

A Review of the Distribution of a New Gibbon Species: The Northern Yellow-cheeked Crested Gibbon *Nomascus annamensis* Thinh, Mootnick, Thanh, Nadler and Roos, 2010

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Abstract: *Nomascus annamensis* is a newly described gibbon endemic to the Indochina peninsula (Cambodia, Laos and Vietnam). We review the published and unpublished literature relevant to *N. annamensis* to clarify its distribution and help inform conservation management and policy related to this species. The best current distribution estimate for *N. annamensis* is east of the Mekong River, from 16°55'N to approximately 14°00'N in central Vietnam, and from 16°00'N in the south of Laos to about 13°57'N in northeast Cambodia. There is a large forest tract overlapping the borders of Cambodia, Laos and Vietnam that is probably an important habitat for this gibbon. The distribution and population status of this species in Cambodia and Laos is poorly known, however. In addition, information on the biogeographic boundaries with other gibbon species is still lacking. Various biogeographic barriers based on rivers and forest types have been hypothesized to explain the biogeography of gibbons in this region; however, our review of the evidence suggests that these factors might not fully explain the distribution of *Nomascus annamensis* and its close relatives (*N. siki* and *N. gabriellae*). We propose that climatic conditions may be a driver shaping the distribution of the gibbon. Further studies are needed, therefore, to provide comprehensive information on the distribution of *N. annamensis* and to clarify its boundaries with adjacent gibbon species.

Key Words: Gibbon, *Nomascus annamensis*, *Nomascus siki*, *Nomascus gabriellae*, distribution

Introduction

The crested gibbons, *Nomascus*, occur in Indochina (Cambodia, Laos and Vietnam) and southern China, east of the Mekong River, the only exception being *N. concolor* that has a small population west of the Mekong in China, near the Myanmar border (Geissmann *et al.* 2000; Groves 2001). Early studies on gibbon systematics recognized just one species for Indochina (Groves 1972). Based on anatomy and calls, however, later studies suggested that some subspecies should be recognized as full species (Dao Van Tien 1983; Geissmann 2002). The recognition that gibbon populations in northeastern Cambodia and central Vietnam are distinct from *N. siki* to the north and *N. gabriellae* to the south in both their calls and their mitochondrial DNA allowed Van Ngoc Thinh *et al.* (2010a) to describe a new species, *Nomascus*

annamensis (the northern yellow-cheeked gibbon or Annamite crested gibbon).

Nomascus annamensis inhabits broadleaf evergreen forests and semi-evergreen forest across a wide range of elevations. They are found at low elevations (~100 m above sea level) in Ratanakiri Province, Cambodia (Rawson *et al.* 2011) and medium elevations from 400 m–800 m above sea level (Bach Ma National Park, central Vietnam; Geissmann *et al.* 2007), and as high as between 1,028 m and 1,503 m above sea level in Kon Ka Kinh National Park, south-central Vietnam (Ha Thang Long *et al.* 2011).

Due to the previous misidentification of *N. annamensis* as either *N. gabriellae* or *N. siki*, there is a lack of clarity concerning the species' distribution (Van Ngoc Thinh *et al.* 2010b; Rawson *et al.* 2011). A comprehensive review of *N. annamensis* distributional data is crucial to assess its conservation

status. Herein, we review the published and unpublished literature relevant to *N. annamensis* to help clarify and better understand the distribution of this Indochina endemic and provide an up-to-date review of its global conservation status.

Recorded Distribution of *Nomascus annamensis*

Recent *N. annamensis* records throughout Indochina from 1995 to 2017 are presented in Table 1 and Figure 1. Since the species was only recently described and field identification is difficult, studies on the distribution are still in progress, so the distribution information is likely incomplete.

Inferred Distribution

Nomascus annamensis occurs in a small area in the southern Annamite Mountains, on the border of Vietnam, Lao People's Democratic Republic (Laos) and Cambodia, where its range is limited by the Mekong River to the west (Van Ngoc Thinh *et al.* 2010b; Roos *et al.* 2013). In particular, the species occurs in southern Laos (from Banhiang River, about 16°00'–16°03'N, in Savanakhet Province to the Cambodia border), central Vietnam (from south of the Thach Han River, about 16°40'N–16°50'N, to north of the Ba River, about 13°00'N–13°10'N), and northeast Cambodia (from the border of Laos to Srepok River, 13°30'N) (Fig. 1).

The geographical restriction of *N. annamensis* to the Annamite Mountains is probably due to historical climate change and the geomorphological events related to the Mekong River formation. Forested areas in Indochina shrank during glacial periods in the Late Pliocene and Pleistocene, restricting forest species (including *Nomascus*) into isolated refugia, such as the highlands of the Annamite Mountains (Meijaard and Groves 2006). Mitochondrial evidence also suggests that *Nomascus* originated in the border area of Vietnam and China in the Early Pliocene, and the genus then successfully dispersed south into Indochina during the Early Pleistocene (Van Ngoc Thinh *et al.* 2010b). The Mekong River established its present course after that, in the Late Pleistocene, and subsequently acted as a biogeographic barrier to primate dispersal (Meijaard and Groves 2006).

Conservation of *Nomascus annamensis*

Priority sites

The largest global population of *N. annamensis* is potentially in the large forest tracts found in Virachey National Park (Cambodia), Veun Sai forest (Cambodia) and Xe Pian National Protected Area (Laos). Virachay National Park alone supports over 2,600 km² of evergreen forest that was predicted to be suitable habitat for gibbons by Traeholt *et al.* (2005). South of this national park, in Veun Sai forest (Cambodia), gibbons persist in relatively high densities, where approximately 500 groups were estimated in only 550 km² of the conservation area (Rawson *et al.* 2011). There is also possibly a large gibbon population in Xe Pian National Protected Area, Laos (Duckworth 2008; Laos, MAF 2011); however,

reliable population data is lacking for this area. Other areas that might still be strongholds for the Annamite gibbon population is the remaining contiguous complex forest from Dakrong Nature Reserve to Phong Dien Nature Reserve, both in Vietnam, with more than 800 km² of suitable habitat (Rawson *et al.* 2011). In Vietnam, the contiguous forest from Song Thanh Nature Reserve to Ngoc Linh Nature Reserve and the Central Highlands is also a priority site for the species (Rawson *et al.* 2011).

Conservation status

The status of this species was assessed during an IUCN SSC Red Listing Workshop, organized by the Primate Specialist Group at Wildlife Reserves Singapore, 23–27 November 2015. The assessment resulted in its categorization as Endangered, based on observed, estimated, inferred or suspected population size reduction of $\geq 50\%$ over the last 10 years due to habitat loss and hunting. This assessment is not definitive, however, as it is still pending final approval and possible adjustments by the IUCN Red List Unit, prior to its posting on the IUCN Red List website (<<https://www.iucnredlist.org>>). All gibbons in Vietnam and Laos are at the highest level of legal protection. In Cambodia, *N. annamensis* is identified as “rare” and protected under the Cambodian Forestry Law.

As indicated in the Singapore assessment, habitat loss and hunting are the primary threats to this gibbon. Due to rapid development in Vietnam, few forest areas remain intact, and its distribution is highly fragmented. Similarly, large areas in Virachey National Park, Cambodia, and the national protected areas Xe Pian and Dong Amphan, Laos, which have been identified as priority areas for the conservation of yellow-cheeked gibbons, have recently been cleared for farming (Laos MAF 2011). Illegal hunting with guns is also a major threat to *N. annamensis* in Cambodia, Laos and Vietnam (Rawson 2010; Rawson *et al.* 2011; Laos MAF 2011). Gibbons are hunted for food and traditional medicine, and for trading (Van Ngoc Thinh *et al.* 2007; Nguyen Quang Hoa Anh *et al.* 2010; Rawson *et al.* 2011; Laos MAF 2011). Controlling hunting and providing for strict protection of gibbon habitat, particularly areas known to include gibbons, are the important conservation action priorities.

Areas of Further Study

Due to the only recent recognition of this species, information on the distribution of *N. annamensis* throughout Indochina is still scarce and inadequate for informed management and conservation (Van Ngoc Thinh *et al.* 2010a; Rawson *et al.* 2011). Its range in Laos and Cambodia is still poorly known, excepting the Veun Sai forest in Cambodia. In Vietnam, there are some protected areas with the possibility of high gibbon densities, but data are lacking, for example, Ngoc Linh Natural Reserve of Kon Tum Province and the Elephant Species/habitat Conservation Area of Quang Nam Province. In addition, information about the occurrence of this gibbon in green

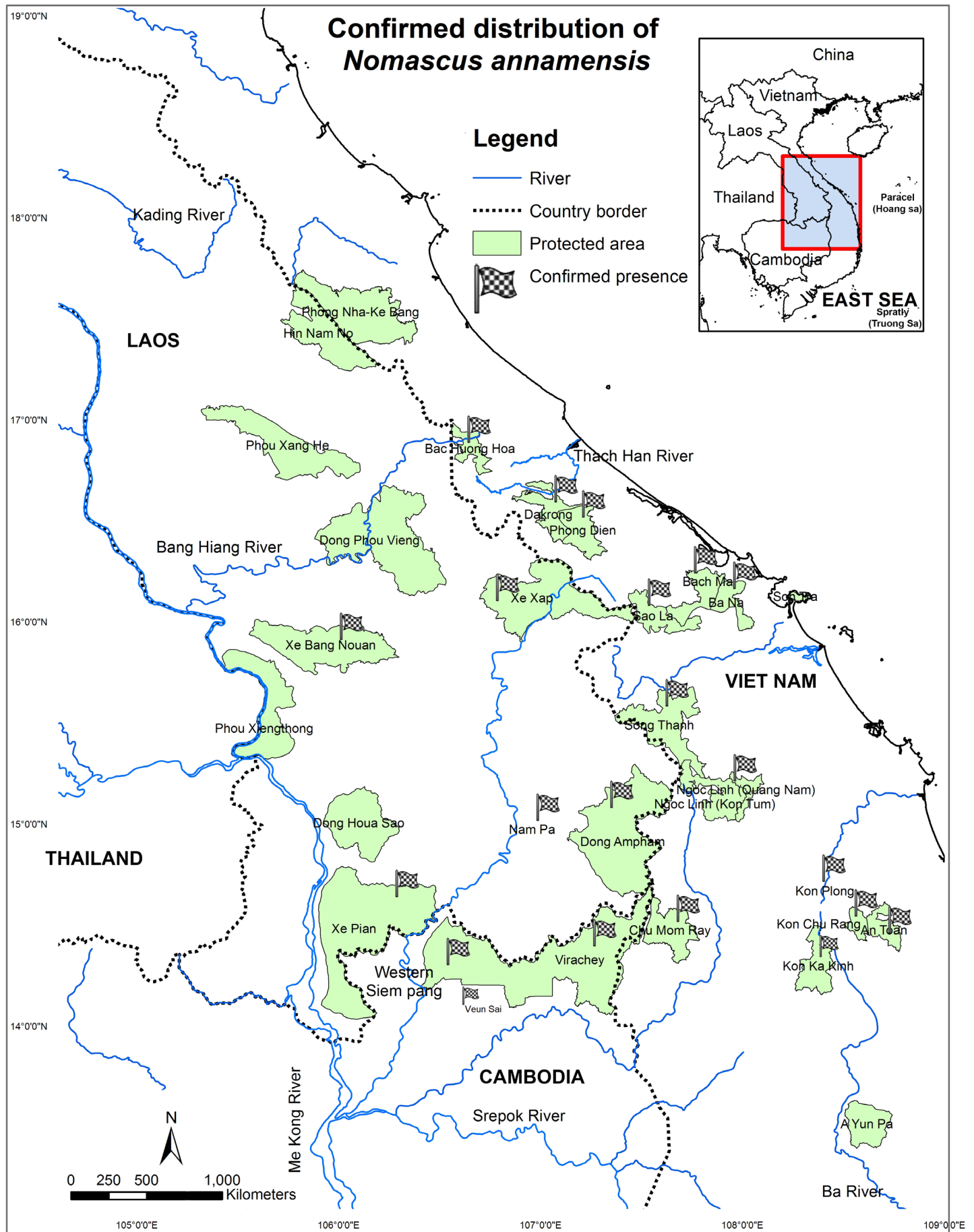


Figure 1. Confirmed presence of *N. annamensis* noted in Table 1, highlighting protected areas in central Indochina (Cambodia, Laos and Vietnam).

Table 1a. Compilation of distribution records of *N. annamensis* in Cambodia and Laos.

Location	No. of groups detected	Estimate of population size	Notes
CAMBODIA			
Veun Sai forest, Ratanakiri Province	At least 77 groups were detected (not including solo males) (Kidney <i>et al.</i> 2016).	Population of about 456 groups (95% CI: 421–490); approximately 1600 individuals (Rawson <i>et al.</i> 2012).	Coverage survey using auditory techniques; population estimated for the whole area (Rawson <i>et al.</i> 2012).
Virachey National Park, Ratanakiri Province and Stung Treng Province	71 groups detected (Traeholt <i>et al.</i> 2005).	2.21 group/km ² , crude population estimate of 5,750 groups.	Auditory survey recorded from five locations inside the national park (three listening posts in each location). The total population is a crude estimate (2.21 group/km ² in 2,600 km ² of suitable habitat).
LAOS			
Xe Pian National Protected Area, Champasak Province	At least five groups have been detected (Phaphothong pers. comm.).	Crude population estimate of 400–6,720 groups (Duckworth <i>et al.</i> 1995).	Intensive wildlife surveys in 1992–1993 found gibbons in high densities across 1,500 km ² of the national protected area. However, surveys in 2000, 2001, 2006 suggested that the gibbons persist in smaller numbers (Duckworth 2008).
Xe Sap National Protected Area, Saravan Province and Xe Kong Province	26–29 gibbon groups recorded (Gray <i>et al.</i> 2013).	NA	Gibbons heard in all 12 camp sites to the west and east of the national protected area during a mammal and bird survey from May–June 2012.
Dong Ampham National Protected Area, Attapeu and Xekong provinces	In 2008, over 10 groups heard around Xe Kaman dam, inside the national protected area (verbal report cited in Duckworth 2008).	NA	Although no recent gibbon population survey in the area, the national protected area is relatively remote and has significant natural terrain-based protection. Vocal analysis suggested the species' presence in this national protected area (Ruppell 2010). Dong Ampham is listed as a Priority Conservation Site in Laos' gibbon action plan (Laos, MAF 2011).
Nam Pa Production forest, Attapu Province	About 11 groups recorded (SUFORD 2010).	NA	Auditory survey with only three listening posts in 2010 during a wildlife survey.

Table 1b. Compilation of distribution records of *N. annamensis* in Vietnam.

Location	No. of groups detected	Estimate of population size	Notes
Bac Huong Hoa Nature Reserve, Quang Tri Province	At least 10 groups in this nature reserve (Nguyen Van Thien <i>et al.</i> 2017).	NA	Auditory survey, as part of survey effort to confirm the presence of <i>N. annamensis</i> in Vietnam.
Dakrong Nature Reserve, Quang Tri Province	At least 56 groups detected (Nguyen Quang Hoa Anh <i>et al.</i> 2010).	0.591 groups/km ² , crude estimate for the border areas between Dakrong and Phong Dien nature reserves, where 46 gibbon groups were detected in 77.9 km ² .	Intensive surveys in 2010 (including transects and listening posts) in 77.9 km ² located in the border areas between Dakrong and Phong Dien nature reserves detected 20 groups in Dakrong Nature Reserve and 26 groups in Phong Dien Nature Reserve. The number reported here for the two nature reserves is a combination from this survey and previous surveys (Nguyen Manh Ha 2007; Van Ngoc Think <i>et al.</i> 2007; Nguyen Quang Hoa Anh <i>et al.</i> 2010).
Phong Dien Nature Reserve, Thua Thien Hue Province	Total of 26 groups confirmed (Nguyen Quang Hoa Anh <i>et al.</i> 2010).		
Bach Ma National Park, Thua Thien Hue Province	8 groups recorded in 2001 (Geissmann <i>et al.</i> 2007), 13 groups detected between 2009 and 2012 (Nguyen Van Thien <i>et al.</i> 2017).	1.3 groups/km ² (Geissmann <i>et al.</i> 2007).	Geissmann <i>et al.</i> (2007), conducted in 6 km ² of the NP. The density was a crude estimate (8 groups/6 km ² = 1.3 groups/km ²)

Other areas in Thua Thien Hue Province	20 groups in A Luoi, 13 groups in Nam Dong, 9 groups in Phu Loc, 2 groups in Huang Thuy District and eight groups in Hue Sao La Nature Reserve (Nguyen Quang Hoa Anh <i>et al.</i> 2010).	NA	Data combined from different surveys, coverage survey is incomplete.
Ba Na – Nui Chua Nature Reserve, Da Nang City	13 groups recorded (Bui Van Tuan <i>et al.</i> in press).	NA	Survey in small part of the nature reserve (Song Bac and Song Nam area) during primate taxa surveys in 2016.
Song Thanh Nature Reserve, Quang Nam Province	17–18 groups recorded (Minh Hoang <i>et al.</i> 2005).	NA	Auditory survey in parts of nature reserves, as part of a primate conservation program in Quang Nam province.
Ngoc Linh Nature Reserve, Quang Nam Province	13 groups recorded (Minh Hoang <i>et al.</i> 2005).	NA	
Ba To district, Quang Ngai Province	29 groups detected (Hoang Minh Duc <i>et al.</i> 2016).	66 groups estimated (CI 95%: 42–91).	Auditory survey.
An Toan Nature Reserve, Quang Ngai Province	17 groups detected (Hoang Minh Duc <i>et al.</i> 2016).	33 groups estimated (CI 95%: 30–38).	Auditory survey.
Chu Mom Ray National Park, Kon Tum Province	14 groups detected (Vu Ngoc Thanh <i>et al.</i> 2007).	54 individuals estimated.	Auditory survey that covered only the eastern portion of the national park.
Konplong district, Kon Tum Province	19 groups with 59 individuals have been detected (Trinh Dinh Hoang <i>et al.</i> 2016).	NA	Detected during line transect surveys for grey-shanked doucs, from September 2015 to January 2016. (No listening posts established).
Kon Cha Rang Nature Reserve, Gia Lai Province	13 groups confirmed (Luu Quang Vinh <i>et al.</i> 2010; Vu Tien Thinh and Dong Thanh Hai 2015).	Initial estimate of 20 groups (Luu Quang Vinh <i>et al.</i> 2010), later study estimated 27 groups, density estimate of 0.53 group/km ² (Vu Tien Thinh and Dong Thanh Hai 2015).	Auditory survey with 17 listening posts across the nature reserve. Population estimates were made for the entire reserve. The 2015 research applied weighted correction factor (Vu Tien Thinh and Dong Thanh Hai 2015).
Kon Ka Kinh National Park, Gia Lai Province	Nine groups confirmed (Ha Thang Long <i>et al.</i> 2011).	42 groups estimated, density estimated of 0.12 groups per km ² (Ha Thang Long <i>et al.</i> 2011)	Auditory survey with 18 listening posts across the national park. Population estimates were made for the entire site.
Green corridor between Kon Ka Kinh National Park and Kon Cha Rang Nature Reserve	Four groups recorded (Nguyen Ai Tam <i>et al.</i> 2017).	NA	Recorded during a wildlife survey in 2016.

corridors and/or forests outside the protected area system is sparse, although we believe gibbons might persist in these areas. Recent wildlife surveys in the corridor between Kon Ka Kinh National Park and Kon Cha Rang Nature Reserve detected four gibbon groups (Nguyen Ai Tam *et al.* 2017). The presence of gibbons in these green corridors throughout Vietnam should be investigated for the long-term conservation of wildlife in this country.

Methods for estimating population size for gibbon populations is not standardized, compromising the accuracy and comparability of the various survey results. The results are difficult to compare across studies because of the different methods used. Gibbons can be detected through their early morning vocalizations, and some surveys have made good

use of this (Vu Tien Thinh and Rawson 2011; Vu Tien Thinh and Dong Thanh Hai 2015; Kidney *et al.* 2016). It is, thus, challenging to offer a global assessment of the status of the species and to identify the most important remaining populations. There is an obvious and urgent need to standardize methods for surveying and estimating gibbon populations.

It is unclear whether *N. annamensis* overlaps with other crested gibbon taxa. The northern limit of *N. annamensis* is in doubt. The Thach Han River was supposed to be a natural barrier (Van Ngoc Thinh *et al.* 2010a), but recent acoustic surveys confirmed this species in Bac Huong Hoa Nature Reserve, north of this river (Nguyen Van Thien *et al.* 2017). In the south, *N. annamensis* is thought to be separated from *N. gabriellae* by the Ba River (Vietnam) and the Srepok River

(Cambodia). These rivers are separated and run in different directions, however. The Srepok River flows westward into the Mekong River, while the Ba River flows eastward to the East Sea (South China Sea). Gibbons might be able to disperse to the south in the area between these rivers. In addition, the presence of *N. gabriellae* north of the Ba River has been documented based on the analysis of gibbon songs (Tran Van Bang and Hoang Minh Duc 2015). It is unlikely that these rivers fully explain the distribution boundaries and biogeography of *N. annamensis*. We need to understand better the range limits of *N. annamensis* and its neighboring gibbon taxa. Understanding species distributions is of critical importance for any conservation management and policy. Meanwhile, reliable field data on *N. annamensis* is lacking, especially in Cambodia and Laos. Now that we have compiled and reviewed the available data on the presence of *N. annamensis* populations, it is possible to use ecological niche modelling (ENM) (species distribution modeling) to improve our understanding of the potential distribution of this species as well as that of its sister taxa and to suggest likely areas for future field surveys.

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