conservation plan for each species and an appropriate operational plan for each nature reserve or at provincial level.

Publications: As a result of our research, we described two new species for science and reported a series of new provincial records of reptiles and amphibians from Vietnam. Five articles were published in academic journals and another manuscript was recently submitted to the Biodiversity Data Journal.

2.2 Background of the study

Tropical rain forests are recognized as ideal natural laboratories for taxonomic, natural history, and bio-geographic research (Dirzo & Raven 2003). Vietnam contains a large proportion of tropical rain forests, which are mainly located on high mountains in the northern part of the country and Truong Son Range. A wide range of elevations and the complexity of landforms have given the montane region a great diversity of natural habitats and a high level of biodiversity (Sterling et al. 2006). At present, a total of 770 species of reptiles and amphibians have been recorded in Vietnam and approximately 190 new species have been described from the country since 2010 (Frost 2021, Uetz et al. 2021). However, many species of reptiles and amphibians are under threat of extinction with an approximately 15% of the total recorded species from Vietnam are listed in the globally or nationally threatened categories due to habitat loss and degradation, overharvesting, and impacts of climate change (IUCN 2021).

The NEF Bio-ecological Nature Conservation Project in Mountainous Region of North Vietnam aims to explore the biodiversity and to evaluate conservation potentials of limestone karst forests of northeastern Vietnam. As a part of this project, the herpetology group intends to evaluate the species diversity, distribution pattern and conservation value of reptiles and amphibians in four target protected areas, namely Cham Chu NR (Tuyen Quang Province), Bac Me NR (Ha Giang Province), Phia Oac-Phia Den NP (Cao Bang Province) and Nam Xuan Lac HSCA (Bac Kan Province).

2.3. Literature review

2.3.1 Natural features of the study area

Topography: The northeastern region's geology is of largely south Chinese origin with hilly and montane areas in the north and the Red River Delta in the south. The landscape here is formed by a combination of exposed ancient metamorphic basement rock and eroded marine sediments deposited in the late mid-Devonian (370–360 million years ago) and early Triassic (245–224 million years ago) (Averyanov et al. 2003). Northeastern Vietnam contains both karst and granite formations: Ngan Son and Bac Son are two large karst formations, stand at 1000 m a.s.l., their hilltops rising between 100–600 m over the intervening lowland valleys and flat depressions. The karst formations are normally at elevation of 300–700 m, however nearer to the border with China they often reach 1400–1600 m. A number of isolated granite mountain systems are Tay Con Linh (2419 m), Pu

Tha Ca (2274 m), Pia Da (1980 m), and Pia Oac (1930 m) (Averyanov et al. 2003). The northeastern coastline is dotted by more than 2000 offshore islands in the Gulf of Tonkin (Sterling et al. 2006).

Climate: The northeastern region is characterized by the monsoon tropical climate with cold winter and summer rains. This coldness and seasonality is caused by the northeast monsoon winds that bring cold air from the edge of the Tibetan Plateau into northern Vietnam in the winter (from November to March). The hot weather and rain in summer result from the arrival of southwestern monsoon winds blowing in from southerly oceans. Average annual temperature in the region are from 18°C to 23.5°C; average annual rainfall varies considerably from 1343.5 mm (in Cho Ra, Bac Kan Province) to 2749.0 mm (in Huu Lung, Lang Son Province); and the average annual humidity ranges between 81–84% (Nguyen et al. 2000) (Table 1).

Table 1. Climate stations in northeastern Vietnam

Name	Elevation (m a.s.l.)	Temperature (°C)		Rainfall (mm)		Average annual humidity (%)
		Annual average	Range monthly average	Annual average	Range monthly average	
Ha Giang	118	22.7	15.4–27.8	2430.1	31.5–515.6	84
Nguyen Binh	208	20.3	12.3–26.1	1763.0	34.7–312.1	82
Cao Bang	258	21.6	14.0–27.3	1442.7	16.1–267.1	81
Trung Khanh	520	19.9	11.7–26.0	1646.4	31.6–301.5	81
Cho Ra	210	22.0	14.1–27.5	1343.5	18.2–249.4	83
Ngan Son	566	20.1	12.3–25.7	1593.1	24.8–314.8	81
Dinh Hoa	220	22.6	15.3–28.1	1666.9	14.8–315.1	83
Lang Son	258	21.2	13.3–27.0	1391.9	23.0–255.0	82
Huu Lung	40	22.8	15.3–28.4	2749.0	37.6–598.6	83

Source: Nguyen K. V. et al. (2000)

Vegetation and habitats: The dominant habitat type in northeastern Vietnam is evergreen, including both broad-leaved and coniferous plants (Averyanov et al. 2003). The forests developed on highly eroded rocky limestone mountains are an important element of the natural landscape in northeastern Vietnam, and house a number of endemic species. The limestone forests are restricted to Ha Giang, Tuyen Quang, Bac Kan, Cao Bang, and Lang Son provinces in the mainland, as well as to many isolated islands in the Ha Long Bay. Mangrove forests can also be found in coastal areas from Quang Ninh to Nam Dinh provinces. Main dominants in these floristically richest forests are subendemic coniferous trees: *Pinus kwangtungensis*, *Pseudotsuga brevifolia*, and *Tsuga chinensis*. Other rare gymnosperm species like *Amenthotaxus argotaenia*, *A. hatuyensis*, *A. yunnanensis*; *Cupressus torulosa*, *Fokienia hodginsii*, *Kateleeria davidiana*, *Nageia fleurii*, *N. wallichiana*, *Podocarpus brevifolius*, *P. neriifolius*, *Taxus chinensis*, and *Xanthocyparis vietnamensis* are also more or less regular components of the limestone forests in northeastern Vietnam (Averyanov et al. 2003).

2.3.2 Overview of study sites

Field surveys were conducted in four protected areas in northern Vietnam: Cham Chu Nature Reserve in Tuyen Quang Province, Bac Me Nature Reserve in Ha Giang Province, Phia Oac - Phia Den National Park in Cao Bang Province and Nam Xuan Lac Habitat and Species Conservation Area in Bac Kan Province. General information about study sites was provided as the following, which was based on the Sourcebook of Existing and Proposed Protected Areas in Vietnam: Second Edition (Birdlife International 2004) and official websites of provincial governments.

Cham Chu Nature Reserve

Management history: Cham Chu NR was established in 2001 by the Decision No 1536/QĐ-UBND of Tuyen Quang PC, however, without management board. An investment plan for Cham Chu proposed nature reserve was prepared by Tuyen Quang Provincial FPD (2000). The total area of the proposed nature reserve given in this investment plan is 58,187 ha, comprising a strict protection area of 17,904 ha and a forest rehabilitation area of 40,283 ha. Cham Chu was included on a list of Special-use Forests to be established by the year 2010, prepared by the FPD of MARD, as a 58,187 ha nature reserve (FPD 2003). The NR has been under the management of the Cham Chu Special-use Forest Management Board since 2008.

Topography and hydrology: Cham Chu NR is located in Chiem Hoa and Ham Yen districts, Tuyen Quang Province. The nature reserve is centred on Mount Cham Chu, which, at 1,587 m, is the highest point in Tuyen Quang province. Near Mount Cham Chu, there are several other peaks above 1,000 m, although most of the proposed nature reserve is below 800 m in elevation. In the southwest of the proposed nature reserve, about 8 km from Mount Cham Chu, there is a large area of limestone karst, which is bisected by the Lo river.

The west of the proposed nature reserve is drained by the Lo river, while the east is drained by the Gam river, which joins the Lo river upstream of Tuyen Quang town. The Lo river joins the Red River at Viet Tri City.

Biodiversity values: Cham Chu NR supports lowland evergreen forest, lower montane evergreen forest and limestone forest. In November 1999, Fauna & Flora International and the Institute of Ecology and Biological Resources conducted a rapid survey in Trung Ha and Ha Lang communes, Chiem Hoa district (Dang Ngoc Can and Nguyen Truong Son 1999). This survey concentrated on the endemic and critically endangered Tonkin Snub-nosed Monkey *Rhinopithecus avunculus*, which, prior to the survey, was only known to survive at Na Hang NR. Based on interview data and the remains of hunted animals, the authors estimated that the Cham Chu area may support five groups of Tonkin Snub-nosed Monkey, totalling 75 to 89 animals (Dang Ngoc Can and Nguyen Truong Son 1999). Subsequent surveys have provided additional information about the Tonkin Snub-nosed Monkey population at the site, and confirmed that Cham Chu NR is a globally important site for the conservation of this species.

Conservation issues: Tuyen Quang Provincial FPD (*in litt.* 2000) identified the main threats to biodiversity at the site as illegal exploitation of forest products, clearance of forest for agriculture, forest fire and hunting. Dang Ngoc Can and Nguyen Truong Son (1999) received reports of five individuals of the Tonkin Snub-nosed Monkey being hunted there between 1998 and 1999.

Bac Me Nature Reserve

Management history: In 1994, Ha Giang Provincial DARD prepared an investment plan for Bac Me, which proposed establishing a 27,800 ha special-use forest, comprising a strict protection area of 9,450 ha, a forest rehabilitation area of 17,125 ha and an administration and services area of 1,225 ha. This investment plan was approved by Official Letter No. 88/NL-TL of MARD, dated 8 March 1994, and by Decision No. 142/QD-UB of Ha Giang Provincial People's Committee, dated on 22 April 1994. According to Bac Me Special-use

Forest Management Board (*in litt.* 2003), the proposed nature reserve also contains an historical site, called Cang Bac Me (<http://hagiang.gov.vn>, 2020).

Topography and hydrology: Bac Me NR is situated in Bac Me District in southeastern Ha Giang Province. The topography of the proposed nature reserve is mountainous, and there are several peaks above 1,000 m, the highest of which is 1,420 m, on the border with Tuyen Quang Province. The lowest point in the proposed nature reserve is under 200 m. Streams originating in the north and west of the proposed nature reserve feed the Gam river, which flows south, into Tuyen Quang Province, and eventually meets the Lo river. Streams originating in the south-east of the proposed nature reserve feed the Pao Nam river, a tributary of the Gam river.

Biodiversity values: Bac Me NR supports a representative example of the limestone forest ecosystem typical of north-eastern Vietnam (Bac Me Special-use Forest Management Board *in litt.* 2003). To date, however, the biodiversity of the site has not been comprehensively surveyed.

Conservation issues: In 2003, around 7,000 people lived inside the nature reserve, and over 5,000 more lived in the buffer zone. The majority of these people belong to the H'Mong, Tay and Dao ethnic groups. These people practice both fixed and shifting cultivation, and there were 411 ha of wet rice land and 884 ha of hill agricultural land inside the nature reserve (Bac Me Forest Enterprise *in litt.* 2000, Bac Me Special-use Forest Management Board *in litt.* 2003). In recent years, human pressures on the proposed nature reserve have increased, particularly clearance of forest for agriculture.

Other documented values: Bac Me NR protects part of the catchment of the Gam river. In addition, with its beautiful landscape and scenic caves, the nature reserve has potential for ecotourism development. Furthermore, Bac Me NR includes the Cang Bac Me historical site, where political prisoners, including some senior members of the Vietnamese Communist Party, were held by the French Colonial Regime, between 1938 and 1942 (Bac Me Special-use Forest Management Board *in litt.* 2003).

Phia Oac - Phia Den National Park

Management history: Mount Phia Oac NR is located in Tinh Tuc Town and Quang Thanh, Thanh Cong, Phan Thanh, Mai Long, Ca Thanh, Vu Nong and Hung Dao communes, Nguyen Binh District, Cao Bang Province (Tordoff *et al.* 2000). Mount Phia Oac was included on Decision 194/CT of the Chairman of the Council of Ministers, dated on 9 August 1986 (MARD 1997), which decreed the establishment of a 10,000 ha nature reserve

for the protection of "subtropical mountain forests" (Cao Van Sung 1995). An investment plan for Mount Phia Oac was prepared by the Vietnam Forestry University in 1994. This investment plan was approved by Cao Bang Provincial People's Committee in the same year. This investment plan proposed establishing a 13,312 ha nature reserve, comprising a 5,244 ha strict protection area, a 8,053 ha forest rehabilitation area, and a 15 ha administration and services area (Anon. 1999).

Recently, Phia Oac - Phia Den was upgraded to the National Park by the Decision No. 57/QD-TTg of the Prime Minister, dated on 11 January 2018. The national park has a total area of 10,593.5 ha, located in Thanh Cong, Quang Thanh, Phan Thanh, Hung Dao communes and Tinh Tuc Town of Nguyen Binh District, Cao Bang Province (<http://vpcp.chinhphu.vn>, <http://tapchimoitruong.vn>, 2020).

Topography and hydrology: The NP is centred on Mount Phia Oac (1,931 m) and characterised by steep topography. In the west of the NP, there are patches of limestone karst (Tordoff *et al.* 2000).

Biodiversity values: According to the investment plan (Anon. 1999), Mount Phia Oac NR contained 11,839 ha of natural forest. However, 1998 land-use data provided by the Cao Bang Provincial FPD and ground-truthed during a rapid field survey in 1999 indicated that the nature reserve supported only 3,174 ha of natural forest, which was mainly distributed above 1,000 m. The forest has been subjected to high levels of disturbance in the past and is secondary in places. Natural regeneration does, however, appear to be taking place. Below 700 m, the vegetation is dominated by scrub and grassland. In the west of the NP, there were areas of limestone karst without forest, and, at lower elevations in the south, there were *Pinus massoniana* plantations (Tordoff *et al.* 2000).

Mammal diversity at Mount Phia Oac has been severely reduced by hunting, and it would appear that the site supports few viable populations of species of global conservation importance. However, the area supports a number of bird species restricted to broadleaf evergreen forest above 800 m, and may support one of the few remaining areas of suitable habitat for such species in north-eastern Vietnam (Tordoff *et al.* 2000).

Conservation issues: Below 1,000 m, most of the natural forest in the NP has been cleared for cultivation. Above, 1,000 m, however, the natural forest is distributed on steep hillsides at high elevations, which are unsuitable for cultivation. Consequently, clearance for agriculture is not a major threat to biodiversity at Mount Phia Oac (Tordoff *et al.* 2000).

Mount Phia Oac and the surrounding area are rich in minerals, particularly zinc. Mining activities during the French colonial era resulted in clearance of large areas of forest and high levels of disturbance to remaining areas. Although these activities have now largely ceased, the forest is under continued pressure from local people, who extract bamboo, bamboo shoots, medicinal plants and firewood from the national park (Tordoff *et al.* 2000).

Another threat to biodiversity at Mount Phia Oac is hunting, as a result of which population sizes of large and medium-sized mammal species have reportedly declined dramatically (Tordoff *et al.* 2000).

The proposed boundary defined in the investment plan for Mount Pia Oac (Anon. 1999) includes 10,073 ha of non-forest land, a town, a zinc mine and several thousand people. Consequently, both Wege *et al.* (1999) and Tordoff *et al.* (2000) recommended that the boundary be revised to exclude all areas of scrub, grassland, agricultural land and habitation.

Other documented values: Cao Bang Provincial People's Committee are considering developing the area around Mount Pia Oac as a site for tourism. The potential for the development of tourism in the area is high for several reasons: the area is easily accessible from Cao Bang town by surfaced road; there are several ruined French villas that could be renovated; there is a colourful ethnic minority market in the area; and the summit of Mount Pia Oac is easily accessible on foot (Tordoff *et al.* 2000).

Nam Xuan Lac HSCA

Management history: Nam Xuan Lac had not been included on any government decision or official set of proposals regarding the national Special-use Forests system until the year 2000 (MARD 1997, FPD 2003). However, in 2001, a survey of Ban Thi and Xuan Lac communes, Cho Don District, was conducted as part of the *Creating Protected Areas for Resource Conservation Using Landscape Ecology (PARC) Project*. The objectives of this survey were to evaluate the biodiversity values of the site and to assess the suitability of the site for Special-use Forest status, either as part of a habitat extension of Na Hang proposed nature reserve, or as a separate protected area. The survey revealed that the site supports biodiversity of international importance (Le Trong Trai *et al.* 2001). Consequently, Bac Kan Provincial FPD proposed establishing a 1,788 ha species/habitat conservation area (a sub-category of nature reserve), called Nam Xuan Lac, at the site (Bac Kan Provincial FPD *in litt.* 2003).

In 2003, with the support of the PARC Project, Bac Kan Provincial FPD submitted a formal proposal and five-year investment plan (2004-2008) to Bac Kan Provincial People's Committee and MARD for the establishment of a species/habitat conservation area at Nam Xuan Lac. This proposal was approved in November 2003 (PARC Project *in litt.* 2003).

With support from the PARC Project, Bac Kan Provincial FPD developed a trial management structure for Nam Xuan Lac, which aimed to introduce a co-management approach for the site. It was proposed that the management board included representatives of the provincial FPD, Xuan Lac commune and nearby villages in the buffer zone (PARC Project *in litt.* 2003).

The Nam Xuan Lac SHCA was officially established by the Decision No. 342/QD-UB, dated on 17 March 2004 by Bac Kan PC, with a total area of 1,788 ha, located in Na Da and Ban Khang villages of Xuan Lac commune, Cho Don District. According to the Decision No. 109/QD-UB of Bac Kan PC, dated on 14 January 2014, the area of Nam Xuan Lac HSCA was extended to 4,155.67 ha, comprising a core zone of 2,552.5 ha, a rehabilitation zone of 1,586.12 ha and an administration zone of 9.04 ha (<http://kiemlam.backan.gov.vn>, 2020).

Topography and hydrology: Nam Xuan Lac is situated in western Bac Kan province. To the west, the site is contiguous with the Ban Bung sector of Na Hang Nature Reserve. The topography of the site is characterised by steep limestone karst formations, separated by flat-bottomed valleys.

Biodiversity values: In 2001, a globally endangered bird species, the White-eared Night Heron *Gorsachius magnificus*, was recorded at the site (Le Trong Trai *et al.* 2001). This is the first confirmed record of this restricted-range bird species in Vietnam since at least 1975, and indicates that Nam Xuan Lac may lie within the South-east China Mountains Endemic Bird Area. Because of the occurrence of White-eared Night Heron, and the importance of the site for biome-restricted bird species, some of which are known from few other sites in Vietnam, the site qualifies as an Important Bird Area, called Ban Thi-Xuan Lac (Tordoff 2002).

Le Trong Trai *et al.* (2001) recorded a number of other globally threatened species on the basis of reports by local people, including the Francois's Leaf Monkey *Trachypithecus francoisi*, a primate species endemic to northern Vietnam and southern China. Additional surveys, by the Institute of Ecology and Biological Resources, have also revealed that the

Nam Xuan Lac area is particularly important for several plant taxa, notably slipper orchids *Paphiopedilum*.

Of particular significance, Nam Xuan Lac might support a population of the globally critically endangered, endemic primate, the Tonkin Snub-nosed Monkey *Rhinopithecus avunculus*, or at least provide additional habitat for the population that occurs in the Ban Bung sector of Na Hang Nature Reserve in Tuyen Quang Province. During a field survey for the species in 1999, Dang Ngoc Can and Nguyen Truong Son (1999) received reports of a group of 18 to 20 individuals, which ranged occasionally into forest in Xuan Lac commune. During interviews with PARC Project staff in October 2003, residents of Na Da village, near the north-western border of the site, stated that they had seen four or five individuals at the site in 2002 (Bezuijen and Trinh Thang Long 2003).

Conservation issues: The principle threats to biodiversity at Nam Xuan Lac HSCA were habitat fragmentation and loss, due to agricultural expansion and mining; and exploitation of wildlife, timber and non-timber forest products by local communities and mine workers in and around the site (Le Trong Trai *et al.* 2001, Bezuijen and Trinh Thang Long 2003, Momberg and Fredricksson 2003). Exploitation of forest products by local communities and mine workers was for both domestic and commercial trade, particularly in the case of wildlife (Bezuijen and Trinh Thang Long 2003, Nguyen Xuan Dang *et al.* 2003). The FPD and the PARC Project had initiated environmental management activities with local communities and mine companies in an attempt to address these issues.

Other documented values: Mining of non-ferrous metals has been conducted near the southern and eastern boundaries of the site for more than 80 years. In 2000s, most mining operations were controlled by the Thai Nguyen Non-ferrous Metals Corporation, consisting of four companies operating in three mine leases close to the site. Nam Xuan Lac HSCA included 214 ha of the Pha Khao mine lease, and is adjacent to the Lung Chay mine lease (Bezuijen and Trinh Thang Long 2003). The mining corporation had agreed to develop an environmental agreement with the FPD and appropriate management measures to protect biodiversity within and near the proposed nature reserve (Bezuijen and Trinh Thang Long 2003).

2.4 Group's purpose and subjects

Purpose and subjects

1. This project aims to explore the diversity and community structure of the

herpetofauna (reptiles and amphibians) in the karst forests of northeastern Vietnam based on morphological and molecular data with spatial information of species assembly.

2. In addition, the project will help to strengthen the professional capacity for young researchers in herpetology in Vietnam. Three students from the Institute of Ecology and Biological Resources and Hanoi National University of Education will involve in this study in order to complete their doctoral and master degrees.

Objectives

Specific objectives of this study are:

1. To evaluate the species richness and genetic diversity of reptiles and amphibians in karst forests of northeastern Vietnam.
2. To elucidate the functional composition of herpetological communities across a biogeographic gradient in northeastern Vietnam (i.e. Ngan Son and Bac Son karst formations). It is expected to record about 100 species of reptiles and amphibians from different studied sites.
3. To predict the potential distribution of some endemic or threatened species under the influence of climate change;
4. To provide essential data for biodiversity conservation of the region. Based on the results of our surveys and referred to the published literature we will define the hot spots for the herpetofauna conservation in NE Vietnam. Criteria for hot spot identification are as the following: 1) species richness, 2) number of rare, threatened and/or endemic species, 3) forest area and habitat quality, and 4) human disturbance factors. In each category, a higher number represents a better score (ranking score based on the number of survey sites).

2.5 Materials and Methods

2.5.1 Working schedule and study sites

Eight field surveys were conducted in Tuyen Quang Ha Giang, Cao Bang, and Bac Kan provinces in the three years, from October 2018 to September 2021.

- Trip 1 from 24 to 31 October 2018 in Cham Chu Nature Reserve, Nam Luong Village, Phu Luu Commune, Ham Yen District, Tuyen Quang Province.
- Trip 2 from 12 to 19 April 2019 in Cham Chu Nature Reserve, Cao Duong Village,

Yen Thuan Commune, Ham Yen District, Tuyen Quang Province.

- Trip 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.
- Trip 4 from 14 to 21 October 2019 in Bac Me Nature Reserve, Minh Son and Minh Ngoc communes, Bac Me District, Ha Giang Province.
- Trip 5 from 20 to 27 May 2020 in Phia Oac-Phia Den National Park, Nguyen Binh District, Cao Bang Province.
- Trip 6 from 24 to 31 August 2020 in Nam Xuan Lac Habitat and Species Conservation Area, Cho Don District, Bac Kan Province.
- Trip 7 from 03 to 10 October 2020 in Phia Oac-Phia Den National Park, Nguyen Binh District.
- Trip 8 from 22 to 29 April 2021 in Nam Xuan Lac HSCA, Cho Don District.

For schedule of activities see Table 2. The coordinates of the sites were determined by using the GPS Garmin 60CX (Table 2, Figs. 1–3).

Table 2. Information of survey sites in northeastern Vietnam

Date	Site	Coordinate	Elevation (m)
Trip 1: Cham Chu NR, Tuyen Quang Province, from 24 to 31 October 2018			
24/10	Camp 1: Nam Luong Village, Phu Luu Commune	22°12.642'N, 105°02.962'E	124
25/10	Cave 1	22°18.185'N, 105°03.416'E	418
	Cave 2	22°12.239'N, 105°03.381'E	338
	Stream 1	22°12.322'N, 105°03.317'E	213
27/10	Cliff 1	22°20.996'N, 105°05.048'E	157
	Cliff 2	22°20.871'N, 105°05.621'E	246
	Stream 2	22°20.717'N, 105°05.495'E	286
28/10	Cliff 3	22°12.755'N, 105°04.047'E	388
	Stream 3	22°12.728'N, 105°04.059'E	359
		22°12.629'N, 105°03.925'E	240
29/10	Stream 4	22°12.603'N, 105°03.833'E	246
		22°12.516'N, 105°04.895'E	315
		22°12.445'N, 105°03.938'E	405
30/10	Cave 3	22°13.904'N, 105°02.666'E	420

Date	Site	Coordinate	Elevation (m)
	Stream 5	22°13.978'N, 105°02.645'E 22°13.746'N, 105°02.766'E	410 374
26/10	Camp 2: Cham Chu Mountain	22°12.891'N, 105°04.647'E	980
26/10	Stream 6	22°12.565'N, 105°04.480'E 22°12.466'N, 105°04.401'E	1024 984
27/10	Stream 7	22°12.414'N, 105°04.423'E 22°12.462'N, 105°04.487'E	981 1023
28/10	Forest path	22°12.891'N, 105°04.647'E 22°12.653'N, 105°04.536'E	980 1056
Trip 2: Cham Chu NR, Tuyen Quang Province, from 12 to 19 April 2019			
12/4	Camp 1: Cao Duong Village, Yen Thuan Commune	22°17.699'N, 104°59.310'E	685
13/4	Cave 1 Cave 2 Stream 1	22°17.349'N, 104°59.419'E 22°17.380'N, 104°59.438'E 22°17.329'N, 104°59.386'E	649 664 641
14/4	Stream 2 Forest path 1 Cave 3	22°16.271'N, 104°59.501'E 22°16.167'N, 104°59.744'E 22°16.091'N, 104°59.831'E 22°16.594'N, 104°59.561'E 22°18.036'N, 104°59.447'E	631 679 750 650 773
15/4	Cave 4 Cliff 1 Cave 5 Stream 3	22°17.906'N, 104°59.623'E 22°17.560'N, 104°59.535'E 22°17.587'N, 105°59.478'E 22°18.074'N, 104°59.087'E 22°17.588'N, 104°58.575'E	641 685 750 679 720
16/4	Forest path 2 Pond 1 Pond 2 Pond 3	22°18.129'N, 104°59.384'E 22°18.266'N, 104°59.265'E 22°18.282'N, 104°59.192'E 22°18.333'N, 104°58.586'E 22°18.295'N, 104°59.013'E	693 760 785 780 776

Date	Site	Coordinate	Elevation (m)
	Cave 6	22°17.128'N, 104°59.061'E	655
	Pond 4	22°17.110'N, 104°59.117'E	644
	Pond 5	22°17.100'N, 104°59.156'E	646
17/4	Stream 4	22°15.366'N, 104°59.143'E	705
		22°15.255'N, 104°59.023'E	654
	Stream 5	22°19.070'N, 104°58.669'E	640
		22°19.230'N, 104°58.867'E	697
18/4	Forset path 3	22°15.275'N, 104°59.175'E	698
		22°16.476'N, 104°59.490'E	830
Trip 3: Bac Me Nature Reserve, Ha Giang Province, from 24 to 31 May 2019			
24/5	Camp 1: Lung Cang Village, Minh Ngoc Commune	22°42.834'N, 105°11.268'E	217
25/5	Forest path 1	22°42.528'N, 105°11.206'E	235
		22°42.143'N, 105°10.916'E	369
	Stream 1	22°41.991'N, 105°11.152'E	468
		22°41.916'N, 105°11.169'E	520
26/5	Steam 2	22°43.102'N, 105°11.301'E	202
		22°43.31'N, 105°11.304'E	209
27/5	Cliff 1	22°43.512'N, 105°12.213'E	175
	Cliff 2	22°44.08'N, 105°12.03'E	169
28/5	Camp 2: Na Lai Village, Thuong Tan Commune	22°42.796'N, 105°15.626'E	1051
28/5	Stream 3	22°42.554'N, 105°15.110'E	655
	Forest path 2	22°42.662'N, 105°15.494'E	834
29/5	Pond 1	22°42.893'N, 105°15.484'E	1005
	Pond 2	22°42.920'N, 105°15.493'E	985
30/5	Camp 3: Lac Nong Commune	22°45.330'N, 105°15.353'E	195
30/5	Cave 1	22°45.657'N, 105°14.004'E	269
	Cave 2	22°45.674'N, 105°14.009'E	285
Trip 4: Bac Me NR, Ha Giang Province, from 14 to 21 October 2019			

Date	Site	Coordinate	Elevation (m)
14/10	Camp1: Phieng Deng Village, Minh Son Commune	22°50.828'N, 105°09.756'E	635
15/10	Stream 1S	22°51.087'N, 105°09.479'E	591
	Stream 1F	22°50.974'N, 105°09.277'E	689
	Stream 2S	22°50.823'N, 105°09.683'E	561
	Stream 2F	22°50.913'N, 105°09.395'E	709
	Cliff 1	22°51.056'N, 105°09.394'E	629
	Cliff 2	22°50.965'N, 105°09.382'E	641
16/10	Forest path 1	22°51.144'N, 105°09.327'E	646
	Stream 3S	22°51.139'N, 105°09.137'E	693
	Stream 3F	22°51.313'N, 105°09.247'E	616
	Stream 4S	22°50.584'N, 105°08.961'E	863
	Stream 4F	22°50.487'N, 105°08.894'E	938
	Forest path 2	22°50.502'N, 105°08.912'E	912
17/10	Stream 5S	22°50.438'N, 105°09.801'E	363
	Stream 5F	22°50.385'N, 105°09.691'E	418
	Forest path 3	22°50.535'N, 105°09.813'E	422
18/10	Stream 6S	22°50.908'N, 105°09.985'E	478
	Stream 6F	22°50.905'N, 105°09.740'E	586
19/10	Camp 2: Lung Cang Village, Minh Ngoc Commune	22°42.834'N, 105°11.268'E	217
19/10	Stream 7S	22°42.650'N, 105°11.219'E	242
	Stream 7F	22°42.473'N, 105°11.204'E	275
20/10	Forest path 4	22°42.528'N, 105°11.206'E	235
		22°42.143'N, 105°10.916'E	369
	Stream 8	22°41.991'N, 105°11.152'E	468
		22°41.916'N, 105°11.169'E	520
Trip 5: Phia Oac-Phia Den NP, Cao Bang Province, from 20 to 27 May 2020			
21-26/05	Surveying forest habitats around Phia Oac mountain	22°36.394'N, 105°52.031'E	1750

Date	Site	Coordinate	Elevation (m)
21/05	Stream 1	22°36.310'N, 105°52.133'E	1601
		22°36.441'N, 105°52.116'E	1711
	Forest path 1	22°36.394'N, 105°52.031'E	1750
		22°36.295'N, 105°52.121'E	1650
22/05	Stream 2	22°36.662'N, 105°53.036'E	1262
		22°36.607'N, 105°52.862'E	1350
23/05	Forest path 2	22°35.968'N, 105°52.906'E	1287
		22°35.942'N, 105°52.424'E	1297
24/05	Stream 3	22°36.882'N, 105°52. 881'E	1226
		22°36.834'N, 105°52. 739'E	1359
	Stream 4	22°37.246'N, 105°52. 611'E	1159
		22°37.236'N, 105°52. 505'E	1240
25/05	Stream 6	22°36.508'N, 105°52. 210'E	1566
		22°36.526'N, 105°52. 095'E	1690
26/05	Stream 7	22°36.419'N, 105°52. 272'E	1517
		22°36.507'N, 105°52. 211'E	1550
Trip 6: Nam Xua Lac HSCA, Bac Kan Province, from 24 to 31 August 2020			
25-30/08	Binh Trai Ranger Station Area	22°16.503'N, 105°31.007'E	802
25/08	Stream 1	22°16.251'N, 105°30.390'E	696
		22°16.270'N, 105°30.427'E	723
26/08	Stream 2	22°16.447'N, 105°31.456'E	650
		22°16.484'N, 105°31.449'E	697
	Stream 3	22°16.284'N, 105°30.194'E	646
		22°16.380'N, 105°30.240'E	655
	Forest path 1	22°16.216'N, 105°30.211'E	646
27/08	Forest path 2	22°15.303'N, 105°31.144'E	723
	Stream 4	22°15.214'N, 105°31.126'E	709
		22°15.182'N, 105°31.106'E	714
28/08	Stream 5	22°16.228'N, 105°31.115'E	740
		22°16.165'N, 105°31.142'E	810

Date	Site	Coordinate	Elevation (m)
	Stream 6	22°17.413'N, 105°30.330'E 22°17.342'N, 105°30.185'E	695 776
29/05	Forest path 3	22°16.117'N, 105°30.548'E 22°16.270'N, 105°30.425'E	747 646
30/08	Pond 1 Stream 7	22°16.282'N, 105° 31.202'E 22°16.295'N, 105°31.099'E 22°16.223'N, 105°31.090'E	699 714 762
Trip 7: Phia Oac-Phia Den NP, Cao Bang Province, from 3 to 10 October 2020			
04/10	Stream 1	22°36'29.9"N, 105°52'11.3"E 22°36'23.7"N, 105°52'16.9"E	1511 1574
05/10	Stream 2 Forest path 1	22°36'39.7"N, 105°53'2.2"E 22°36'35.0"N, 105°52'47.4"E 22°36'36.7"N, 105°52'54.1"E	1262 1454 1364
06/10	Stream 3	22°35'33.4"N, 105°52'51.9"E 22°35'26.2"N, 105°52'54.7"E	1229 1293
07/10	Stream 4	22°37.246'N, 105°52. 611'E 22°37.236'N, 105°52. 505'E	1159 1240
08/10	Forest path 2 Stream 5	22°36'55.6" N, 105°51'49.5"E 22°36'29.9"N, 105°52'11.3"E 22°36'33.0" N, 105°52'06"E 22°36'43.5"N, 105°52'05.3"E	1903 1574 1610 1676
09/10	Stream 6	22°35'39.1"N, 105°53' 06.2"E 22°35'43.6"N, 105°53'09.9"E	1257 1300
04/10	Stream 1	22°36'29.9"N, 105°52'11.3"E 22°36'23.7"N, 105°52'16.9"E	1511 1574
05/10	Stream 2 Forest path 1	22°36'39.7"N, 105°53'2.2"E 22°36'35.0"N, 105°52'47.4"E 22°36'36.7"N, 105°52'54.1"E	1262 1454 1364

Date	Site	Coordinate	Elevation (m)
06/10	Stream 3	22°35'33.4"N, 105°52'51.9"E 22°35'26.2"N, 105°52'54.7"E	1229 1293
Trip 8: Nam Xuan Lac HSCA, Bac Kan Province, from 24 to 31 April 2021			
23-25/04	Ban Thi Commune	22°16'50.3"N, 105°29'31.6"E	288
23/04	Stream 1	22°15'51.6"N, 105°29'16.1"E 22°16'0.8"N, 105°29'22.8"E	342 371
	Forest path 1	22°14'45.1"N, 105°29'30.6"E 22°14'45.5"N, 105°29'56.0"E	276 434
24/04	Stream 2	22°16'23.1"N, 105°30'20.8"E 22°16'38.7"N, 105°30'25.4"E	652 659
	Forest path 2	22°17'15.6"N, 105°31'8.3"E 22°17'35.2"N, 105°30'33.7"E	864 746
25/04	Forest path 3	22°13'55.3"N, 105°28'57.4"E 22°14'10.4"N, 105°28'40.5"E	388 485
26-28/04	Ta Vao Ranger Station Area	22°18'20.0"N, 105°33'49.1"E	278
26/04	Forest path 4	22°17'19.7"N, 105°33'14.6"E 22°16'46.0"N, 105°33'20.0"E	291 407
27/04	Forest path 5	22°17'22.3"N, 105°33'17.9"E 22°17'07.8"N, 105°33'25.7"E	289 321
28/04	Stream 3	22°16'29.9"N, 105°33'17.2"E 22°16'28.4"N, 105°33'17.0"E	458 461
	Stream 4	22°16'47.9"N, 105°33'21.5"E 22°16'26.2"N, 105°33'12.6"E	377 537

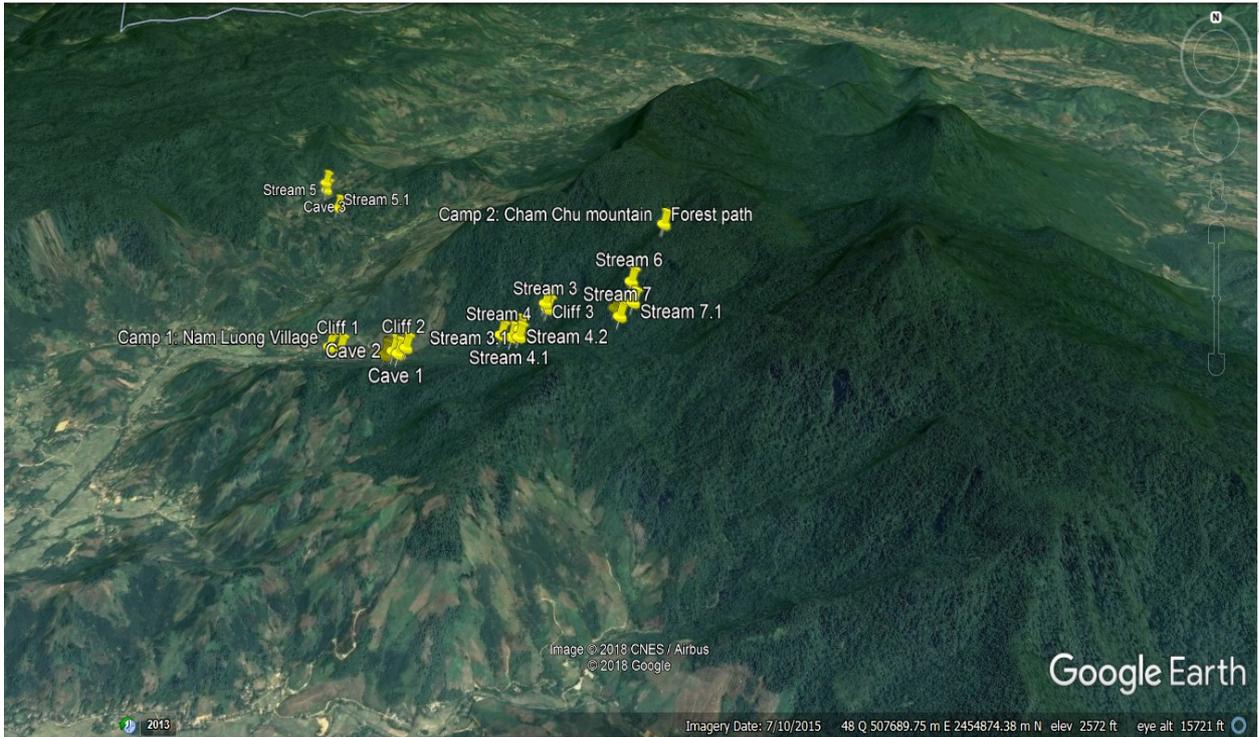


Figure 1. Map showing survey sites in Cham Chu Nature Reserve (Trip 1)

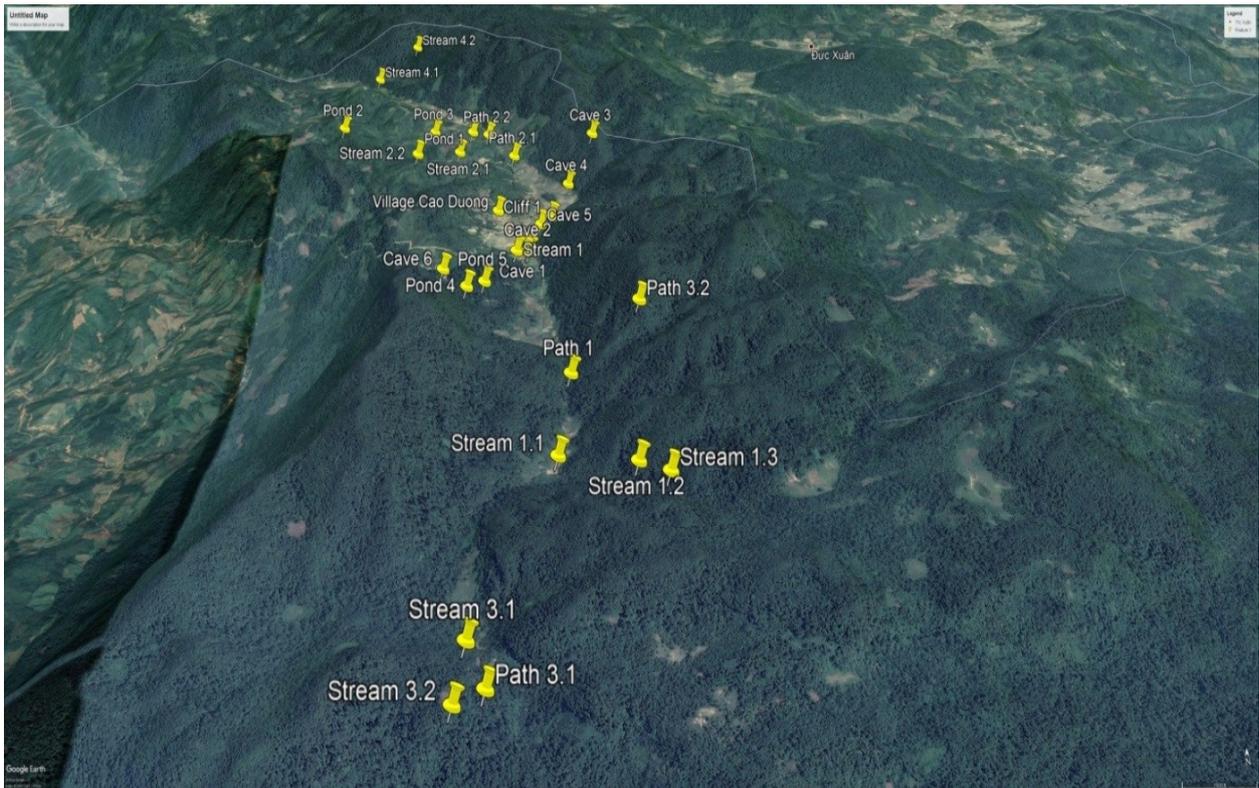


Figure 2. Map showing survey sites in Cham Chu Nature Reserve (Trip 2)

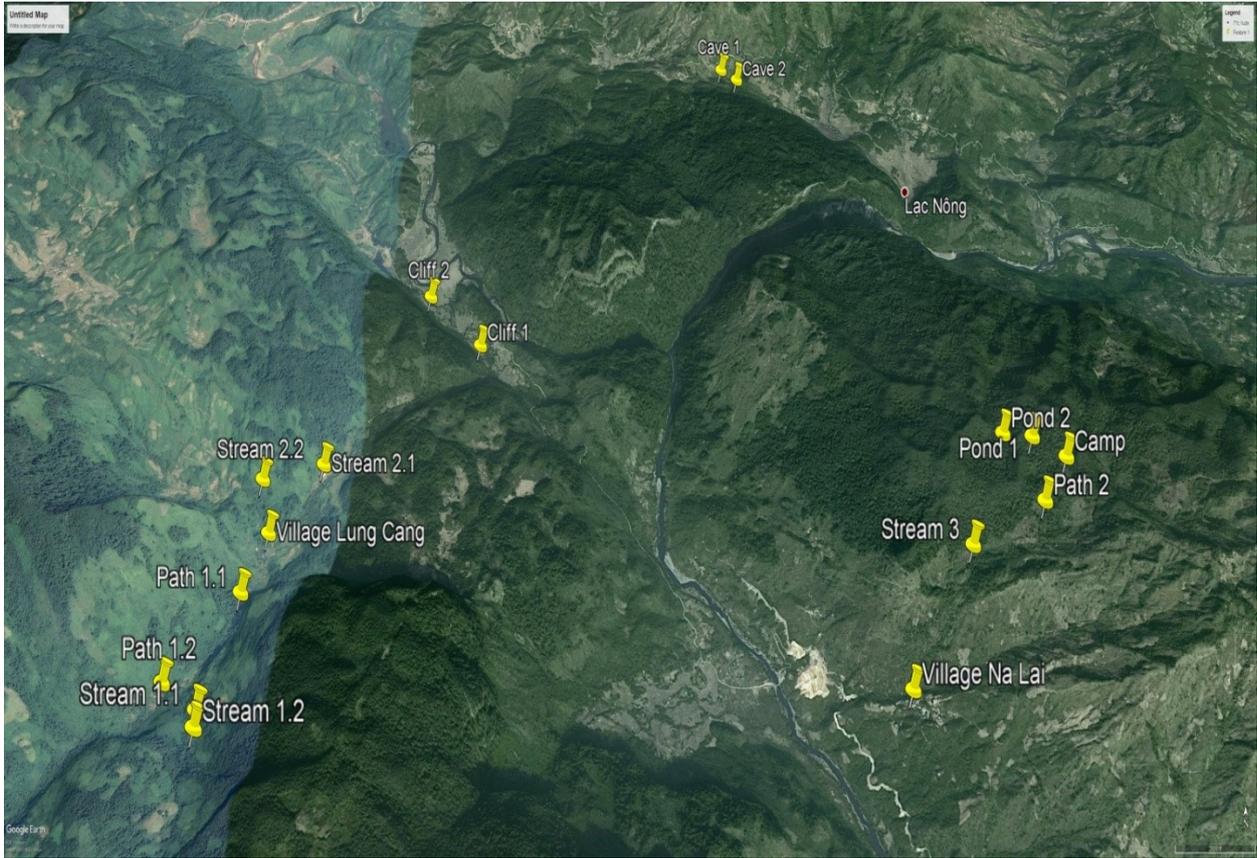


Figure 3. Map showing survey sites in Bac Me Nature Reserve (Trip 3)

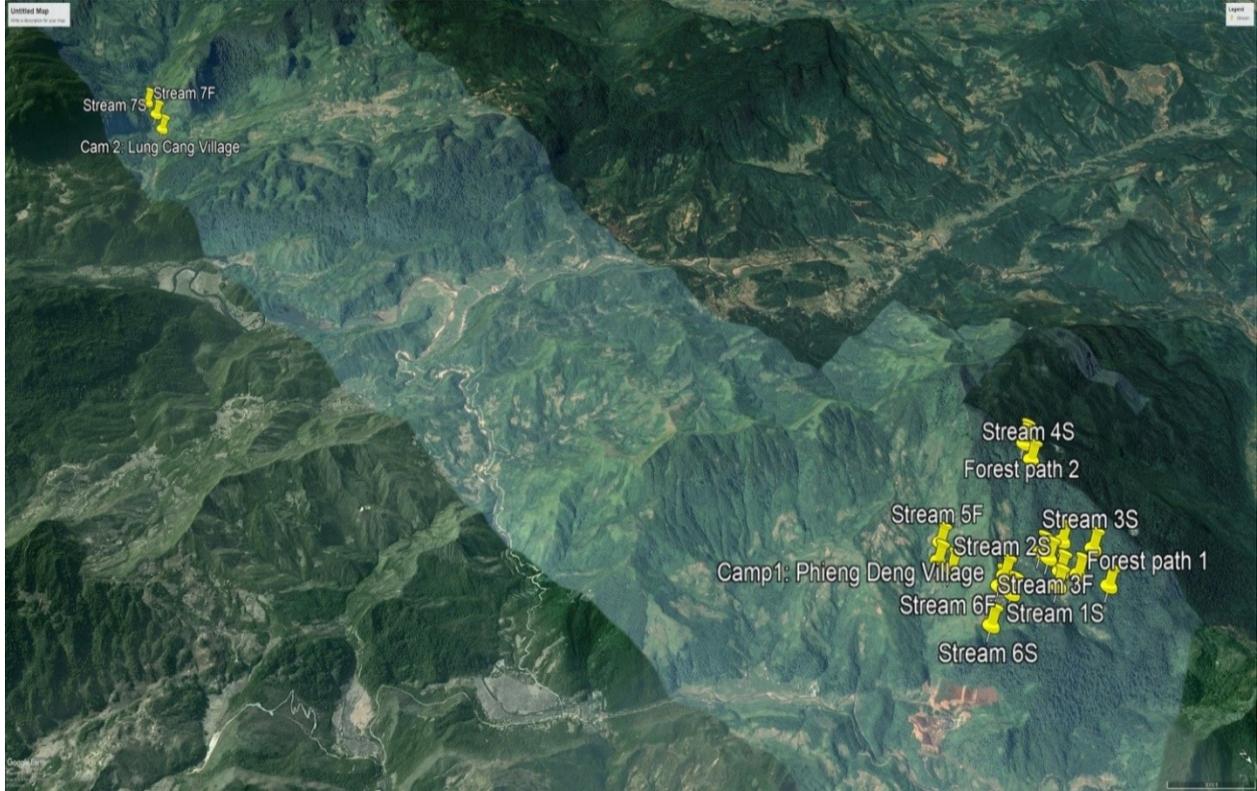


Figure 4. Map showing survey sites in Bac Me Nature Reserve (Trip 4)

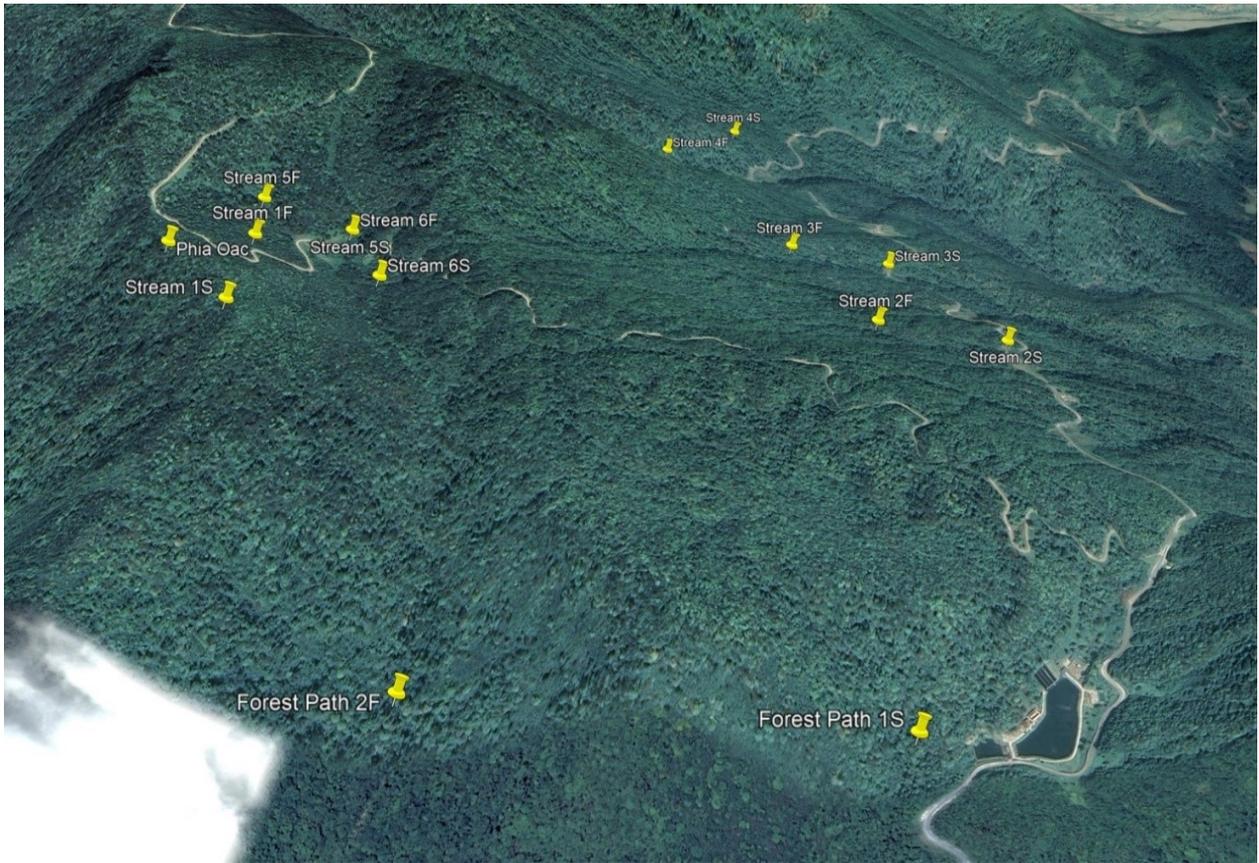


Figure 5. Map showing survey sites in Phia Oac-Phia Den NP (Trip 5)

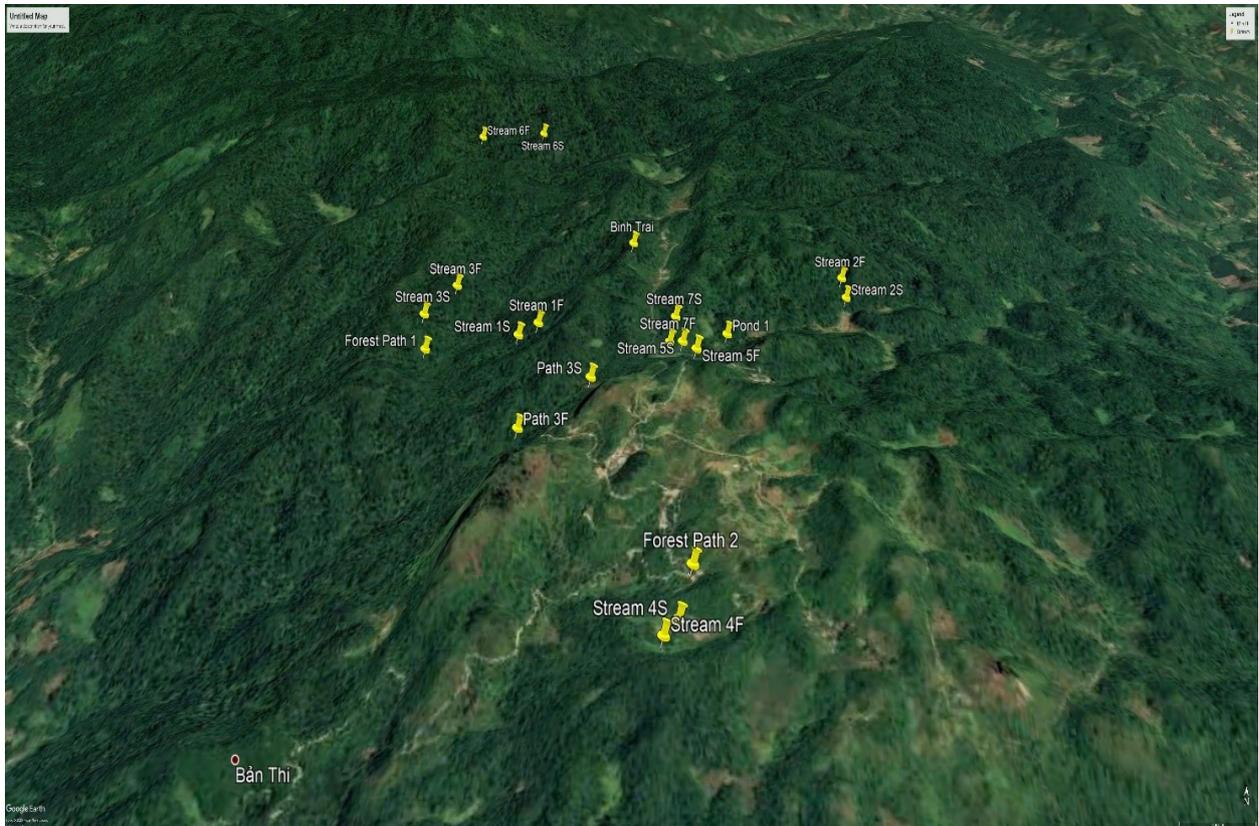


Figure 6. Map showing survey sites in Nam Xuan Lac (Trip 6)

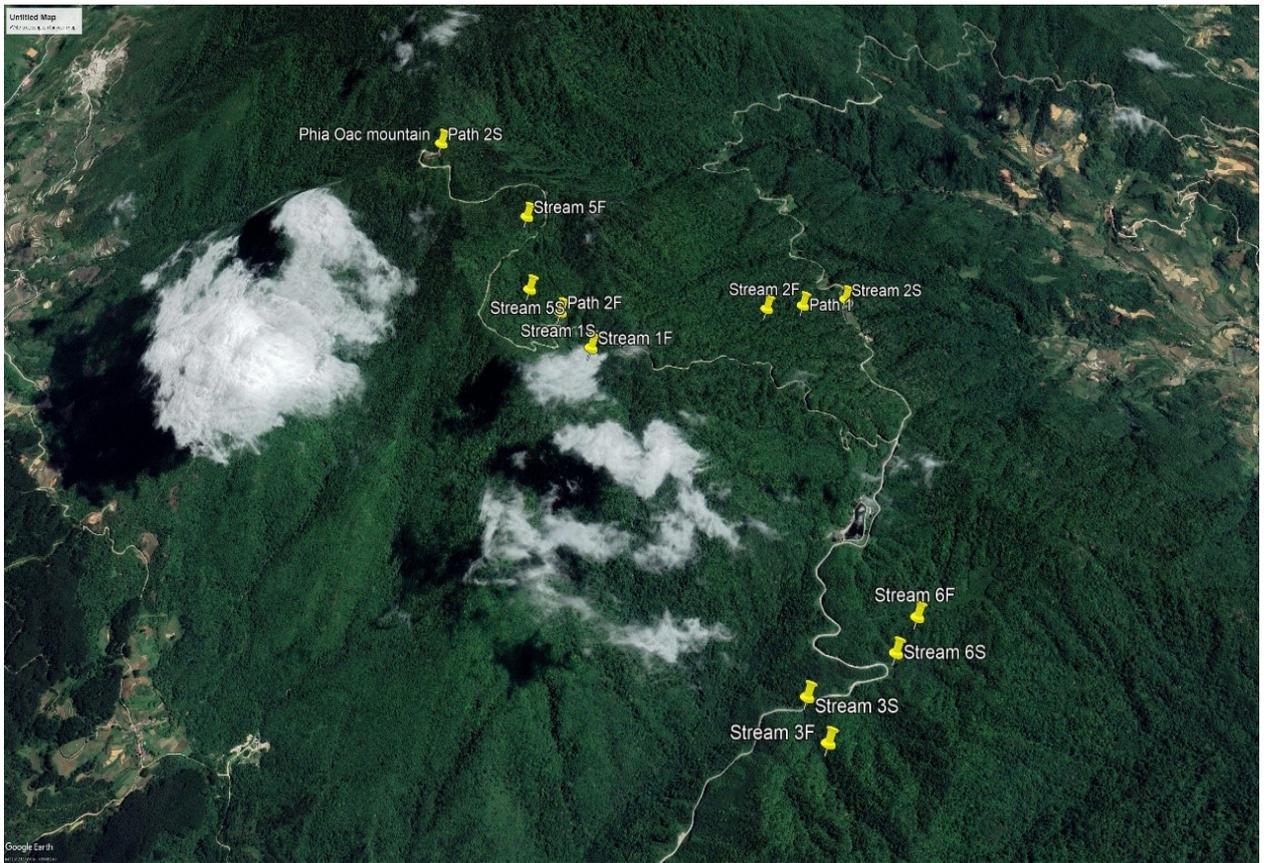


Figure 7. Map showing survey sites in Phia Oac-Phia Den NP (Trip 7)

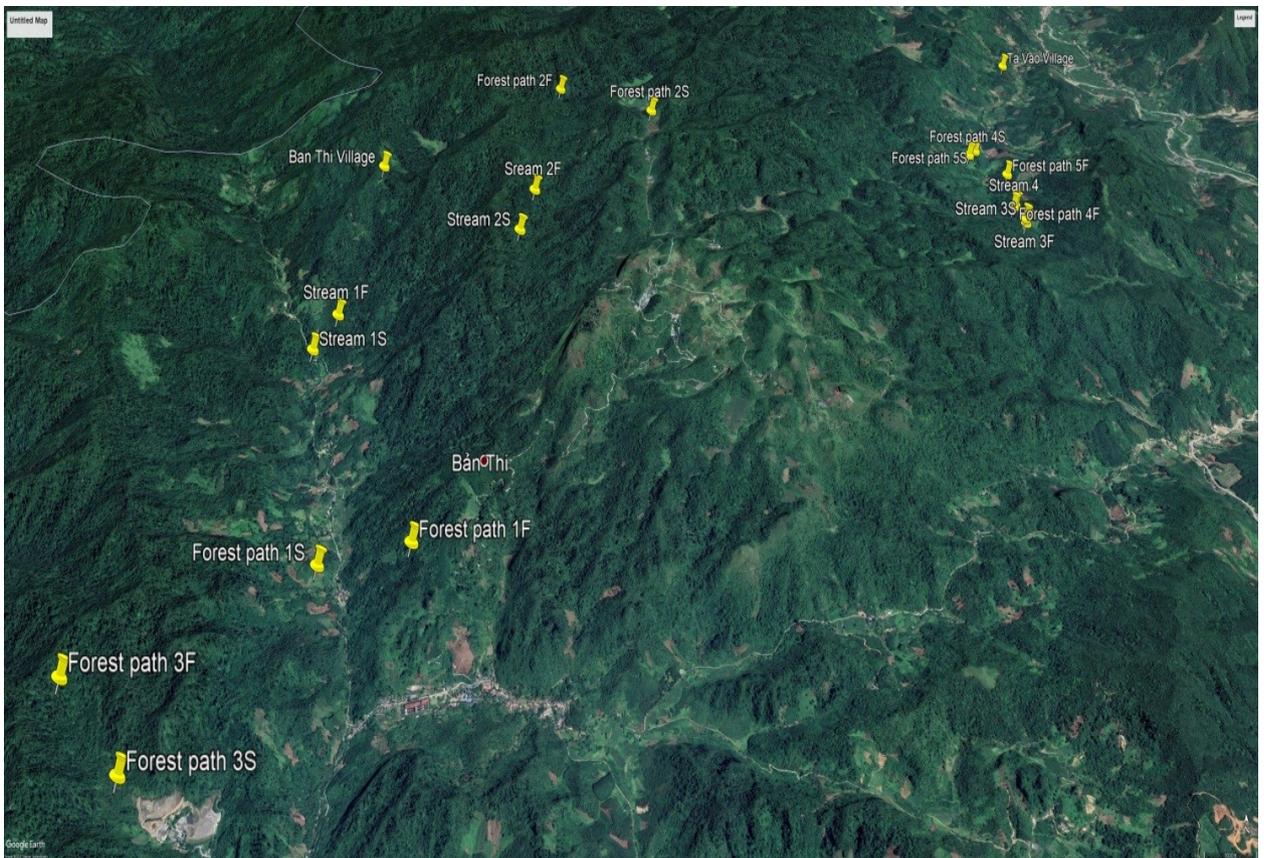


Figure 8. Map showing survey sites in Nam Xuan Lac HSCA (Trip 8)

2.5.2 Methods

Site selection: Survey transects were set up along streams, pools, small ponds or along the forest paths. Lizards and snakes usually inhabit rock crevices, under the leaf litter or on tree branches, we thus also surveyed some cave entrances and cliffs.

Sampling: Snakes, turtles, lizards, and few species of amphibians (e.g., toads) can be found or observed during the day. However, most of amphibians and snakes are nocturnal, therefore the bulk of our search effort was carried out in the evening from 18:00 to 24:00. Most of specimens were collected by hand. Venomous snakes were collected by snake hook or snake tong, and lizards were collected by forceps. Collected amphibians were kept in plastic bags, while snakes and lizards were kept in cloth bags. After photographing in life, common species (e.g., Gecko, Common Toad) were released at the collecting site, other ones were preserved for voucher specimens.

Specimen preservation:

- Euthanasia: Specimens were euthanized in a closed vessel with a piece of cotton wool containing ethyl acetate (Simmons 2002). For molecular analysis, tissue samples of muscle and liver were preserved in 70% ethanol. The field tags was labelled with an Indian ink, which are not ethanol- and water-soluble. Furthermore the labels and thread were tearproof, ethanol- and waterproof. The field tags were attached with a tearproof twine at the knee bend of lizards and amphibians or around the neck in snakes.
- Fixation: Specimens were arranged in a natural position and covered by tree-cloth or blotting-paper, they were preserved in 80% ethanol for 3–10 hours. Specimens of reptiles and large-sized amphibians were injected with 80% ethanol with a hypodermic needle into the body cavity to prevent internal rotting processes.
- Specimen storage: Specimens were subsequently transferred into 70% ethanol for longterm storage.

2.5.3 Taxonomic identification and data analysis

Specimen identification: Morphological comparisons were made with the voucher specimens that are deposited in the collections of the Institute of Ecology and Biological Resources and Vietnam National Museum of Nature in Hanoi. For taxonomic identification, we used the following documents: Pope (1935), Smith (1935, 1943), Taylor (1962, 1963), Inger et al. (1999), Bain & Nguyen (2004), Bain et al. (2003, 2007), Bourret (2009), Nguyen (2011), Pham et al. (2012), Mcleod et al. (2015), Pham et al. (2016), Ye et al.

(2017), Luong et al. (2019), Yu et al. (2019), Nguyen et al. (2020) and other relevant papers. Species names followed Nguyen et al. (2009), Frost (2021), Uetz et al. (2021), and some recently published papers.

Molecular analysis was also applied to compare genetic divergence between species of the species complex for new species description or between tadpoles and mature individuals in amphibian species.

Conservation status of threatened species was referred to the Vietnam Red Data Book (2007); IUCN Red List (2021); CITES appendices (2019); the Governmental Decree No. 06/2019/ND-CP; and the Governmental Decree No. 64/2019/ND-CP. The endemic species of Vietnam are species that currently known only from Vietnam.

Statistic analysis: The software PAST (Hammer et al. 2001) was used to calculate diversity indices and cluster analysis. The Sorensen-Dice Index was used to compare the similarity of the species composition between two sites based on the presence/absence of the species with the formula: $d_{jk} = 2M/(2M+N)$, where M is the number of species found in both areas and N is the total number of species found in each area only.

2.6 Results

2.6.1. Species diversity of reptiles and amphibians

Species diversity: Based on specimen identification and direct observations in the fields, we recorded a total of 126 species, comprising 65 species of reptiles and 61 species of amphibians from four protected areas in northeastern Vietnam (Table 3). For species list of each study site see Appendices. Remarkably, two new species were discovered from Phia Oac-Phia Den NP, northern Vietnam, viz. *Lycodon pictus* and *Megophrys caobangensis*. These new species were described based on morphological differences and molecular data.

In terms of species diversity, Colubridae is the most diverse family (26 recorded species), followed by Rhacophoridae (18 species), Megophryidae (16 species), Scincidae (14 species), Ranidae (10 species), Scincidae and Dicroglossidae (8 species each), Viperidae and Microhylidae (6 species each), Agamidae (5 species), Gekkonidae (4 species), Elapidae (3 species), Paretidae and Salamandridae (2 species each), Paretidae and Elapidae (2 species each), Anguidae, Lacertidae, Typhlopidae, Xenodermidae, Geoemydidae, and Bufonidae (1 species each) (Fig. 9).

Table 3. List of reptile and amphibian species recorded from four study sites in northeastern Vietnam

No	Scientific name	Common name	Study site			
			1	2	3	4
	REPTILE	REPTILES				
	SQUAMATA	SQUAMATA				
	SAURIA	LIZARDS				
	Agamidae	Agamid Lizards				
1.	<i>Acanthosaura lepidogaster</i> (Cuvier, 1829)	Brown Pricklenape	+	+	+	+
2.	<i>Acanthosaura</i> sp.	Pricklenape			+	
3.	<i>Draco maculatus</i> (Gray, 1845)	Spotted Flying Dragon		+		
4.	<i>Pseudocalotes brevipes</i> (Werner, 1904)	Vietnam False Bloodsucker	+	+	+	+
5.	<i>Physignathus cocincinus</i> Cuvier, 1829	Green Water Dragon		+		
	Gekkonidae	Geckos				
6.	<i>Gekko palmatus</i> Boulenger, 1907	Palm Gecko	+	+	+	
7.	<i>Gekko reevesii</i> (Gray, 1831)	Reeves' Tokay Gecko		+		+
8.	<i>Hemidactylus frenatus</i> Schlegel, 1836	Common House Gecko	+	+	+	+
9.	<i>Hemidactylus platyurus</i> (Schneider, 1797)	Flat-tailed House Gecko				+
	Scincidae	Skinks				
10.	<i>Ateuchosaurus chinensis</i> Gray, 1845	Chinese short-limbed skink			+	
11.	<i>Eutropis longicaudatus</i> (Hallowell, 1857)	Longtail Mabuya	+	+	+	+
12.	<i>Eutropis macularius</i> (Blyth, 1853)	Bronze Mabuya	+	+	+	+
13.	<i>Eutropis multifasciatus</i> (Kuhl, 1820)	Common Sun Skink		+		
14.	<i>Plestiodon quadrilineatus</i> Blyth, 1853	Four-striped Skink			+	
15.	<i>Scincella reevesii</i> (Gray 1838)	Reeves' Smooth Skink	+			

No	Scientific name	Common name	Study site			
			1	2	3	4
16.	<i>Scincella</i> sp1.	Smooth Skink				+
17.	<i>Scincella</i> sp2.	Smooth Skink			+	
18.	<i>Scincella</i> sp3.	Smooth Skink			+	
19.	<i>Lygosoma</i> sp.	Short-limbed Skink			+	
20.	<i>Sphenomorphus cryptotis</i> Darevsky, Orlov & Ho, 2004	Depressed-eared Forest Skink	+	+		
21.	<i>Sphenomorphus indicus</i> (Gray, 1853)	Himalayan Forest Skink			+	
22.	<i>Tropidophorus hainanus</i> Smith, 1923	Hainan Water Skink	+	+	+	
23.	<i>Tropidophorus murphyi</i> Hikida, Orlov, Nabhitabhata & Ota, 2002	Murphy's water skink			+	
	Anguidae					
24.	<i>Dopasia harti</i> (Boulenger, 1899)	Hart's Glass Lizard			+	
	Lacertidae					
25.	<i>Takydromus sexlineatus</i> Daudin, 1802	Asian Grass Lizard			+	
	SERPENTES	SNAKES				
	Typhlopidae	Blind snakes				
26.	<i>Indotyphlops braminus</i> (Daudin, 1803)	Flowerpot Snake		+		
	Colubridae	Colubrids				
27.	<i>Ahaetulla prasina</i> (Boie, 1827)	Oriental Whip Snake	+	+		+
28.	<i>Boiga kraepelini</i> Stejneger, 1902	Kelung Cat Snake			+	
29.	<i>Boiga multomaculata</i> (Boie, 1827)	Many-spotted cat snake		+		
30.	<i>Boiga guangxiensis</i> Wen, 1998	Cat snake		+		+
31.	<i>Calamaria pavimentata</i> Duméril, Bibron & Duméril, 1854	Collared Reed Snake	+			
32.	<i>Coelognathus radiatus</i> (Boi, 1827)	Radiated Ratsnakes		+		
33.	<i>Gonyosoma coeruleum</i> Liu & Hou & Lwin & Wang & Rao 2021	Green Ratsnake			+	

No	Scientific name	Common name	Study site			
			1	2	3	4
34.	<i>Hebius</i> sp.	Keelback	+			
35.	<i>Hebius chapaensis</i> (Bourret, 1934)	Vietnam Water Snake		+	+	
36.	<i>Hebius boulengeri</i> (Gressitt, 1937)	Boulenger's keelback			+	
37.	<i>Lycodon fasciatus</i> (Anderson, 1879)	Banded Wolf Snake			+	
38.	<i>Lycodon futsingensis</i> (Pope, 1928)	Futsing Wolf Snake			+	
39.	<i>Lycodon meridionalis</i> (Bourret, 1935)	Wolf snake		+	+	+
40.	<i>Lycodon</i> sp.	Wolf snake				+
41.	<i>Pseudoxenodon</i> sp.	Bamboo Snake			+	
42.	<i>Oligodon taeniatus</i> (Günther, 1861)	Striped kukri snake		+		
43.	<i>Oligodon</i> sp1.	Kukri snake		+		
44.	<i>Oligodon</i> sp2.	Kukri snake				+
45.	<i>Opisthotropis lateralis</i> Boulenger, 1903	Tonkin Mountain Keelback	+			
46.	<i>Oreocryptophis porphyraceus</i> (Cantor, 1839)	Red Bamboo Snake	+			
47.	<i>Elaphe moellendorffi</i> (Boettger, 1886)	Flower Snake	+	+		+
48.	<i>Ptyas korros</i> (Schlegel, 1837)	Chinese Ratsnake	+	+		+
49.	<i>Ptyas major</i> (Günther, 1858)	Chinese Green Snake			+	
50.	<i>Ptyas multicinctus</i> (Roux, 1907)	Many-banded Green Snake		+	+	
51.	<i>Rhabdophis subminiatus</i> (Schlegel, 1837)	Red-necked Keelback		+		+
52.	<i>Trimerodytes percarinatus</i> (Boulenger, 1899)	Eastern Water Snake	+	+	+	+
	Pareatidae	Slug Snake				
53.	<i>Pareas hamptoni</i> (Boulenger, 1905)	Hampton's Slug Snake	+	+	+	+

No	Scientific name	Common name	Study site			
			1	2	3	4
54.	<i>Pareas margaritophorus</i> (Jan, 1866)	Mountain Slug Snake		+		
	Xenodermidae	Burrowing Snake				
55.	<i>Achalinus</i> sp.	Burrowing Snake	+			
	Elapidae	Kraits				
56.	<i>Bungarus fasciatus</i> (Schneider, 1801)	Banded Krait		+	+	
57.	<i>Naja atra</i> Cantor, 1842	Chinese cobra		+	+	
58.	<i>Calliophis maculiceps</i> (Günther, 1858)	Speckled Coral Snake			+	
	Viperidae	Vipers				
59.	<i>Protobothrops mucrosquamatus</i> (Cantor, 1839)	Brown Spotted Pitviper	+	+	+	+
60.	<i>Protobothrops maolanensis</i> Yang, Orlov & Wang, 2011	Mao-lan pitviper		+		
61.	<i>Ovophis monticola</i> (Günther, 1864)	Chinese Mountain Pitviper			+	
62.	<i>Trimeresurus albolabris</i> Gray 1842	White-lipped Pitviper	+	+	+	
63.	<i>Trimeresurus stejnegeri</i> Schmidt, 1925	Chinese Green Tree Viper	+			+
64.	<i>Trimeresurus yunnanensis</i> Schmidt, 1925	Yunnan Bamboo Pitviper			+	
	TESTUDINES	TURTLES				
	Geoemydidae	Pond Turtles				
65.	<i>Cuora mouhotii</i> (Gray, 1862)	Keeled Box Turtle			+	
	AMPHIBIA	AMPHIBIANS				
	ANURA	FROGS				
	Bufonidae	Toads				
1.	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	Asian Common Toad	+	+	+	+
	Megophryidae	Asian Toads				
2.	<i>Leptobranchella minima</i> (Taylor, 1962)	Asian Toad	+	+		

No	Scientific name	Common name	Study site			
			1	2	3	4
3.	<i>Leptobrachella nahangensis</i> (Lathrop, Murphy, Orlov & Ho, 1998)	Nahang Asian Toad	+	+		+
4.	<i>Leptobrachella nyx</i> (Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler & Dubois, 2011)	Asian Toad	+	+	+	
5.	<i>Leptobrachella petrops</i> (Rowley, Dau, Hoang, Le, Cutajar, Nguyen, 2017)	Stone Litter Toad	+			
6.	<i>Leptobrachella sungi</i> (Lathrop, Murphy, Orlov & Ho, 1998)	Sung's Toad	+	+		
7.	<i>Leptobrachella</i> sp.	Toad		+		
8.	<i>Leptobrachella</i> sp1.	Toad			+	
9.	<i>Leptobrachella</i> sp2.	Toad				+
10.	<i>Leptobrachella</i> sp3.	Toad				+
11.	<i>Leptobrachium chapaense</i> (Bourret, 1937)	Chapa Spadefoot Toad			+	
12.	<i>Leptobrachium</i> sp.	Spadefoot Toad			+	
13.	<i>Megophrys caobangensis</i> Nguyen, Pham, Nguyen, Luong & Ziegler, 2020	Cao Bang Spadefoot Toad			+	
14.	<i>Megophrys feae</i> Boulenger, 1887	Kakhien Hill Frog			+	
15.	<i>Megophrys maosonensis</i> Bourret, 1937	Maoson Horned Toad	+	+	+	+
16.	<i>Megophrys microstoma</i> (Boulenger, 1903)	Asian Mountain Toad	+	+	+	+
17.	<i>Megophrys palpebralespinosa</i> Bourret, 1937	Tonkin Spadefoot Toad			+	
	Microhylidae	Rice frogs				
18.	<i>Microhyla butleri</i> Boulenger, 1900	Butler's Rice Frog	+	+		+
19.	<i>Microhyla fissipes</i> Boulenger, 1884	Ornamented Pygmy Frog				+
20.	<i>Microhyla heymonsi</i> Vogt, 1911	Heymon's Narrow-mouthed Frog	+	+	+	+

No	Scientific name	Common name	Study site			
			1	2	3	4
21.	<i>Microhyla pulchra</i> (Hallowell, 1861)	Guangdong Rice Frog	+	+	+	+
22.	<i>Microhyla</i> sp.	Narrow-mouthed Frog	+			
23.	<i>Microhyla</i> sp1.	Narrow-mouthed Frog				+
	Dicroglossidae	Fork-tongued frogs				
24.	<i>Fejervarya limnocharis</i> (Gravenhorst, 1829)	Grass Frog	+	+	+	+
25.	<i>Hoplobatrachus rugulosus</i> (Wiegmann, 1834)	Common Lowlandfrog	+	+	+	+
26.	<i>Limnonectes bannaensis</i> Ye, Fei & Jiang, 2007	Banna Large-headed Frog	+	+	+	+
27.	<i>Limnonectes limborgi</i> (Sclater, 1892)	Limborg's Frog	+			
28.	<i>Limnonectes nguyenorum</i> McLeod, Kurlbaum & Hoang, 2015	Nguyen Large-head Frog	+			
29.	<i>Quasipaa boulengeri</i> (Günther, 1889)	Boulenger's Spiny Frog			+	+
30.	<i>Quasipaa delacouri</i> (Angel, 1928)	Doi Chang Asian Frog	+	+		
31.	<i>Quasipaa verrucospinosa</i> (Bourret, 1937)	Granular Spiny Frog	+	+		
	Ranidae	True Frogs				
32.	<i>Amolops ricketti</i> (Boulenger, 1899)	Chinese Sucker Frog	+	+	+	
33.	<i>Amolops</i> sp.	Cascade Frog	+			
34.	<i>Odorrana chloronota</i> (Günther, 1875)	Green Cascade Frog	+	+	+	+
35.	<i>Odorrana lipuensis</i> Mo, Chen, Wu, Zhang & Zhou, 2015	Lipu Cascade Frog	+			+
36.	<i>Odorrana nasica</i> (Boulenger, 1903)	Tonkin Huia Frog	+	+	+	
37.	<i>Odorrana tiannanensis</i> (Yang & Li, 1980)	Big-eared Frog	+	+		
38.	<i>Odorrana geminata</i> Bain, Stuart, Nguyen, Che & Rao, 2009	Geminated Cascade Frog	+	+	+	
39.	<i>Rana johnsi</i> Smith, 1921	Johns's Frog	+	+	+	+

No	Scientific name	Common name	Study site			
			1	2	3	4
40.	<i>Sylvirana guentheri</i> (Boulenger, 1882)	Gunther's Amoy Frog	+	+	+	+
41.	<i>Sylvirana maosonensis</i> (Bourret, 1937)	Maoson Frog	+	+	+	+
	Rhacophoridae	Flying Frogs				
42.	<i>Gracixalus gracilipes</i> (Bourret, 1937)	Chapa Bubble-nest Frog			+	
43.	<i>Gracixalus nonggangensis</i> Mo, Zhang, Luo, Zhou & Chen, 2013	Nonggang Treefrog				+
44.	<i>Rohanixalus vittatus</i> (Boulenger, 1887)	Two-striped Pigmy Treefrog	+			
45.	<i>Kurixalus hainanus</i> (Zhao, Wang & Shi, 2005)	Hainan Small Treefrog	+	+	+	+
46.	<i>Polypedates megacephalus</i> Hallowell, 1861	Hong Kong Whipping Frog	+	+	+	+
47.	<i>Polypedates mutus</i> (Smith, 1940)	Burmese Whipping Frog	+	+	+	+
48.	<i>Raorchestes parvulus</i> (Boulenger, 1893)	Karin bubble-nest Frog		+	+	+
49.	<i>Rhacophorus kio</i> Ohler & Delorme, 2006	Black-webbed Treefrog	+			+
50.	<i>Rhacophorus larissae</i> Ostroshabov, Orlov & Nguyen, 2013	Larisa Treefrog			+	
51.	<i>Rhacophorus orlovi</i> Ziegler & Köhler, 2001	Orlov's Treefrog	+	+		+
52.	<i>Rhacophorus rhodopus</i> Liu & Hu, 1960	Red-webbed Treefrog		+		
53.	<i>Rhacophorus</i> sp.	Treefrog				+
54.	<i>Theلودerma corticale</i> (Boulenger, 1903)	Tonkin Bug-eyed Frog	+			
55.	<i>Theلودerma albopunctatum</i> (Liu & Hu, 1962)	Dotted Bubble-nest Frog	+	+	+	+
56.	<i>Theلودerma rhododiscus</i> (Liu & Hu, 1962)	Warty Treefrog			+	
57.	<i>Zhangixalus dennysi</i> (Blanford, 1881)	Denny's Whipping Frog	+	+		+

No	Scientific name	Common name	Study site			
			1	2	3	4
58.	<i>Zhangixalus puerensis</i> (He, 1999)	Puere Treefrog			+	
59.	<i>Zhangixalus pachyproctus</i> Yu, Hui, Hou, Wu, Rao & Yang, 2019	Treefrog	+			+
	Salamandridae	Salamanders				
60.	<i>Paramesotriton guangxiensis</i> (Huang, Tang & Tang, 1983)	Guangxi Warty Newt			+	
61.	<i>Tylototriton ziegleri</i> Nishikawa, Matsui & Nguyen, 2013	Ziegler's Knobby Newt		+	+	
Total			61	66	72	53

Study site: 1: Cham Chu NR, 2: Bac Me NR, 3: Phia Oac-Phia Den NP, 4: Nam Xuan Lac SHCA

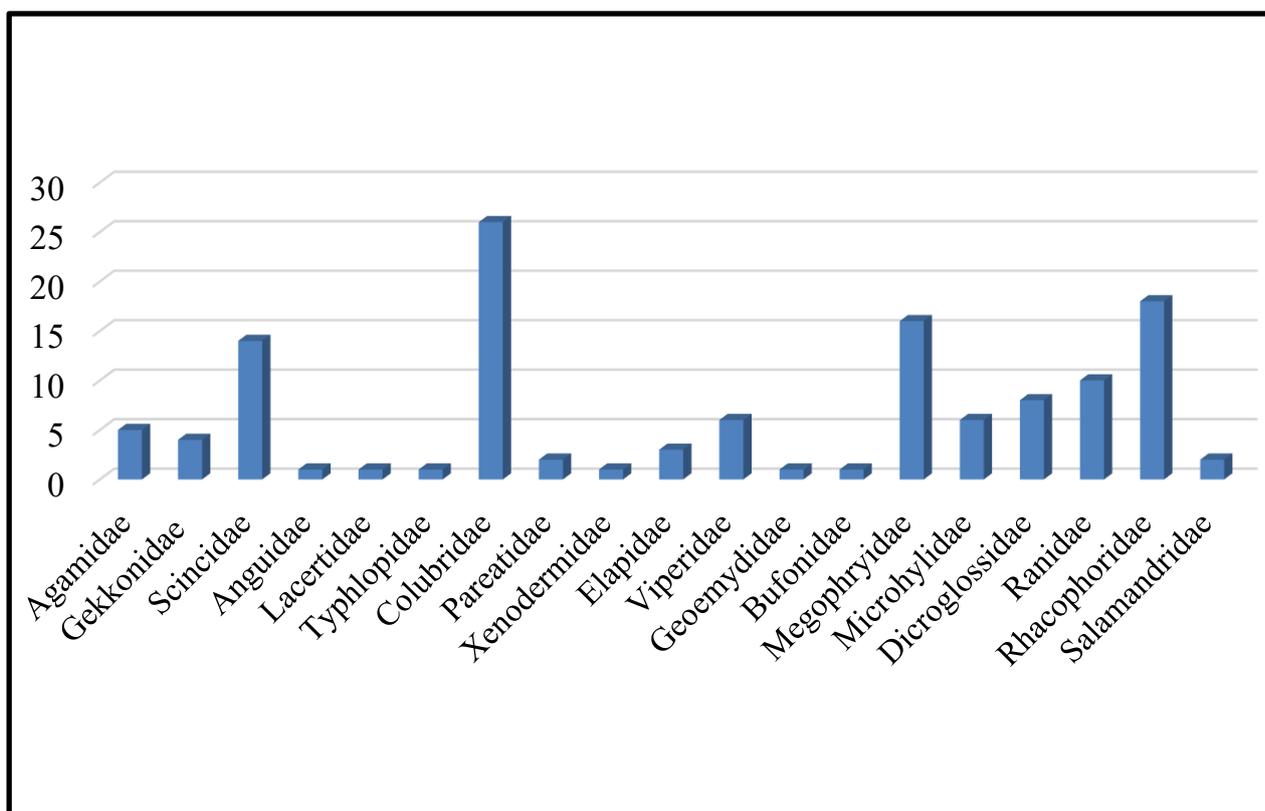


Figure 9. Species diversity of the reptile and amphibian families in study sites

a) Cham Chu Nature Reserve

Species diversity: We recorded a total of 61 species, comprising 22 species of reptiles and 39 species of amphibians from Cham Chu Nature Reserve, Tuyen Quang Province (Table 3).

New provincial records: 17 species were recorded for the first time from Tuyen Quang Province, comprising 6 species of reptiles (*Calamaria pavementata*, *Opisthotropis*

lateralis, *Oreocryptophis porphyraceus*, *Hebius* sp., *Protobothrops mucrosquamatus*, *Trimererusus stejneri*) and 11 species of amphibians (*Leptobranchella minima*, *Leptobranchella nyx*, *Leptobranchella sungi*, *Megophrys microstoma*, *Limnonectes limborgi*, *Limnonectes nguyenorum*, *Odorrana lipuensis*, *Odorrana nasica*, *Rhacophorus kio*, *Rhacophorus orlovi*, and *Zhangixalus smaragdinus*) (Table 3).

In terms of species richness, Ranidae and Rhacophoridae are the most diverse families (10 recorded species each), followed by Colubridae (9 species), Megophryidae and Dicroglossidae (7 species each), and Scincidae (5 species) (Fig. 10).

Because the herpetofauna of Cham Chu Nature Reserve is relatively diverse (61 species) and it is difficult to identify the precise names for all species in the field, it is impossible to estimate the population size or abundance of each species. However, we recorded some species that have a high frequency of occurrence (encountered more than 10 individuals): *Leptolalax sungi*, *Microhyla pulchra*, *Fejervarya limnocharis*, *Limnonectes bannaensis*, and *Polypedates megacephalus*. It is noted that three unidentified species are still under examination (e.g., *Achalinus* sp., *Hebius* sp., *Microhyla* sp., *Amolops* sp.) (Table 3).

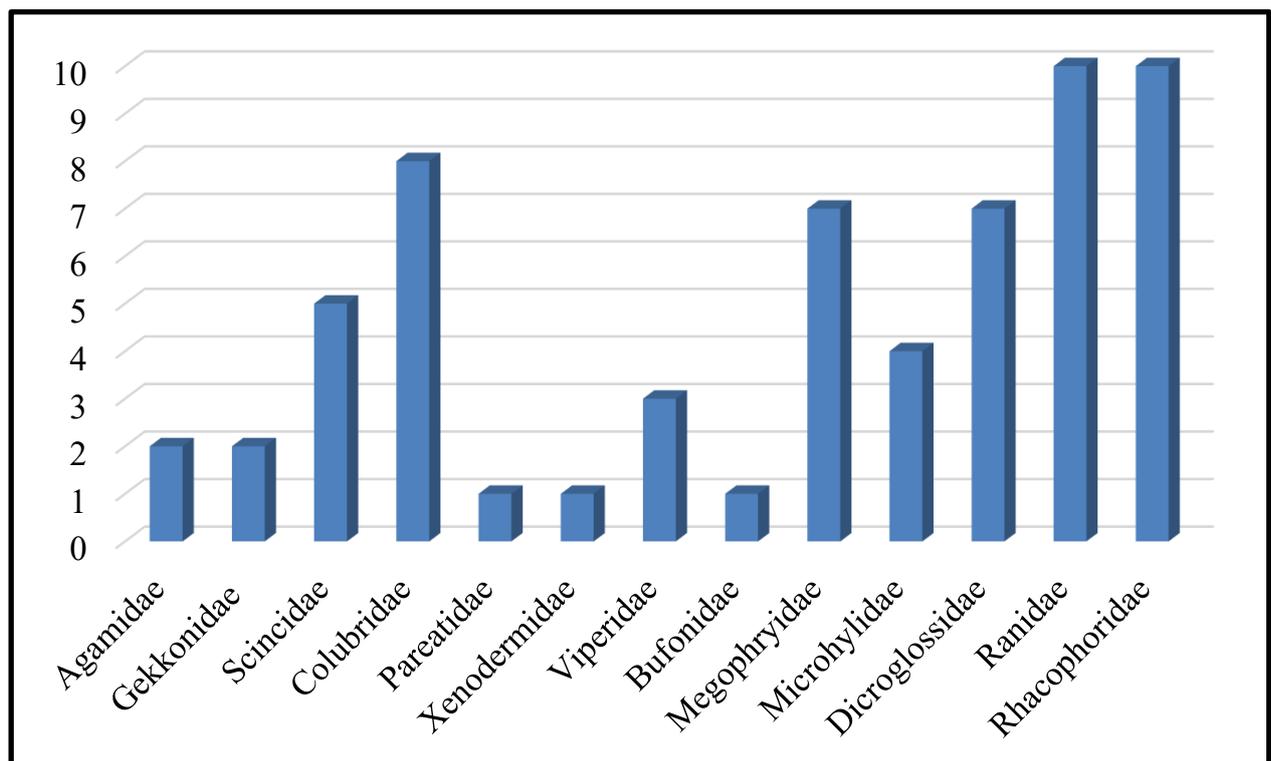


Figure 10. Species diversity of the reptile and amphibian families in Cham Chu NR

b) Bac Me Nature Reserve

Species diversity: We recorded a total of 66 species, comprising 33 species of reptiles and 33 species of amphibians from Bac Me Nature Reserve, Ha Giang Province (Table 3).

New provincial records: 20 species were recorded for the first time from Ha Giang

Province, comprising 13 species of reptiles (*Draco maculatus*, *Eutropis macularius*, *Sphenomorphus cryptotis*, *Indotyphlops braminus*, *Boiga multomaculata*, *Boiga guangxiensis*, *Hebius chapaensis*, *Orthriophis moellendorffi*, *Ptyas multicinctus*, *Pareas margaritophorus*, *Bungarus fasciatus*, *Naja atra*, *Trimeresurus albolabris*) and seven species of amphibians (*Leptobranchella minima*, *L. nahangensis*, *L. sungi*, *Odorrana nasica*, *Polypedates mutus*, *Rhacophorus orlovi*, *Zhangixalus dennysi*).

In terms of species diversity, Colubridae is the most diverse family (13 recorded species), followed by Ranidae and Rhacophoridae (8 species each), Megophryidae (7 species), Scincidae and Dicroglossidae (5 species each), Gekkonidae, Viperidae and Microhylidae (3 species each), Pareasidae and Elapidae (2 species each), Typhlopidae, Bufonidae and Salamandridae (1 species each) (Fig. 11).

Because the herpetofauna of Bac Me Nature Reserve is relatively diverse (66 species) and it is difficult to identify the precise names for all species in the field, it is impossible to estimate the population size or abundance of each species. However, we recorded some species that have a high frequency of occurrence (encountered more than 10 individuals): *Leptolalax sungi*, *Fejervarya limnocharis*, *Limnonectes bannaensis*, *Kurixalus bisacculus* and *Polypedates megacephalus*. It is noted that three unidentified species are still under examination (e.g., *Oligodon* sp., *Leptobranchella* sp.) (see Table 3).

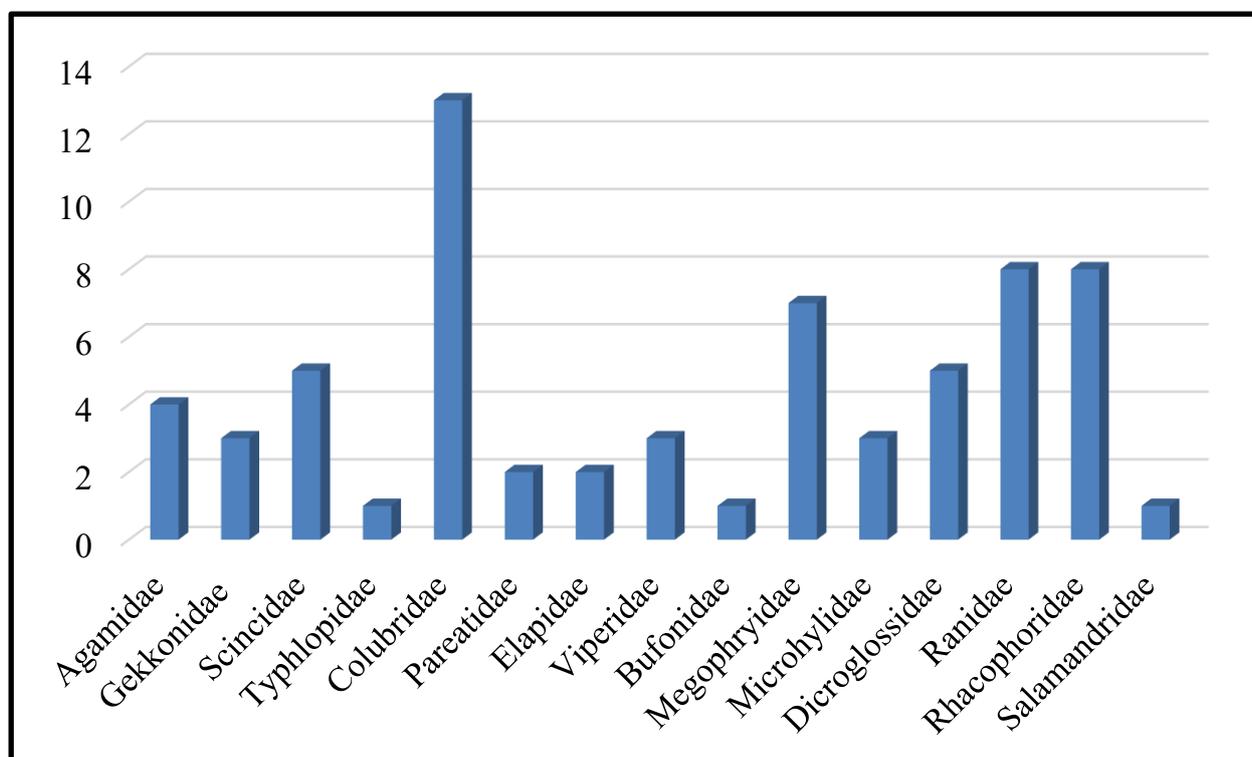


Figure 11. Species diversity of the reptile and amphibian families in Bac Me NR

c) *Phia Oac-Phia Den National Park*

Species diversity: We recorded a total of 72 species, comprising 37 species of reptiles and 35 species of amphibians from Phia Oac-Phia Den National Park, Cao Bang Province (Table 3).

New provincial records: 12 species were recorded for the first time from Cao Bang Province, comprising nine species of reptiles (*Ateuchosaurus chinensis*, *Eutropis macularius*, *Gonyosoma coeruleum*, *Hebius chapaensis*, *Calliophis maculiceps*, *Ovophis monticola*, *Trimeresurus albolabris*, *T. yunnanensis*, *Cuora mouhotii*) and three species of amphibians (*Leptobranchella nyx*, *Theloderma rhododiscus*, *Zhangixalus puerensis*). As a result of this research, a new amphibian species (*Megophrys caobangensis*) and another new snake (*Lycodon pictus*) were described from Cao Bang Province by our working group.

In terms of species diversity, Colubridae is the most diverse family (11 recorded species), followed by Scincidae (10 species), Megophryidae and Rhacophoridae (9 species each), Ranidae (7 species), Viperidae and Dicroglossidae (4 species), Agamidae, Elapidae, and Microhylidae (3 species each), Gekkonidae and Salamandridae (2 species each), Anguillidae, Lacertidae, Pseudisidae, Geoemydidae, Bufonidae (1 species) (Fig. 12).

Because the herpetofauna of Phia Oac-Phia Den National Park is relatively diverse (72 species) and it is difficult to identify the precise names for all species in the field, it is impossible to estimate the population size or abundance of each species. However, we recorded some species that have a high frequency of occurrence (encountered more than 10 individuals): *Fejervarya limnocharis*, *Gracixalus gracilipes*, *Kurixalus hainanus* and *Polypedates megacephalus*. It is noted that six unidentified species are still under examination (e.g., *Acanthosaura* sp., *Scincella* sp., *Lygosoma* sp., *Leptobranchella* sp., *Leptobranchium* sp.) (see Table 3).

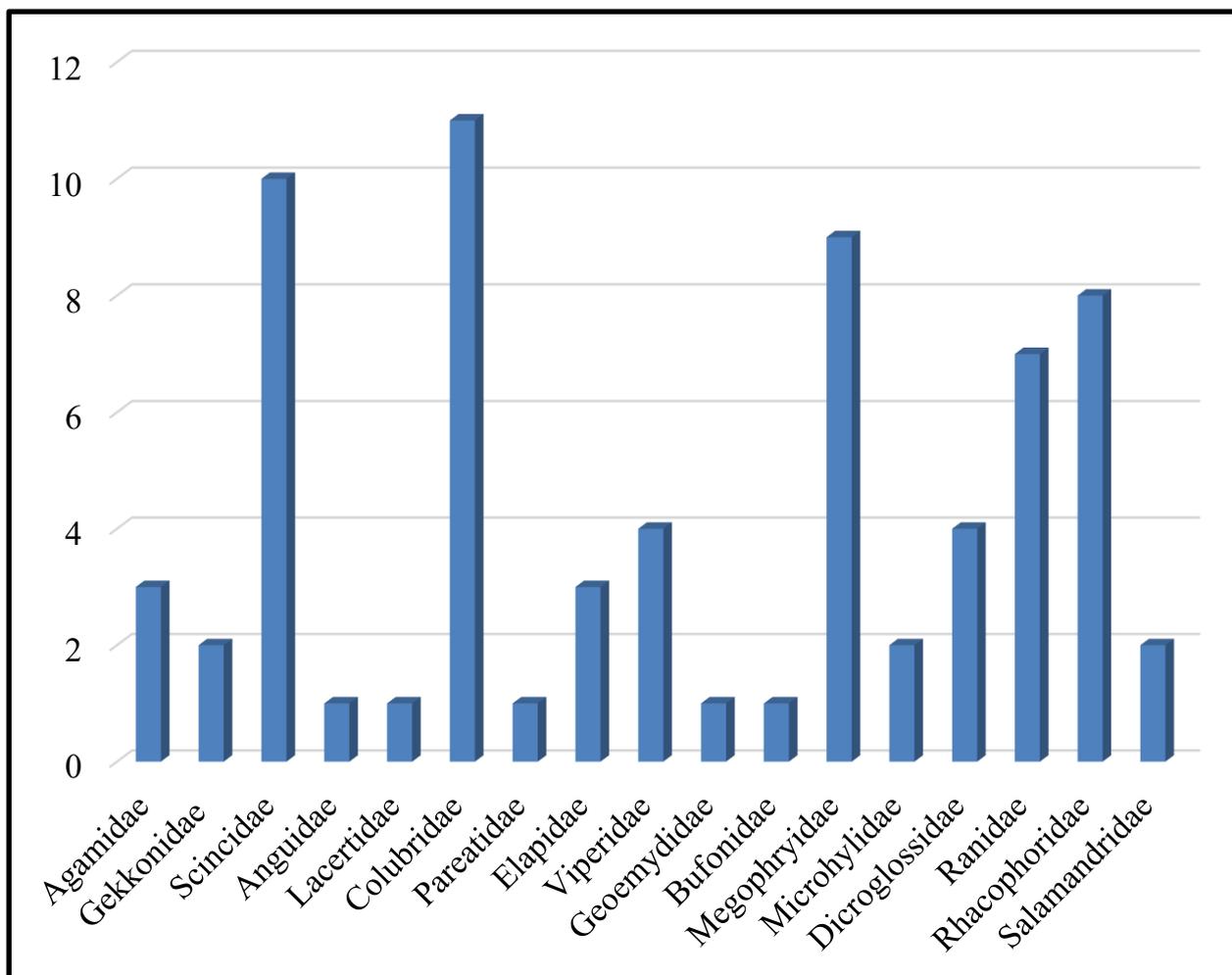


Figure 12. Species diversity of the reptile and amphibian families in Phia Oac-Phia Den NP

d) Nam Xuan Lac HSCA

Species diversity: We recorded a total of 53 species, comprising 22 species of reptiles and 31 species of amphibians from Nam Xuan Lac HSCA, Bac Kan Province (Table 3).

New provincial records: eight species were recorded for the first time from Bac Kan Province, comprising one species of reptiles (*Boiga guangxiensis*) and seven species of amphibians (*Microhyla butleri*, *Leptobranchella nahangensis*, *Quasipaa boulengeri*, *Odorrana lipuensis*, *Rana johnsi*, *Gracixalus nonggangensis*, *Rhacophorus orlovi*).

In terms of species diversity, Rhacophoridae is the most diverse family (11 recorded species), followed by Colubridae (9 species), Microhylidae, Megophryidae, and Ranidae (5 species each), Gekkonidae and Dicroglossidae (4 species each), Scincidae (3 species), Agamidae, Gekkonidae, and Viperidae (2 species each), Paretidae and Bufonidae (1 species each) (Fig. 13).

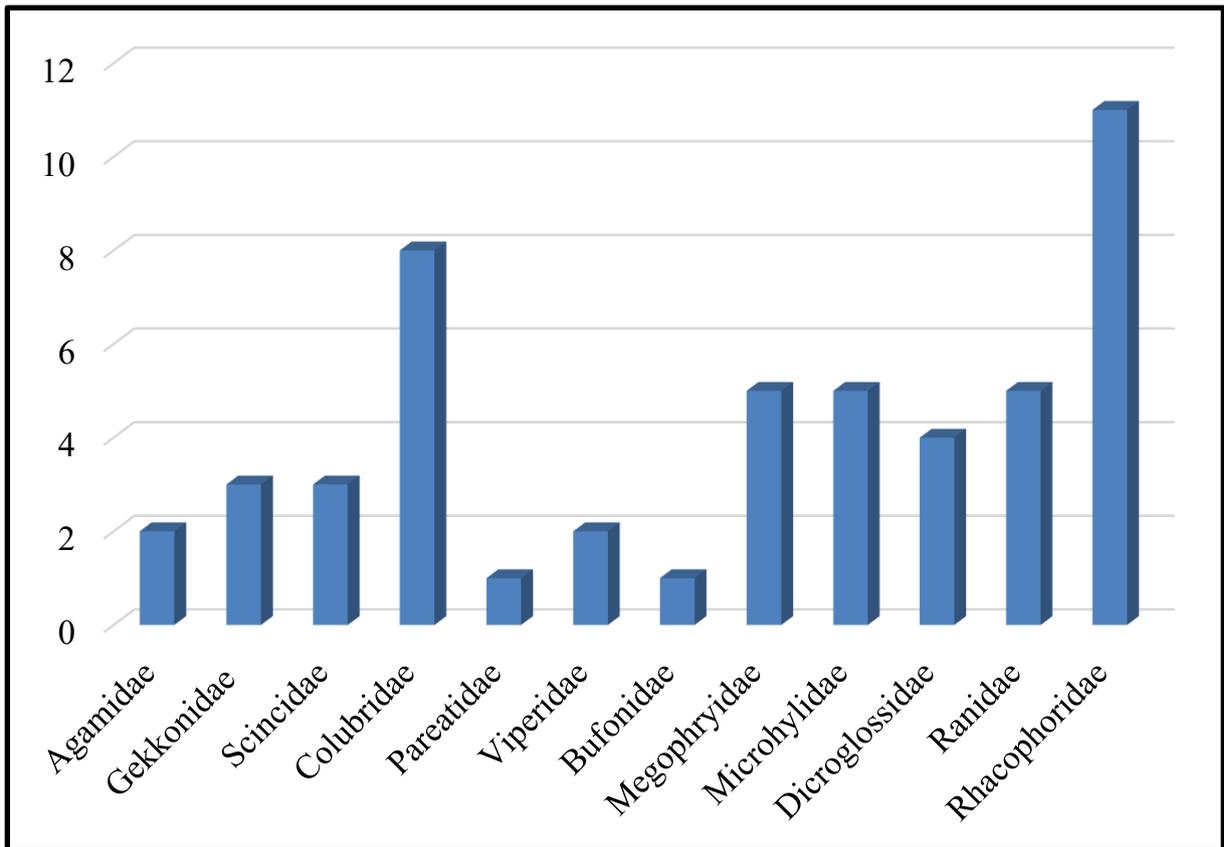


Figure 13: Species diversity of the reptile and amphibian families in Nam Xuan Lac HSCA

2.6.2 Comparison of the herpetofaunal diversity

a) Between study sites

Statistic analysis showed that the herpetofauna of Cham Chu NR is most similar to those of Bac Me NR and Nam Xuan Lac HSCA (Sorensen-Dice index >0.5 , $d_{jk} = 0.67717$ and 0.59459 , respectively) and they are embedded in the same clade (Table 4, Fig. 14). This can be explained based on the similarities in habitat and elevation as well as the closely geographic position between Cham Chu NR and Bac Me NR/Nam Xuan Lac HSCA.

The herpetofauna of Phia Oac-Phia Den NP differs from those of Cham Chu NR and Nam Xuan Lac HSCA (Sorensen-Dice index < 0.5 , $d_{jk} = 0.45455$ and 0.44628 , respectively) (Table 4, Fig. 14). This can be explained based on the difference in habitat and elevation between Phia Oac-Phia Den NP (containing both limestone karst forest and granitic forest, at elevations between 1000 and 1900 m) with Cham Chu NR and Nam Xuan Lac HSCA (characterized by limestone karst forest only, at elevations lower than 1000 m).

Table 4. Comparison of the species composition of the herpetofaunas between study sites (Sorensen-Dice similarity index)

Site	Cham Chu	Bac Me	Phia Oac-Phia Den	Nam Xuan Lac
Cham Chu	1			
Bac Me	0.67717	1		
Phia Oac-Phia Den	0.45455	0.55474	1	
Nam Xuan Lac	0.59459	0.60345	0.44628	1

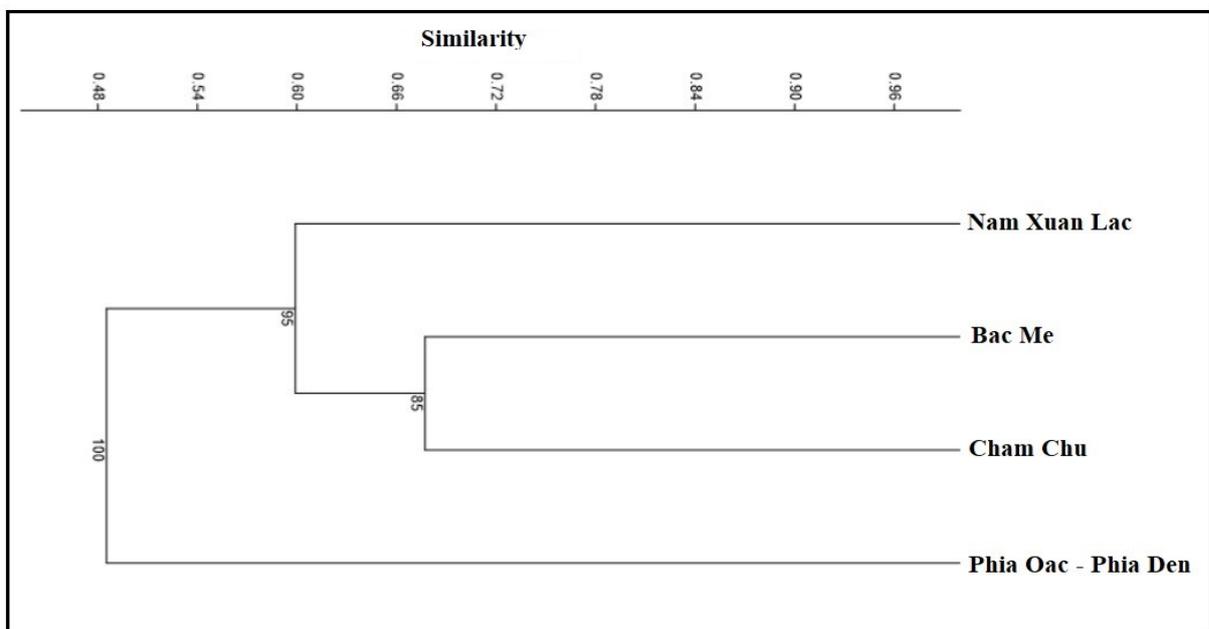


Figure 14. Cluster analysis of the species composition of the herpetofaunas between study sites (bootstrap value: 1000 replications)

b) Between study sites and other limestone karst forests in northeastern Vietnam

Based on data of previous studies, i.e. Nguyen Quang Truong et al. (2018), Pham Thi Kim Dung et al. (2015), Lehmann (2012), Pham et al. (2017), Nguyen Quang Truong et al. (2018), Nguyen Thien Tao et al. (2018) and this study, we compare the herpetofaunal diversity of the Cham Chu NR, Bac Me NR, Phia Oac-Phia Den NP, and Nam Xuan Lac HSCA with those of adjacent areas: Sinh Long-Lam Binh forest (Tuyen Quang Province), Kim Hy NR (Bac Kan Province), Phia Oac-Phia Den NP and Ha Lang forest (Cao Bang Province), and Cat Ba NP (Hai Phong City). However, it is noted the number of recorded species from the afore mentioned areas is depended on various aspects, for example the area of forest, habitat quality, and survey effort. At present,

only preliminary results on the herpetofaunal diversity of Kim Hy NR and Ha Lang forest are available for comparison.

Statistic analysis showed that the herpetofaunas of four study sites differ from those of Cat Ba NP, Kim Hy NR and Ha Lang forest (Sorensen-Dice index, d_{jk} ranged between 0.3721 and 0.4477) (Table 5, Fig. 15). The herpetofauna of Cat Ba NP is distinct from those of four target sites in this study because Cat Ba habitat is characterized by limestone karst forest on islands in the Gulf of Tonkin, that separated from the mainland.

Table 5. Comparison of the species composition of the herpetofaunas between study sites and other limestone karst forests in northeastern (Sorensen-Dice similarity index)

Site	Cham Chu	Bac Me	Phia Oac-Phia Den	Nam Xuan Lac	Ha Lang	Kim Hy	Sinh Long-Lam Bnh	Cat Ba
Cham Chu	1							
Bac Me	0.6772	1						
Phia Oac-Phia Den	0.4546	0.5547	1					
Nam Xuan Lac	0.6000	0.6087	0.4500	1				
Ha Lang	0.4138	0.3802	0.3651	0.4423	1			
Kim Hy	0.4727	0.5044	0.4167	0.5510	0.5192	1		
Sinh Long-Lam Binh	0.4762	0.4364	0.4348	0.4516	0.3434	0.3871	1	
Cat Ba	0.3721	0.4477	0.3597	0.4102	0.3902	0.4957	0.3393	1

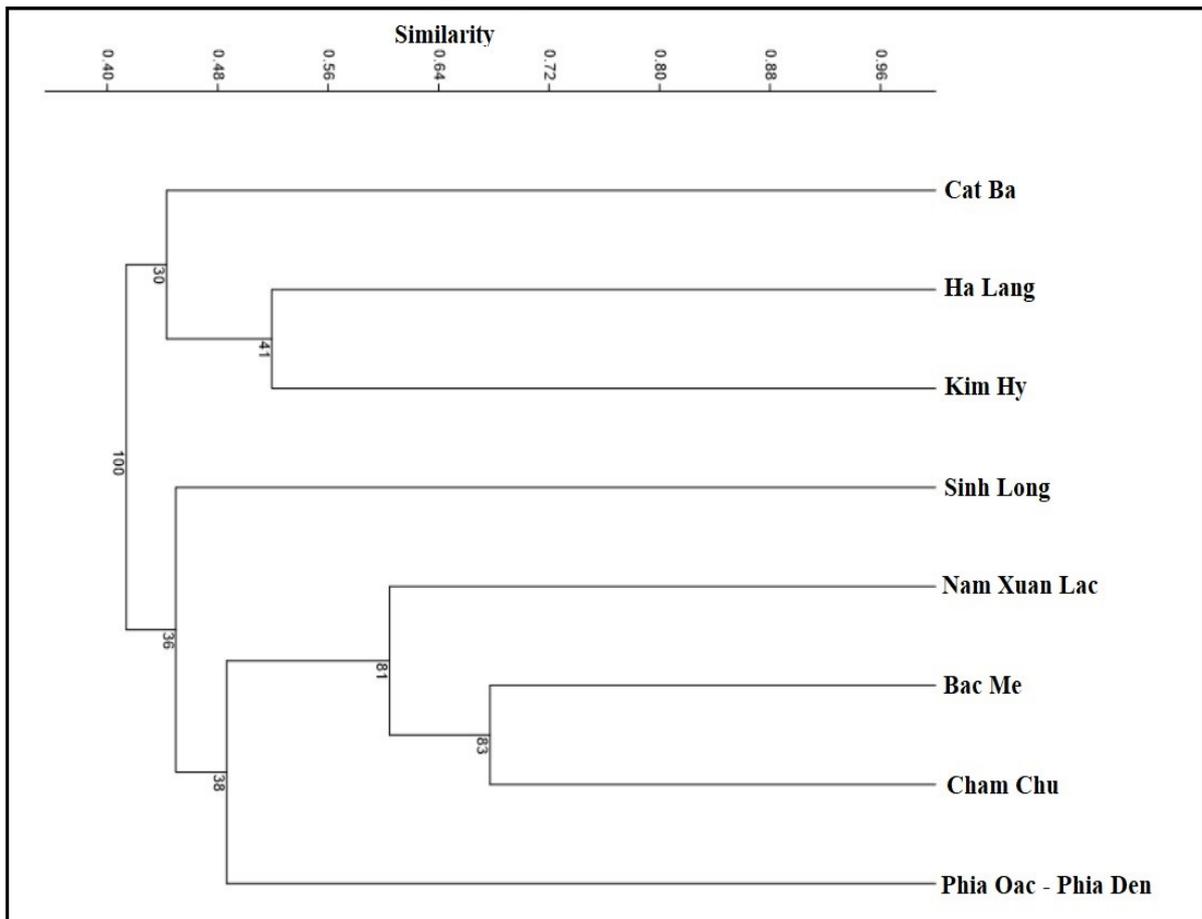


Figure 15. Cluster analysis of the species composition of the herpetofaunas between study sites and other limestone karst forests in northeastern Vietnam (bootstrap value: 1000 replications)

2.6.3 Species of conservation concern

Among 127 recorded species of reptiles and amphibians from four study sites in northeastern Vietnam, 28 species are globally or nationally threatened at different levels (Table 6).

- Red Data Book of Vietnam (2007): 12 species, with one species categorized as CR, five species as EN, and six species as VU.
- IUCN Red List (2021): Nine species, with three species categorized as EN, four species as VU, and two species as NT.
- Governmental Decree No. 06 (2019): Four species listed in the Group IIB.
- CITES (2020): Four species listed in the Appendix II.
- Endemism: 11 species are currently known only from Vietnam.

Table 6. List of threatened and endemic species recorded from four study sites

No	Scientific name	RBVN (2007)	IUCN (2021)	Decree 06 (2019)	CITES (2019)	Endemic	Study sites			
							1	2	3	4
	Reptiles									
1.	<i>Physignathus cocincinus</i>	VU	VU					+		
2.	<i>Gekko palmatus</i>					+		+	+	+
3.	<i>Gekko reevesii</i>	VU								+
4.	<i>Tropidophorus murphyi</i>					+			+	
5.	<i>Sphenomorphus cryptotis</i>					+	+	+		
6.	<i>Oreocryptophis porphyraceus</i>	VU					+			
7.	<i>Elaphe moellendorffi</i>	VU					+	+		+
8.	<i>Ptyas korros</i>	EN					+	+		+
9.	<i>Coelognathus radiatus</i>	VU						+		+
10.	<i>Bungarus fasciatus</i>	EN						+	+	
11.	<i>Naja atra</i>	EN	VU	IIB	II			+	+	
12.	<i>Cuora mouhotii</i>		EN	IIB	II				+	
	Amphibia									
13.	<i>Leptolalax nahangensis</i>					+	+	+		+
14.	<i>Leptobranchella nyx</i>					+	+	+	+	
15.	<i>Leptobranchella petrops</i>					+	+			
16.	<i>Megophrys caobangensis</i>					+			+	

No	Scientific name	RBVN (2007)	IUCN (2021)	Decree 06 (2019)	CITES (2019)	Endemic	Study sites			
							1	2	3	4
17.	<i>Megophrys palpebralespinosa</i>	CR						+		
18.	<i>Limnonectes nguyenorum</i>					+	+			
19.	<i>Quasipaa boulengeri</i>		EN					+	+	
20.	<i>Quasipaa delacouri</i>	EN				+	+	+		
21.	<i>Quasipaa verrucospinosa</i>		NT				+	+		
22.	<i>Odorrana geminata</i>		VU				+	+	+	
23.	<i>Rhacophorus kio</i>	EN					+		+	
24.	<i>Rhacophorus larissae</i>					+		+		
25.	<i>Theloderma corticale</i>	EN					+			
26.	<i>Theloderma rhododiscus</i>		NT					+		
27.	<i>Paramesotriton quangxiensis</i>		EN	IIB	II			+		
28.	<i>Tylototriton zieglerei</i>		VU	IIB	II	+		+	+	
Total		12	9	4	4	11	13	14	14	8

RBVN (2007) = Vietnam Red Data Book. Part I. Animals. Descriptions of nationally endangered species of wild animals: EN = Endangered, VU = Vulnerabile. IUCN (2020) = The IUCN Red List of Threatened Species: EN = Endangered, VU = Vulnerabile, NT = Near Threatened. Decree 06 (2019) = Governmental Decree No. 06/2019/ND-CP, dated on 22 January 2019, by the Government of Vietnam on the management of endangered wild flora and fauna: Group IB = prohibit exploitation and use for commercial purpose and Group IIB = limit exploitation and use for commercial purpose. CITES (2019) = Convention on International trade in Endangered species of wild fauna and flora. Study site: 1: Cham Chu NR, 2: Bac Me NR, 3: Phia Oac-Phia Den NP, 4: Nam Xuan Lac SHCA

a) Cham Chu Nature Reserve

Among 61 recorded species of reptiles and amphibians from Cham Chu NR, 13 species are globally or nationally threatened at different levels (Table 6):

- Red Data Book of Vietnam (2007): six species, namely *Ptyas korros* (EN), *Quasipaa delacouri* (EN), *Rhacosphorus kio* (EN), *Theloderma corticale* (EN) *Oreocryptophis porphyraceus* (VU) and *Elaphe moellendorffi* (VU).
- IUCN Red List (2021): two species, namely *Odorrana geminata* (VU) and *Quasipaa verrucospinosa* (NT).
- Endemism: Six species, *Sphenomorphus cryptotis*, *Leptolalax nahangensis*, *Leptobranchella nyx*, *Leptobranchella petrops*, and *Limnonectes nguyenorum*, are currently known only from Vietnam.

b) Bac Me Nature Reserve

Among 66 recorded species of reptiles and amphibians from Bac Me NR, 14 species are globally or nationally threatened at different levels (Table 6):

- Red Data Book of Vietnam (2007): Six species, namely *Ptyas korros* (EN), *Bungarus fasciatus* (EN), *Quasipaa delacouri* (EN), *Physignathus cocincinus* (VU), *Orthriophis moellendorffi* (VU) and *Coelognathus radiatus* (VU).
- IUCN Red List (2021): Five species, namely *Physignathus cocincinus* (VU), *Naja atra* (VU), *Odorrana geminata* (VU), *Tylototriton zieglerei* (VU) and *Quasipaa verrucospinosa* (NT).
- Decree No. 06 (2019): Two species, namely *Naja atra* (IIB) and *Tylototriton zieglerei* (IIB).
- CITES (2020): Two species, namely *Naja atra* (II) and *Tylototriton zieglerei* (II).
- Endemism: Six species *Gekko palmatus*, *Sphenomorphus cryptotis*, *Leptobranchella nahangensis*, *Leptobranchella nyx*, *Quasipaa delacouri* and *Tylototriton zieglerei* are currently known only from Vietnam.

c) Phia Oac-Phia Den National Park

Among 72 recorded species of reptiles and amphibians from Phia Oac-Phia Den NP, 14 species are globally or nationally threatened at different levels (Table 6).

- Red Data Book of Vietnam (2007): Two species, namely *Bungarus fasciatus* (EN), *Naja atra* (EN), *Megophrys palpebralespinosa* (CR).

- IUCN Red List (2021): Six species, namely *Naja atra* (VU), *Cuora mouhotii* (EN), *Quasipaa boulengeri* (EN), *Theloderma rhododiscus* (NT), *Paramesotriton guangxiensis* (EN) and *Tylototriton zieglerei* (VU).
- Decree 06 (2019): Three species, namely *Naja atra* (IIB), *Cuora mouhotii* (IIB), *Paramesotriton guangxiensis* (IIB), and *Tylototriton zieglerei* (IIB).
- CITES (2019): Three species, namely *Naja atra* (II), *Cuora mouhotii* (II), *Paramesotriton guangxiensis* (II) and *Tylototriton zieglerei* (II).
- Endemism: Seven species *Gekko palmatus*, *Tropidophorus murphyi*, *Leptobranchella nyx*, *Megophrys caobangensis*, *Rhacophorus larissae* and *Tylototriton zieglerei* are currently known only from Vietnam.

d) Nam Xuan Lac HSCA

Among 53 recorded species of reptiles and amphibians from Nam Xuan Lac HSCA, eight species are globally or nationally threatened at different levels (Table 6).

- Red Data Book of Vietnam (2007): five species, namely *Gekko reevesii* (VU), *Coelognathus radiates* (VU), *Orthriophis moellendorffi* (VU), *Ptyas korros* (EN), and *Rhacophorus kio* (EN).
- IUCN Red List (2021): One species, namely *Quasipaa boulengeri* (EN).
- Endemism: Two species *Gekko palmatus* and *Leptobranchella nahangensis* are currently known only from Vietnam.

2.6.4 Ecological and conservation aspects

Threats to the populations of reptiles and amphibians in four study sites are habitat loss/degradation and illegal wildlife hunting.

Some parts of natural forest have been converted into agricultural land (planting fruit trees or rice/corn fields). Ore mining activities have also influenced the natural forest in Phia Oac-Phia Den National Park. Negative impacts on habitat and population of wildlife species are timber logging and non-timber forest product exploitation, cattle raising and electronic fishing.

Some species of reptiles and amphibians were collected by local people for food, for example: *Physignathus cocincinus*, *Coelognathus radiatus*, *Orthriophis moellendorffi*, *Ptyas korros*, *Naja atra*, *Cuora mouhotii*, *Duttaphrynus melanostictus*, *Hoplobatrachus rugulosus*, *Limnonectes bannaensis*, *Quasipaa boulengeri*, *Quasipaa verrucospinosa*, *Odorrana chloronota*, *Zhangixalus dennysi*, *Zhangixalus pachyproctus*...

a) Cham Chu Nature Reserve

Habitat loss and degradation: Some parts of natural forest in Phu Luu commune have been degraded by cultivated activities (planting fruit trees) of local people. Cultivated activities have negative impacts on habitat of wildlife species. Direct observation in the field showed that natural forest in Cham Chu has been fragmented and degraded. The populations of some native species of hardwoods have been declined as a result of timber logging in the past. Exploitation of plants for different purposes is a major cause of natural habitat degradation, particularly the sensitive ecosystem like limestone karst forest.

Illegal wildlife hunting: Hunting activities are uncommon in the Cham Chu NR. Only few cases of collecting reptiles and amphibians for food were seen during our surveys.

b) Bac Me Nature Reserve

Habitat loss and degradation: Some parts of natural forest in Minh Son, Minh Ngoc, and Lac Nong communes have been degraded by cultivated activities (corn fields) of local people and ore mining in Minh Son Commune, and that has negative impacts on habitat of wildlife species. Direct observation in the field showed that natural forest in Bac Me NR has been fragmented, habitat quality has been degraded, and populations of some native species of hardwoods have been declined as a result of timber logging in the past. Exploitation of plants for different purposes is a major cause of natural habitat degradation, particularly the sensitive ecosystem like limestone karst forest.

Illegal wildlife hunting: Hunting activities are uncommon in the Bac Me NR. Only few cases of collecting reptiles and amphibians for food were seen during our survey.

c) Phia Oac-Phia Den National Park

Habitat loss and degradation: Some parts of natural forest in Quang Thanh and Thanh Cong communes have been degraded by cultivated activities (rice and corn fields). Ore mining activities have also influenced the natural forest in Thanh Cong Commune and Tinh Tuc Town. Direct observation in the field showed that natural forest in Phia Oac-Phia Den NP has been fragmented, habitat quality has been degraded, and populations of some native species of hardwoods have been declined as a result of timber logging in the past. Exploitation of plants for different purposes is another cause of natural habitat degradation.

Illegal wildlife hunting: Hunting activities are uncommon in the Phia Oac-Phia Den NP. Only few cases of collecting reptiles and amphibians for food were seen during our survey.

d) Nam Xuan Lac HSCA

Habitat loss and degradation: Some parts of natural forest in Xuan Lac and Ban Thi communes have been degraded by cultivated activities (corn fields) of local people and ore mining near Binh Trai Ranger Station, and that has negative impacts on habitat of wildlife species. Direct observation in the field showed that natural forest in Bac Me NR has been fragmented, habitat quality has been degraded, and populations of some native species of hardwoods have been declined as a result of timber logging in the past. Exploitation of plants for different purposes is a major cause of natural habitat degradation, particularly the sensitive ecosystem like limestone karst forest.

Illegal wildlife hunting: Hunting activities are uncommon in the Nam Xuan Lac HSCA. Only few cases of collecting reptiles and amphibians for food were seen during our survey.

Priority localities for conservation

To define the priority localities for conservation actions in each study sites, we use a tally technique to rank the quality of all survey sites. The following criteria will be used: species richness, estimated forest area, habitat quality, and human disturbance. In each criterion, a higher number represents a better score. According to our evaluation, the relative value of each site is ranked as follows: Phia Oac - Phia Den NP with 15 points, Bac Me NR (13 points), Cham Chu NR (eight points), and Nam Xuan Lac SHCA with the lowest value of four points (Table 7).

Table 7. Evaluation of priority localities for conservation in four study sites

Site	Species richness	Number of endemic and threatened species	Forest area/ habitat quality	Human disturbance	Total
Cham Chu	2	2	2	2	8
Bac Me	3	4	3	3	13
Phia Oac - Phia Den	4	3	4	4	15
Nam Xuan Lac	1	1	1	1	4

In Cham Chu NR, two priority locations for conservation are Cham Chu Mountain and forest near Cao Duong Village of Yen Thuan Commune. In Bac Me NR, two priority locations for conservation are forest near Na Lai Village of Thuong Tan Commune and forest near Phieng Den Village of Minh Son Commune. In Phia Oac-Phia Den NR, a priority location for conservation is Phia Oac Mountain. In Nam Xuan Lac SHCA, a priority location for conservation is forest near Binh Trai Ranger Station.

2.7 Discussion

2.7.1 Biodiversity exploration

A total of 126 species, comprising 65 species of reptiles and 61 species of amphibians from four study sites. In Cham Chu NR, a total of 61 species (22 species of reptiles and 39 species of amphibians) was documented and 17 of them were recorded for the first time from Tuyen Quang Province. In Bac Me NR, a total of 66 species (33 species of reptiles and 33 species of amphibians) was documented and 20 of them were recorded for the first time from Ha Giang Province. In Phia Oac-Phia Den NP, a total of 72 species (37 species of reptiles and 35 species of amphibians) was documented and 13 of them were recorded for the first time from Cao Bang Province. Remarkably, two new species were discovered from Phia Oac-Phia Den NP, viz. *Lycodon pictus* and *Megophrys caobangensis*. In Nam Xuan Lac HSCA, a total of 53 species (22 species of reptiles and 31 species of amphibians) was documented, eight of them were recorded for the first time from Bac Kan Province.

The herpetofaunas of study sites are relative similar to each other and somehow distinct from those of other limestone karst forests in northeastern Vietnam.

2.7.2 Conservation value

The herpetofaunas of four study sites in northeastern Vietnam contain a high level of conservation concern. Among 126 recorded species of reptiles and amphibians from study sites, 28 species (approximately 22%) are globally or nationally threatened at different levels. In Cham Chu NR, we recorded 13 threatened species, comprising two species listed in the Vietnam Red Data Book, six species listed in the IUCN Red List, and six species are endemic to Vietnam. In Bac Me NR, we recorded 14 threatened species, comprising six species listed in the Vietnam Red Data Book, five species listed in the IUCN Red List, two species listed in the Governmental Decree No. 06, two species listed in CITES and six species are endemic to Vietnam. In Phia Oac-Phia Den NP, we recorded 14 threatened species, comprising two species listed in the Vietnam Red Data Book, six species listed in the IUCN Red List, three species listed in the Governmental Decree No. 06, three species listed in CITES and seven species are endemic to Vietnam. In Nam Xuan Lac HSCA, we recorded 8 threatened species, comprising five species listed in the Vietnam Red Data Book, one species listed in the IUCN Red List and two species is endemic to Vietnam.

2.7.3 Conservation issues

Data about species richness, new findings, and conservation value of reptile and amphibian species in Cham Chu NR (Tuyen Quang Province), Bac Me NR (Ha Giang Province), Phia

Oac-Phia Den NP (Cao Bang Province) and Nam Xuan Lac SHCA (Bac Kan Province) underline the important role limestone karst forests in biodiversity conservation in northern Vietnam. Based on this data, provincial authorities (i.e. Department of Agriculture and Rural Development, Forest Protection Department) and decision makers can develop conservation program for each species and an appropriate operational plan for each nature reserve or at provincial level in the following aspects:

- Target species of conservation: If a species is under the risk of extinction (e.g., habitat loss/degradation or population decline), it should be included in the list of protected species. In addition, urgent conservation measures should be applied to protect the endangered species. We recently prepared a proposal for listing of all salamander species in Vietnam, including *Paramesotriton* spp. and *Tylototriton* spp., in the CITES Appendix II and the Group IIB of the Governmental Decree No. 06 in 2019 as well as the the Governmental Decree No. 84 in 2021. These species were found in the project area. Other species of reptiles, for example *Cuora mouhotii*, *Naja atra*, *Physignathus cocincinus* or the species endemic to Vietnam (*Tropidophorus murphyi*, *Leptobrachella nyx*, *Megophrys caobangensis*, *Rhacophorus larissae*, *Tylototriton ziegleri*) should be considered as flagship species of conservation in four protected areas.
- Priority sites of conservation: The site that harbours a high level of species diversity, a high number of threatened/endemic species and provides a suitable habitat for wildlife species should be considered as priority sites of conservation. In this study, priority localities for conservation were ranked based on site assessment as the following: Phia Oac-Phia Den NP (15 points), Bac Me NR (13 points), Cham Chu NR (8 points), and Nam Xuan Lac SHCA (4 points). The same method could be applied to identify the priority sites of conservation based on the data of all groups.
- Conservation activities: The follow up actions could be conducted at the nature reserve, for instance habitat protection and restoration, improvement of management and patrolling activities, control of wildlife hunting and illegal trade, and of awareness programs. Afore mentioned activities should be included in the operational plan of four protected areas for the period 2021-2025.
- Establishment of the conservation corridor: Isolated forest patches could be linked in order to create green corridors or extend habitat for wildlife species. Proposed green corridors could be identified based on research findings of other biological and GIS groups.

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2.9 Publications and products

Three papers were published in ISI journals by the herpetology group:

Janssen H.Y., Pham C.T., Ngo H.T., Le M.D., Nguyen T.Q., Zielger T. (2019): A new species of *Lycodon* Boie, 1826 (Serpentes, Colubridae) from northern Vietnam. *Zookeys*, 875: 1–29.

Truong Quang Nguyen, Cuong The Pham, Tao Thien Nguyen, Anh Mai Luong & Thomas Ziegler (2020): A new species of *Megophrys* (Amphibia: Anura: Megophryidae) from Vietnam. *Zootaxa*, 4722: 401–422.

Dzung Trung Le, Loc Thi Nguyen, Minh Duc Le, Cuong The Pham & Truong Quang Nguyen (2021): Tadpole description of *Leptobrachella petrops* (Rowley, Dau, Hoang, Le, Cutajar et Nguyen, 2017) (Anura: Megophryidae), an endemic species of Vietnam. *Russian Journal of Herpetology*, 28(3):145–151.

Two papers were published in the Vietnamese journals by our working group:

Pham The Cuong, Nguyen Quang Truong, Luong Mai Anh, Phan Quang Tien & Le Trung Dung (2019): New records of cascade frogs (Amphibia: Anura: Ranidae: *Odorrana*) from Tuyen Quang Province. Pp. 173–177. In: Proceedings of the fourth National Scientific Conference on Amphibians and Reptiles in Vietnam. Publishing House for Science and Technology, Hanoi.

Pham The Cuong, Phan Quang Tien, Do Trong Dang, Nguyen Quang Truong (2019): New provincial records of the genus *Limnonectes* (Amphibia: Anura: Dicroglossidae) from Vietnam. *Tap chi Sinh hoc*, 41(2se1&2se2): 169–176.

Another manuscript was submitted to Biodiversity Data Journal in August 2021:

Anh Mai Luong, Quyen Hanh Do, Chung Van Hoang, Tien Quang Phan, Truong Quang Nguyen & Cuong The Pham (under review): New records of amphibians from Bac Kan Province, Vietnam. *Biodiversity Data Journal*.

3. EMPOWERMENT OF YOUNG SCIENTISTS

3.1 Guiding principles for education and training

Three young scientists have been involved in this project, one PhD student and one master student from Hanoi National University of Education and another master student from

Vietnam National University, Hanoi. In order to strengthen the professional capacity for young researchers in herpetology in Vietnam, students were participated in the field surveys, specimens examination in laboratory and data analysis for publication.

PhD student:

Research of Luong Mai Anh, a PhD student of the Hanoi National University of Education, focuses on the taxonomy and phylogenetic relationships of the amphibian family Megophryidae in Vietnam.

Master students:

Research of Phan Quang Tien, a master student of the Hanoi National University of Education, focused on the herpetofaunas of some selected forest areas in Quang Ninh and Tuyen Quang provinces.

Research of Do Hanh Quyen, a master student of the Vietnam National University (Hanoi), focuses on slender geckos of the genus *Hemiphyllocladactylus*.

3.2 Achievement of each young scientist

Luong Mai Anh used the collection of amphibians from Tuyen Quang, Ha Giang, Cao Bang, and Bac Kan provinces for morphological and molecular analyses. She successfully defended the dissertation in June and will obtain the doctoral degree in the end of 2021.

Luong Mai Anh is a co-author of two papers:

Pham The Cuong, Nguyen Quang Truong, Luong Mai Anh, Phan Quang Tien & Le Trung Dung (2019): New records of cascade frogs (Amphibia: Anura: Ranidae: *Odorrana*) from Tuyen Quang Province. Pp. 173–177. In: Proceedings of the fourth National Scientific Conference on Amphibians and Reptiles in Vietnam. Publishing House for Science and Technology, Hanoi.

Nguyen T.Q., Pham C.T., Nguyen T.T., Luong A.M. & T. Ziegler T. (2020): A new species of *Megophrys* (Amphibia: Anura: Megophryidae) from Vietnam. *Zootaxa*, 4722: 401–422.

Phan Quang Tien used the collection of snakes from Tuyen Quang Province as a part of materials for his master thesis. He obtained the master degree in December 2018. Phan Quang Tien is a co-author of two papers:

Pham The Cuong, Nguyen Quang Truong, Luong Mai Anh, Phan Quang Tien & Le Trung Dung (2019): New records of cascade frogs (Amphibia: Anura: Ranidae: *Odorrana*) from Tuyen Quang Province. Pp. 173–177. In: Proceedings of the fourth

National Scientific Conference on Amphibians and Reptiles in Vietnam. Publishing House for Science and Technology, Hanoi.

Pham The Cuong, Phan Quang Tien, Do Trong Dang, Nguyen Quang Truong (2019): New provincial records of the genus *Limnonectes* (Amphibia: Anura: Dicroglossidae) from Vietnam. *Tap chi Sinh hoc*, 41(2se1&2se2): 169–176.

Do Hanh Quyen has used the collection of gecko specimens from northeastern Vietnam for her master thesis and it is expected to be complete in the end of 2021.

4. Appendices

Appendix 1. Illustrational plates

Appendix 1.1: Cham Chu Nature Reserve, Tuyen Quang Province

Figure 1. a & b) Limestone karst forests in Cham Chu Nature Reserve

Figure 2. a & b) Survey team in the field in Cham Chu Nature Reserve

Figure 3. New records of reptiles from Tuyen Quang: a) *Calamaria pavementata*, b) *Opisthotropis lateralis*

Figure 4. New records of reptiles from Tuyen Quang: a) *Oreocryptophis porphyraceus*, b) *Hebius chapaensis*

Figure 5. New records of reptiles from Tuyen Quang: a) *Protobothrops mucrosquamatus*, b) *Trimererusus stejnegeri*

Figure 6. New records of amphibians from Tuyen Quang: a) *Leptobranchella minima* (male), b) *Leptobranchella minima* (female), c) *Leptobranchella nyx*, d) *Leptobranchella sungi*, e) *Megophrys microstoma*, f) *Limnonectes limborgi*, g) *Limnonectes nguyenorum*, h) *Odorrana nasica*

Figure 7. New records of amphibians from Tuyen Quang: a) *Odorrana lipuensis* (male), b) *Odorrana lipuensis* (female), c) *Rhacophorus orlovi* (male), d) *Rhacophorus orlovi* (female), e) *Rhacophorus kio*, f) *Zhangixalus smaragdinus*

Appendix 1.2: Bac Me Nature Reserve, Ha Giang Province

Figure 8. a) Karst forest in Bac Me NR, Ha Giang Province, b & c) Habitat types in Bac Me NR, d & e) Survey team in the field

Figure 9. a) *Acanthosaura lepidogaster*, b) *Draco maculatus*, c) *Pseudocalotes brevipes*

Figure 10. a) *Physignathus cocincinus* b) *Gekko palmatus*, c) *Hemidactylus frenatus*

Figure 11. a) *Eutropis longicaudatus*, b) *Sphenomorphus cryptotis*, c) *Tropidophorus hainanus*

Figure 12. a) *Ahaetulla prasina*, b & c) *Boiga guangxiensis* (adult & juveniles), d) *Boiga multomaculata*, e) *Lycodon meridionalis*, f) *Trimerodytes percarinatus*, g) *Pareas hamptoni*, g) *Protobothrops maolanensis*

Figure 13. a) *Duttaphrynus melanostictus*, b) *Leptobrachella sp.*, c) *Leptobrachella nahangensis*, d) *Leptobrachella minima*, e) *Leptobrachella nyx*, f) *Leptobrachella sungi*, g) *Megophrys microstoma*, h) *Megophrys maosonensis*

Figure 14. a) *Microhyla heymonsi*, b) *Microhyla pulchra*, c) *Fejervarya limnocharis*, d) *Hoplobatrachus rugulosus*, e & f) *Limnonectes bannaensis* (male & female), g) *Quasipaa delacouri*, h) *Quasipaa verrucospinosa*

Figure 15. a) *Amolops ricketti*, b) *Odorrana chloronota*, c) *Odorrana geminata*, d) *Odorrana nasica*, e) *Odorrana tiannanensis*, f) *Rana johnsi*, g) *Sylvirana maosonensis*, h) *Sylvirana guentheri*

Figure 16. a) *Kurixalus hainanus*, b) *Polypedates mutus*, c) *Polypedates megacephalus*, d) *Raorchestes parvulus*, e) *Rhacophorus orlovi*, f) *Rhacophorus rhodopus*, g) *Zhangixalus dennysi*, h) *Tylototriton zieglerei*

Appendix 1.3: Phia Oac-Phia Den National Park, Cao Bang Province

Figure 17. a) Forest in Phia Oac-Phia Den NP, Cao Bang Province b, c & d) Habitat types in Phia Oac-Phia Den NP, e) Survey team in the field

Figure 18. a) *Tropidophorus hainanus*, b) *Dopasia harti*, c) *Ptyas multicinctus*, d) *Gonyosoma prasinum*, e) *Hebius chapaensis*, f) *Lycodon fasciatus*, g) *Lycodon futsingensis*, h) *Lycodon meridionalis*.

Figure 19. a) *Trimerodytes percarinatus*, b) *Pareas hamptoni*, c) *Bungarus fasciatus*, d) *Naja atra*, e) *Protobothrops mucrosquamatus*, f) *Ovophis monticola*, g) *Trimeresurus albolabris*, h) *Cuora mouhotii*.

Figure 20. a) *Duttaphrynus melanostictus*, b) *Leptobrachella nyx*, c) *Leptobrachium chapaense*, d) *Megophrys microstoma*, e) *Megophrys maosonensis*, f) *Megophrys palpebralespinosa*, g) *Microhyla heymonsi*, h) *Microhyla pulchra*.

Figure 21. a) *Limnonectes bannaensis*, b) *Quasipaa boulengeri*, c) *Amolops ricketti*, d) *Odorrana nasica*, e) *Rana johnsi*, f) *Gracixalus gracilipes*.

Figure 22. a) *Kurixalus hainanus*, b) *Rhacophorus larissae*, c) *Theloderma rhododiscus*, d) *Zhangixalus puerensis*, e) *Paramesotriton guangxiensis*, f) *Tylototriton zieglerei*.

Appendix 1.4: Nam Xuan Lac HSCA, Bac Kan Province

Figure 23. Habitat types in Nam Xuan Lac HSCA.

Figure 24. Survey team in the field.

Figure 25. a) *Acanthosaura lepidogaster*, b) *Pseudocalotes brevipes*, c) *Gekko palmatus*, d) *Hemidactylus frenatus*.

Figure 26. a) *Ahaetulla prasina*, b) *Boiga guangxiensis*, c) *Lycodon meridionalis*, d) *Trimerodytes percarinatus*, e) *Pareas hamptoni*, f) *Trimeresurus stejnegeri*.

Figure 27. a) *Duttaphrynus melanostictus*, b) *Microhyla butleri*, d) *Microhyla heymonsi*, c) *Microhyla pulchra*, d) *Leptobrachella* sp., e) *Leptobrachella nahangensis* g) *Megophrys maosonensis*, h) *Megophrys microstoma*.

Figure 28. a) *Fejervarya limnocharis*, b) *Limnonectes bannaensis*, c) *Quasipaa boulengeri*, d) *Odorrana chloronota*, f) *Odorrana lipuensis*, e) *Rana johnsi*, f) *Sylvirana maosonensis*, h) *Gracixalus nonggangensis*.

Figure 29. a) *Kurixalus hainanus*, b) *Polypedates megacephalus*, c) *Raorchestes parvulus* d) *Rhacophorus kio*, e) *Rhacophorus orlovi*, f) *Theloderma albopunctatum*, g) *Zhangixalus pachyproctus*, h) *Zhangixalus dennysi*.

Appendix 2: List of reptiles and amphibians recorded from study sites

Table 1. List of reptiles and amphibians recorded from Cham Chu Nature Reserve, Tuyen Quang Province

No	Scientific name	Common name	Trip 1 (10/2018)	Trip 2 (4/2019)
	REPTILE	REPTILES		
	SQUAMATA	SQUAMATA		
	SAURIA	LIZARDS		
	Agamidae	Agamid Lizards		
1.	<i>Acanthosaura lepidogaster</i> (Cuvier, 1829)	Brown Pricklenape	+	+
2.	<i>Pseudocalotes brevipes</i> (Werner, 1904)	Vietnam False Bloodsucker		+
	Gekkonidae	Geckos		
3.	<i>Gekko palmatus</i> Boulenger, 1907	Palm Gecko	+	+
4.	<i>Hemidactylus frenatus</i> Schlegel, 1836	Common House Gecko	+	+
	Scincidae	Skinks		
5.	<i>Eutropis longicaudatus</i> (Hallowell, 1857)	Longtail Mabuya	+	+
6.	<i>Eutropis macularius</i> (Blyth, 1853)	Bronze Mabuya	+	
7.	<i>Scincella reevesii</i> (Gray 1838)	Reeves' Smooth Skink	+	
8.	<i>Sphenomorphus cryptotis</i> Darevsky, Orlov & Ho, 2004	Depressed-eared Forest Skink		+
9.	<i>Tropidophorus hainanus</i> Smith, 1923	Hainan Water Skink		+
	SERPENTES	SNAKES		
	Colubridae	Colubrids		
10.	<i>Ahaetulla prasina</i> (Boie, 1827)	Oriental Whip Snake	+	+
11.	<i>Calamaria pavementata</i> Duméril, Bibron & Duméril, 1854*	Collared Reed Snake		+
12.	<i>Opisthotropis lateralis</i> Boulenger, 1903*	Tonkin Mountain Keelback		+

No	Scientific name	Common name	Trip 1 (10/2018)	Trip 2 (4/2019)
13.	<i>Oreocryptophis porphyraceus</i> (Cantor, 1839)*	Red Bamboo Snake		+
14.	<i>Elaphe moellendorffi</i> (Boettger, 1886)	Flower Snake	+	
15.	<i>Ptyas korros</i> (Schlegel, 1837)	Chinese Ratsnake	+	
16.	<i>Trimerodytes percarinatus</i> (Boulenger, 1899)	Eastern Water Snake		+
17.	<i>Hebius</i> sp.*	Keelback		+
18.	<i>Pareas hamptoni</i> (Boulenger, 1905)	Hampton's Slug Snake		+
19.	<i>Achalinus</i> sp.*	Burrowing Snake		+
	Viperidae	Vipers		
20.	<i>Protobothrops mucrosquamatus</i> (Cantor, 1839)*	Brown Spotted Pitviper	+	
21.	<i>Trimeresurus albolabris</i> Gray 1842	White-lipped Pitviper		+
22.	<i>Trimeresurus stejnegeri</i> Schmidt, 1925*	Chinese Green Tree Viper		+
	AMPHIBIA	AMPHIBIANS		
	ANURA	FROGS		
	Bufonidae	Toads		
1.	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	Asian Common Toad	+	+
	Megophryidae	Asian Toads		
2.	<i>Leptobrachella minima</i> (Taylor, 1962)*	Asian Toad		+
3.	<i>Leptobrachella nahangensis</i> (Lathrop, Murphy, Orlov & Ho, 1998)	Nahang Asian Toad	+	+
4.	<i>Leptobrachella nyx</i> (Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler & Dubois, 2011)*	Asian Toad		+
5.	<i>Leptobrachella petrops</i> (Rowley, Dau, Hoang, Le, Cutajar, Nguyen, 2017)	Stone Litter Toad	+	+
6.	<i>Leptobrachella sungi</i> (Lathrop,	Sung's Toad	+	+

No	Scientific name	Common name	Trip 1 (10/2018)	Trip 2 (4/2019)
	Murphy, Orlov & Ho, 1998)*			
7.	<i>Megophrys maasonensi</i> Bourret, 1937	Maoson Horned Toad		+
8.	<i>Megophrys microstoma</i> (Boulenger, 1903)*	Asian Mountain Toad	+	+
	Microhylidae	Rice frogs		
9.	<i>Microhyla</i> sp.	Narrow-mouthed Frog		+
10.	<i>Microhyla butleri</i> Boulenger, 1900	Butler's Rice Frog		+
11.	<i>Microhyla heymonsi</i> Vogt, 1911	Heymon's Narrow-mouthed Frog		+
12.	<i>Microhyla pulchra</i> (Hallowell, 1861)	Guangdong Rice Frog		+
	Dicroglossidae	Fork-tongued frogs		
13.	<i>Fejervarya limnocharis</i> (Gravenhorst, 1829)	Grass Frog	+	+
14.	<i>Hoplobatrachus rugulosus</i> (Wiegmann, 1834)	Common Lowland Frog	+	+
15.	<i>Limnonectes bannaensis</i> Ye, Fei & Jiang, 2007	Banna Large-headed Frog	+	+
16.	<i>Limnonectes limborgi</i> (Sclater, 1892)*	Limborg's Frog		+
17.	<i>Limnonectes nguyenorum</i> McLeod, Kurlbaum & Hoang, 2015*	Nguyen Large-head Frog	+	
18.	<i>Quasipaa delacouri</i> (Angel, 1928)	Doi Chang Asian Frog	+	
19.	<i>Quasipaa verrucospinosa</i> (Bourret, 1937)	Granular Spiny Frog	+	+
	Ranidae	True Frogs		
20.	<i>Amolops ricketti</i> (Boulenger, 1899)	Chinese Sucker Frog	+	+
21.	<i>Amolops</i> sp.	Cascade Frog	+	
22.	<i>Odorrana chloronota</i> (Günther, 1875)	Green Cascade Frog	+	+
23.	<i>Odorrana lipuensis</i> Mo, Chen, Wu, Zhang, and Zhou, 2015*	Lipu Cascade Frog		+

No	Scientific name	Common name	Trip 1 (10/2018)	Trip 2 (4/2019)
24.	<i>Odorrana nasica</i> (Boulenger, 1903)*	Tonkin Huia Frog		
25.	<i>Odorrana tiannanensis</i> (Yang & Li, 1980)	Big-eared Frog	+	+
26.	<i>Odorrana geminata</i> Bain, Stuart, Nguyen, Che & Rao, 2009*	Geminated Cascade Frog	+	
27.	<i>Rana johnsi</i> Smith, 1921	Johns's Frog	+	
28.	<i>Sylvirana guentheri</i> (Boulenger, 1882)	Gunther's Amoy Frog	+	+
29.	<i>Sylvirana maosonensis</i> (Bourret, 1937)	Maoson Frog	+	+
	Rhacophoridae	Flying Frogs		
30.	<i>Rohanixalus vittatus</i> (Boulenger, 1887)	Two-striped Pigmy Tree Frog		+
31.	<i>Kurixalus hainanus</i> (Zhao, Wang & Shi, 2005)	Hainan Small Treefrog	+	+
32.	<i>Polypedates megacephalus</i> Hallowell, 1861	Hong Kong Whipping Frog	+	+
33.	<i>Polypedates mutus</i> (Smith, 1940)	Burmese Whipping Frog	+	+
34.	<i>Rhacophorus kio</i> Ohler & Delorme, 2006*	Black-webbed Treefrog		+
35.	<i>Rhacophorus orlovi</i> Ziegler & Köhler, 2001*	Orlov's Treefrog		+
36.	<i>Theloderma corticale</i> (Boulenger, 1903)	Tonkin Bug-eyed Frog		+
37.	<i>Theloderma albopunctatum</i> (Liu & Hu, 1962)	Dotted Bubble-nest Frog		+
38.	<i>Zhangixalus dennysi</i> (Blanford, 1881)	Denny's Whipping Frog		+
39.	<i>Zhangixalus pachyproctus</i> Yu, Hui, Hou, Wu, Rao & Yang, 2019*	Treefrog		+
	Total		32	50

Notes: * New record for Tuyen Quang Province

Table 2. List of reptile and amphibian species recorded from Bac Me NR, Ha Giang Province

No	Scientific name	Common name	Trip 1 (5/2019)	Trip 2 (10/2019)
	REPTILE	REPTILES		
	SQUAMATA	SQUAMATA		
	SAURIA	LIZARDS		
	Agamidae	Agamid Lizards		
1.	<i>Acanthosaura lepidogaster</i> (Cuvier, 1829)	Brown Pricklenape	+	
2.	<i>Draco maculatus</i> (Gray, 1845)*	Spotted Flying Dragon		+
3.	<i>Pseudocalotes brevipes</i> (Werner, 1904)	Vietnam False Bloodsucker	+	+
4.	<i>Physignathus cocincinus</i> Cuvier, 1829	Green Water Dragon	+	
	Gekkonidae	Geckos		
5.	<i>Gekko palmatus</i> Boulenger, 1907	Palm Gecko	+	+
6.	<i>Gekko reevesii</i> (Gray, 1831)*	Reeves' Tokay Gecko	+	
7.	<i>Hemidactylus frenatus</i> Schlegel, 1836	Common House Gecko	+	+
	Scincidae	Skinks		
8.	<i>Eutropis longicaudatus</i> (Hallowell, 1857)	Longtail Mabuya	+	
9.	<i>Eutropis macularius</i> (Blyth, 1853)*	Bronze Mabuya		+
10.	<i>Eutropis multifasciatus</i> (Kuhl, 1820)	Common Sun Skink	+	
11.	<i>Sphenomorphus cryptotis</i> Darevsky, Orlov & Ho, 2004*	Depressed-eared Forest Skink	+	
12.	<i>Tropidophorus hainanus</i> Smith, 1923	Hainan Water Skink	+	
	SERPENTES	SNAKES		
	Typhlopidae	Blind snakes		
13.	<i>Indotyphlops braminus</i> (Daudin, 1803)*	Flowerpot Snake	+	
	Colubridae	Colubrids		

14.	<i>Ahaetulla prasina</i> (Boie, 1827)	Oriental Whip Snake	+	+
15.	<i>Boiga multomaculata</i> (Boie, 1827)*	Many-spotted cat snake	+	
16.	<i>Boiga guangxiensis</i> Wen, 1998*	Cat snake	+	+
17.	<i>Hebius chapaensis</i> (Bourret, 1934)*	Vietnam Water Snake	+	+
18.	<i>Lycodon meridionalis</i> (Bourret, 1935)	Wolf snake	+	+
19.	<i>Oligodon taeniatus</i> (Günther, 1861)	Striped kukri snake	+	
20.	<i>Oligodon</i> sp.	Kukri snake	+	
21.	<i>Orthriophis moellendorffi</i> (Boettger, 1886)*	Flower Snake	+	
22.	<i>Ptyas korros</i> (Schlegel, 1837)	Chinese Ratsnake	+	
23.	<i>Ptyas multicinctus</i> (Roux, 1907)*	Many-banded Green Snake	+	+
24.	<i>Coelognathus radiatus</i> (Boi, 1827)	Radiated Ratsnakes	+	
25.	<i>Rhabdophis subminiatus</i> (Schlegel, 1837)	Red-necked Keelback		+
26.	<i>Trimerodytes percarinatus</i> (Boulenger, 1899)	Eastern Water Snake	+	+
	Pareatidae	Slug Snakes		
27.	<i>Pareas hamptoni</i> (Boulenger, 1905)	Hampton's Slug Snake	+	
28.	<i>Pareas margaritophorus</i> (Jan, 1866)*	Mountain Slug Snake		+
	Elapidae	Kraits		
29.	<i>Bungarus fasciatus</i> (Schneider, 1801)*	Banded Krait		+
30.	<i>Naja atra</i> Cantor, 1842*	Chinese cobra	+	
	Viperidae	Vipers		
31.	<i>Protobothrops mucrosquamatus</i> (Cantor, 1839)	Brown Spotted Pitviper	+	+
32.	<i>Protobothrops maolanensis</i> Yang, Orlov & Wang, 2011	Mao-lan pitviper	+	
33.	<i>Trimeresurus albolabris</i> Gray 1842*	White-lipped Pitviper	+	+
	AMPHIBIA	AMPHIBIANS		
	ANURA	FROGS		

	Bufonidae	Toads		
1.	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	Asian Common Toad	+	+
	Megophryidae	Asian Toads		
2.	<i>Leptobrachella</i> sp.	Toad	+	
3.	<i>Leptobrachella minima</i> (Taylor, 1962)*	Asian Toad	+	+
4.	<i>Leptobrachella nahangensis</i> (Lathrop, Murphy, Orlov & Ho, 1998)*	Nahang Asian Toad		+
5.	<i>Leptobrachella nyx</i> (Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler & Dubois, 2011)	Asian Toad		+
6.	<i>Leptobrachella sungi</i> (Lathrop, Murphy, Orlov & Ho, 1998)*	Sung's Toad	+	+
7.	<i>Megophrys maasonensi</i> Bourret, 1937	Maoson Horned Toad	+	+
8.	<i>Megophrys microstoma</i> (Boulenger, 1903)	Asian Mountain Toad	+	+
	Microhylidae	Rice frogs		
9.	<i>Microhyla butleri</i> Boulenger, 1900	Butler's Rice Frog		+
10.	<i>Microhyla heymonsi</i> Vogt, 1911	Heymon's Narrow-mouthed Frog	+	
11.	<i>Microhyla pulchra</i> (Hallowell, 1861)	Guangdong Rice Frog	+	
	Dicroglossidae	Fork-tongued frogs		
12.	<i>Fejervarya limnocharis</i> (Gravenhorst, 1829)	Grass Frog	+	+
13.	<i>Hoplobatrachus rugulosus</i> (Wiegmann, 1834)	Common Lowland Frog	+	
14.	<i>Limnonectes bannaensis</i> Ye, Fei & Jiang, 2007	Banna Large-headed Frog	+	+
15.	<i>Quasipaa delacouri</i> (Angel, 1928)	Doi Chang Asian Frog		+
16.	<i>Quasipaa verrucospinosa</i> (Bourret, 1937)	Granular Spiny Frog	+	+

	Ranidae	True Frogs		
17.	<i>Amolops ricketti</i> (Boulenger, 1899)	Chinese Sucker Frog	+	+
18.	<i>Odorrana chloronota</i> (Günther, 1875)	Green Cascade Frog	+	+
19.	<i>Odorrana nasica</i> (Boulenger, 1903)*	Tonkin Huia Frog		+
20.	<i>Odorrana tiannanensis</i> (Yang & Li, 1980)	Big-eared Frog		+
21.	<i>Odorrana geminata</i> Bain, Stuart, Nguyen, Che & Rao, 2009	Geminated Cascade Frog		+
22.	<i>Rana johnsi</i> Smith, 1921	Johns's Frog		+
23.	<i>Sylvirana guentheri</i> (Boulenger, 1882)	Gunther's Amoy Frog	+	
24.	<i>Sylvirana maosonensis</i> (Bourret, 1937)	Maoson Frog	+	+
	Rhacophoridae	Flying Frogs		
25.	<i>Kurixalus hainanus</i> (Zhao, Wang & Shi, 2005)	Hainan Small Treefrog	+	+
26.	<i>Polypedates megacephalus</i> Hallowell, 1861	Hong Kong Whipping Frog	+	+
27.	<i>Polypedates mutus</i> (Smith, 1940)*	Burmese Whipping Frog	+	+
28.	<i>Raorchestes parvulus</i> (Boulenger, 1893)	Karin bubble-nest frog	+	
29.	<i>Rhacophorus orlovi</i> Ziegler & Köhler, 2001*	Orlov's Treefrog	+	
30.	<i>Rhacophorus rhodopus</i> Liu & Hu, 1960	Red-webbed Treefrog	+	
31.	<i>Theلودerma albopunctatum</i> (Liu & Hu, 1962)*	Dotted Bubble-nest Frog	+	
32.	<i>Zhangixalus dennysi</i> (Blanford, 1881)*	Denny's Whipping Frog	+	
	Salamandridae	Newts		
33.	<i>Tylototriton ziegleri</i> Nishikawa, Matsui & Nguyen, 2013	Ziegler's knobby newt	+	
Total			53	38

Notes: * New record for Ha Giang Province

Table 3. List of reptile and amphibian species recorded from Phia Oac-Phia Den NP, Cao Bang Province

No	Scientific name	Common name	Trip 1 (5/2020)	Trip 2 (10/2020)
	REPTILE	REPTILES		
	SQUAMATA	SQUAMATA		
	SAURIA	LIZARDS		
	Agamidae	Agamid Lizards		
1.	<i>Acanthosaura lepidogaster</i> (Cuvier, 1829)	Brown Pricklenape	+	
2.	<i>Acanthosaura</i> sp.	Pricklenape	+	
3.	<i>Pseudocalotes brevipes</i> (Werner, 1904)	Vietnam False Bloodsucker	+	+
	Gekkonidae	Geckos		
4.	<i>Gekko palmatus</i> Boulenger, 1907	Palm Gecko	+	
5.	<i>Hemidactylus frenatus</i> Schlegel, 1836	Common House Gecko	+	+
	Scincidae	Skinks		
6.	<i>Ateuchosaurus chinensis</i> Gray, 1845*	Chinese short-limbed skink		+
7.	<i>Eutropis longicaudatus</i> (Hallowell, 1857)	Longtail Mabuya	+	
8.	<i>Eutropis macularius</i> (Blyth, 1853)*	Bronze Mabuya	+	+
9.	<i>Plestiodon quadrilineatus</i> Blyth, 1853	Four-striped Skink	+	+
10.	<i>Scincella</i> sp1.	Smooth Skink	+	
11.	<i>Scincella</i> sp2.	Smooth Skink	+	+
12.	<i>Lygosoma</i> sp.	Short-limbed Skink	+	
13.	<i>Sphenomorphus indicus</i> (Gray, 1853)	Himalayan Forest Skink	+	
14.	<i>Tropidophorus hainanus</i> Smith, 1923	Hainan water skink	+	+
15.	<i>Tropidophorus murphyi</i> Hikida, Orlov, Nabhitabhata & Ota, 2002	Murphy's water skink	+	
	Anguidae	Glass Lizards		

16.	<i>Dopasia harti</i> (Boulenger, 1899)	Hart's Glass Lizard	+	
	Lacertidae	Grass Lizards		
17.	<i>Takydromus sexlineatus</i> Daudin, 1802	Asian Grass Lizard	+	
	SERPENTES	SNAKES		
	Colubridae	Colubrids		
18.	<i>Boiga kraepelini</i> Stejneger, 1902	Kelung Cat Snake	+	
19.	<i>Gonyosoma coeruleum</i> Liu & Hou & Lwin & Wang & Rao 2021 *	Green Ratsnake	+	
20.	<i>Hebius chapaensis</i> (Bourret, 1934)*	Vietnam Water Snake	+	+
21.	<i>Hebius boulengeri</i> (Gressitt, 1937)	Boulenger's keelback	+	
22.	<i>Lycodon fasciatus</i> (Anderson, 1879)	Banded Wolf Snake	+	
23.	<i>Lycodon futsingensis</i> (Pope, 1928)	Futsing Wolf Snake	+	+
24.	<i>Lycodon meridionalis</i> (Bourret, 1935)	Wolf snake	+	+
25.	<i>Pseudoxenodon</i> sp.	Bamboo Snake		+
26.	<i>Ptyas major</i> (Günther, 1858)	Chinese Green Snake	+	
27.	<i>Ptyas multicinctus</i> (Roux, 1907)	Many-banded Green Snake	+	
28.	<i>Trimerodytes percarinatus</i> (Boulenger, 1899)	Eastern Water Snake		+
	Pareatidae	Slug Snakes		
29.	<i>Pareas hamptoni</i> (Boulenger, 1905)	Hampton's slug snake	+	
	Elapidae	Kraits		
30.	<i>Bungarus fasciatus</i> (Schneider, 1801)	Banded Krait	+	
31.	<i>Naja atra</i> Cantor, 1842	Chinese Cobra	+	
32.	<i>Calliophis maculiceps</i> (GÜNTHER, 1858)*	Speckled Coral Snake	+	
	Viperidae	Vipers		
33.	<i>Protobothrops mucrosquamatus</i> (Cantor, 1839)	Brown Spotted Pitviper	+	
34.	<i>Ovophis monticola</i> (GÜNTHER, 1864)*	Chinese Mountain Pitviper		+

35.	<i>Trimeresurus albolabris</i> Gray 1842*	White-lipped Pitviper	+	+
36.	<i>Trimeresurus yunnanensis</i> Schmidt, 1925*	Yunnan Bamboo Pitviper		+
	TESTUDINES	TURTLES		
	Geoemydidae	Pond Turtles		
37.	<i>Cuora mouhotii</i> (Gray, 1862)*	Keeled Box Turtle	+	
	AMPHIBIA	AMPHIBIANS		
	ANURA	FROGS		
	Bufonidae	Toads		
1.	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	Asian Common Toad	+	+
	Megophryidae	Asian Toads		
2.	<i>Leptobranchella</i> sp.	Toad	+	
3.	<i>Leptobranchella nyx</i> (Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler & Dubois, 2011)*	Asian Toad		+
4.	<i>Leptobranchium chapaense</i> (Bourret, 1937)	Chapa Spadefoot Toad	+	+
5.	<i>Leptobranchium</i> sp.	Spadefoot Toad	+	
6.	<i>Megophrys caobangensis</i> Nguyen, Pham, Nguyen, Luong & Ziegler, 2020	Cao Bang Spadefoot Toad		+
7.	<i>Megophrys feae</i> Boulenger, 1887	Kakhien Hill Frog		+
8.	<i>Megophrys microstoma</i> (Boulenger, 1903)	Asian Mountain Toad	+	+
9.	<i>Megophrys maosonensis</i> Bourret, 1937	Maoson Horned Frog	+	+
10.	<i>Megophrys palpebralespinosa</i> Bourret, 1937	Tonkin Spadefoot Toad		+
	Microhylidae	Rice frogs		
11.	<i>Microhyla heymonsi</i> Vogt, 1911	Heymon's Narrow-	+	

		mouthered Frog		
12.	<i>Microhyla heymonsi</i> Vogt, 1911	Heymon's Narrow-mouthered Frog	+	+
13.	<i>Microhyla pulchra</i> (Hallowell, 1861)	Guangdong Rice Frog	+	
	Dicroglossidae	Fork-tongued frogs		
14.	<i>Fejervarya limnocharis</i> (Gravenhorst, 1829)	Grass Frog	+	+
15.	<i>Hoplobatrachus rugulosus</i> (Wiegmann, 1834)	Common Lowland frog	+	
16.	<i>Limnonectes bannaensis</i> Ye, Fei & Jiang, 2007	Banna Large-headed Frog	+	+
17.	<i>Quasipaa boulengeri</i> (Günther, 1889)	Boulenger's Spiny Frog	+	+
	Ranidae	True Frogs		
18.	<i>Amolops ricketti</i> (Boulenger, 1899)	Chinese Sucker Frog		+
19.	<i>Odorrana chloronota</i> (Günther, 1875)	Green Cascade Frog		+
20.	<i>Odorrana geminata</i> Bain, Stuart, Nguyen, Che & Rao, 2009	Geminated Cascade Frog		+
21.	<i>Odorrana nasica</i> (Boulenger, 1903)	Tonkin Huia Frog	+	+
22.	<i>Rana johnsi</i> Smith, 1921	Johns's Frog	+	+
23.	<i>Sylvirana guentheri</i> (Boulenger, 1882)	Gunther's Amoy Frog	+	
24.	<i>Sylvirana maosonensis</i> (Bourret, 1937)	Mao-Son frog	+	+
	Rhacophoridae	Flying Frogs		
25.	<i>Gracixalus gracilipes</i> (Bourret, 1937)	Chapa Bubble-nest Frog	+	
26.	<i>Kurixalus hainanus</i> (Zhao, Wang & Shi, 2005)	Hainan Small Treefrog	+	+
27.	<i>Polypedates megacephalus</i> Hallowell, 1861	Hong Kong Whipping Frog	+	+
28.	<i>Polypedates mutus</i> (Smith, 1940)	Burmese Whipping Frog	+	+
29.	<i>Raorchestes parvulus</i> (Boulenger,	Karin bubble-nest Frog	+	

	1893)			
30.	<i>Rhacophorus larissae</i> Ostroshabov, Orlov & Nguyen, 2013	Larisa Treefrog	+	
31.	<i>Theloderma albopunctatum</i> (Liu & Hu, 1962)*	Dotted Bubble-nest Frog	+	
32.	<i>Theloderma rhododiscus</i> (Liu & Hu, 1962)*	Warty Treefrog	+	
33.	<i>Zhangixalus puerensis</i> (He, 1999)*	Treefrog	+	
	Salamandridae	Newts		
34.	<i>Paramesotriton guangxiensis</i> (Huang, Tang & Tang, 1983)	Guangxi Warty Newt	+	+
35.	<i>Tylototriton ziegleri</i> Nishikawa, Matsui & Nguyen, 2013	Ziegler's knobby newt	+	
Total			60	37

Notes: * New record for Cao Bang Province

Table 4. List of reptiles and amphibians recorded from Nam Xuan Lac HSCA, Bac Kan Province

TT	Scientific name	Common name	Trip 1 (8/2020)	Trip 2 (4/2021)
	REPTILE	REPTILES		
	SQUAMATA	SQUAMATA		
	SAURIA	LIZARDS		
	Agamidae	Agamid Lizards		
1.	<i>Acanthosaura lepidogaster</i> (Cuvier, 1829)	Brown Pricklenape	+	+
2.	<i>Pseudocalotes brevipes</i> (Werner, 1904)	Vietnam False Bloodsucker	+	
	Gekkonidae	Geckos		
3.	<i>Gekko reeesii</i> (Gray, 1831)	Tokay Gecko		+
4.	<i>Hemidactylus frenatus</i> Schlegel, 1836	Common House Gecko	+	+
5.	<i>Hemidactylus platyurus</i> (Schneider, 1797)	Flat-tailed House Gecko		+
	Scincidae	Skinks		
6.	<i>Eutropis longicaudatus</i> (Hallowell, 1857)	Longtail Mabuya	+	+
7.	<i>Eutropis macularius</i> (Blyth, 1853)	Bronze Mabuya	+	+
8.	<i>Scincella</i> sp.	Forest Skink		+
	SERPENTES	SNAKES		
	Colubridae	Colubrids		
9.	<i>Ahaetulla prasina</i> (Boi, 1827)	Gunther's whip snake		+
10.	<i>Boiga guangxiensis</i> Wen, 1998*	Guangxi cat snake	+	
11.	<i>Lycodon meridionalis</i> (Bourret, 1935)	Wolf snake	+	+
12.	<i>Lycodon</i> sp.	Wolf snake		+
13.	<i>Oligodon</i> sp.	Kukri Snake		+
14.	<i>Orthriophis moellendorffi</i> (Boettger, 1886)*	Flower Snake		+

TT	Scientific name	Common name	Trip 1 (8/2020)	Trip 2 (4/2021)
15.	<i>Ptyas korros</i> (Schlegel, 1837)	Indo-Chinese Rat Snake	+	+
16.	<i>Coelognathus radiatus</i> (Boie, 1827)	Radiated Rat Snakes		+
17.	<i>Rhabdophis subminiatus</i> (Schlegel, 1837)	Red-necked Keelback		+
18.	<i>Trimerodytes percarinatus</i> (Boulenger, 1899)	Eastern Water Snake	+	+
	Pareatidae	Slug Snakes		
19.	<i>Pareas hamptoni</i> (Boulenger, 1905)	Hampton's Slug Snake	+	+
	Viperidae	Vipers		
20.	<i>Trimeresurus stejnegeri</i> Schimidt, 1925	Stejneger's Bamboo pitviper	+	+
21.	<i>Protobothrops mucrosquamatus</i> (Cantor, 1839)	Brown Spotted Pitviper		+
	AMPHIBIA	AMPHIBIANS		
	ANURA	FROGS		
	Bufonidae	Toads		
1.	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	Asian Common Toad	+	+
	Microhylidae	Rice frog		
2.	<i>Microhyla</i> sp.	Rice frog	+	+
3.	<i>Microhyla butleri</i> Boulenger, 1900*	Butler's Rice Frog	+	+
4.	<i>Microhyla fissipes</i> Boulenger, 1884	Ornamented Pygmy Frog	+	+
5.	<i>Microhyla heymonsi</i> Vogt, 1911	Heymon's Ricefrog	+	+
6.	<i>Microhyla pulchra</i> (Hallowell, 1861)	Guangdong rice frog	+	+
	Megophryidae	Asian Toads		
7.	<i>Leptobranchella</i> sp1.	Toad	+	+
8.	<i>Leptobranchella</i> sp2.	Toad		+
9.	<i>Leptobranchella nahangensis</i> (Lathrop, Murphy, Orlov, and Ho, 1998)*	Nahang Asian Toad	+	+

TT	Scientific name	Common name	Trip 1 (8/2020)	Trip 2 (4/2021)
10.	<i>Megophrys microstoma</i> Boulenger, 1903	Asian Mountain Toad	+	+
11.	<i>Megophrys maosonensis</i> (Bourret, 1937)	Maoson Horned Toad	+	+
	Dicroglossidae	Fork-tongued frogs		
12.	<i>Fejervarya limnocharis</i> (Gravenhorst, 1829)	Grass Frog	+	+
13.	<i>Hoplobatrachus rugulosus</i> (Wiegmann, 1834)	Common Lowland Frog		+
14.	<i>Limnonectes bannaensis</i> Ye, Fei & Jiang, 2007	Banna Large-headed Frog	+	+
15.	<i>Quasipaa boulengeri</i> (Günther, 1889)*	Boulenger's Spiny Frog	+	
	Ranidae	True Frogs		
16.	<i>Odorrana chloronota</i> (Günther, 1876)	Green Cascade Frog		+
17.	<i>Odorrana lipuensis</i> Mo, Chen, Wu, Zhang, and Zhou, 2015*	Lipu Cascade frog	+	+
18.	<i>Sylvirana guentheri</i> (Boulenger, 1882)	Guenther's Frog		+
19.	<i>Sylvirana maosonensis</i> (Bourret, 1937)	Mao-Son frog	+	+
20.	<i>Rana johnsi</i> Smith, 1921*	Johns's Frog	+	+
	Rhacophoridae	Flying Frogs		
21.	<i>Gracixalus nonggangensis</i> Mo, Zhang, Luo, Zhou & Chen, 2013*	Nonggang Treefrog		+
22.	<i>Kurixalus hainanus</i> (Zhao, Wang & Shi, 2005)	Hainan Small Treefrog	+	+
23.	<i>Polypedates megacephalus</i> Hallowell, 1861	Hong Kong Whipping Frog	+	+
24.	<i>Polypedates mutus</i> (Smith, 1940)	Burmese Whipping Frog		+
25.	<i>Raorchestes parvulus</i> (Boulenger,	Karin Bubble-nest Frog		+

TT	Scientific name	Common name	Trip 1 (8/2020)	Trip 2 (4/2021)
	1893)			
26.	<i>Rhacophorus kio</i> Ohler and Delorme, 2006	Black-webbed Treefrog	+	+
27.	<i>Rhacophorus orlovi</i> Ziegler and Köhler, 2001*	Orlov's Treefrog	+	+
28.	<i>Rhacophorus</i> sp.	Treefrog	+	+
29.	<i>Theلودerma albopunctatum</i> (Liu and Hu, 1962)	Dotted Bubble-nest Frog	+	+
30.	<i>Zhangixalus dennysi</i> (Blanford, 1881)	Denny's Whipping Frog		+
31.	<i>Zhangixalus pachyproctus</i> Yu, Hui, Hou, Wu, Rao, and Yang, 2019	Treefrog	+	+
Total			34	49

Notes: * New record for Bac Kan Province