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Authors: Pachuau, Samuel V., Qureshi, Qamar, Habib, Bilal, and Nijman, Vincent

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Habitat Use and Documentation of a Historic Decline of Western Hoolock Gibbon (*Hoolock hoolock*) in Dampa Tiger Reserve, Mizoram, India

Samuel V. Pachuau[1,2], Qamar Qureshi[2], Bilal Habib[2] and Vincent Nijman[1]

[1]*Department of Anthropology and Geography, Oxford Brookes University, Oxford, UK*
[2]*Wildlife Institute of India, Dehradun, India*

Abstract: The western hoolock gibbon *Hoolock hoolock* is globally threatened because of a combination of habitat loss, fragmentation and hunting. Most remaining populations are isolated and contain few individuals. We studied a small population of western hoolock gibbons in Dampa Tiger Reserve in Mizoram, India, an area with a deep-rooted tradition of hunting wildlife. We quantified differences in 35-ha sites that were used by gibbons (n = 9) with those that were not (n = 6). We found no statistical differences with respect to canopy continuity, distance to the nearest village or levels of habitat disturbance, but were not able to quantify levels of hunting. Interviews with local villagers (n = 53) from seven villages distributed throughout the reserve suggests that gibbon numbers declined progressively from the early 1970s to the present day, possibly from >100 to <50 individuals. Interviewees pointed at the combined result of fire (from, for instance, slash-and-burn cultivation), reduction of the available habitat, and hunting, exacerbated by an increase in the human population, as possible causes. This corresponds well with our analysis of vegetation maps of the reserve based on satellite imagery, that show a decline in suitable habitat from 63% of the reserve in 1978, to 59% in 1989, and 50% in 2005. We strongly recommend a greater emphasis on quantifying the impacts of hunting on the distribution and persistence of hoolock gibbons.

Key words: Disturbance, habitat, hunting, interviews, population numbers, status assessment

Introduction

The western hoolock gibbon (*Hoolock hoolock*) is the westernmost of the 16 species of smaller apes of South-east Asia (Geissmann 2007). Its range is restricted to the monsoon evergreen and semi-evergreen rainforests of north-east India and eastern Bangladesh, south and east of the Brahmaputra River, and north-west Myanmar, west of the Chindwin River (Brockelman *et al.* 2008). East of the Chindwin River it is replaced by its congener, the eastern hoolock gibbon (*H. leuconedys*) (Brockelman and Geissmann 2008). The western hoolock gibbon is predominantly frugivorous (Ahsan 2001; Islam and Feeroz 1992), confined to tall forest with continuous canopies (Choudhury 1991), and is instantly recognized by its loud and characteristic songs. Groups generally comprise an adult pair with their (dependent) offspring. Average group sizes are between three and four individuals (Das *et al*. 2009). The combined effects of habitat loss, fragmentation (especially in India driven partially by slash-and-burn or '*jhum*' cultivation) and hunting (for food and because of alleged medicinal properties) have led to the species being categorized as Endangered according to IUCN threat criteria (Brockelman *et al*. 2008). With a population of about 300 individuals in Bangladesh and about 2,500 in India, and an unknown number in Myanmar, the species has been on the of the World's 25 Most Endangered Primates list since 2006 (Walker *et al*. 2009). It is protected throughout its range, and included on Schedule I of the Indian Wildlife (Protection) Act of 1972. It is a protected species in Myanmar through the Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law of 1994, and in Bangladesh it is protected under the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974.

Because of continued destruction of its habitat through commercial logging, fragmentation and degradation, coupled with hunting pressures, most populations of western hoolock gibbons are isolated and small, with about 80% of those assessed in India and Bangladesh harboring fewer than 20 individuals, and over half having fewer than 10 (Walker *et al*. 2007). An important determinant of the populations of

gibbons, or primates in general, in the region is the level and intensity of hunting. Even with a good and intact habitat, gibbons are often absent as hunting leads to direct extermination of individuals. In the range of the western hoolock gibbon, the level and intensity of hunting differs from one tribal community to the other and from one region to the next. Even in India, where the majority of the people have a sacred reverence towards primates in general (Lee and Priston 2005), in parts of the country such reverence is absent. This could be attributed to the cultural and religious differences of the different individual tribes inhabiting the different states. We conducted research on western hoolock gibbons in Mizoram State, north-eastern India. Throughout the state the majority of the people have an intricate and deep history of hunting. While national laws prevent them from doing so, the remoteness of the area, and possibly lack of awareness, results in less than optimal enforcement of these non-hunting laws (see Gupta and Sharma 2005).

We set out to study the responses of western hoolock gibbons towards various disturbances in terms of their habitat use in the westernmost part of Mizoram State. We took the opportunity to make an attempt to retrace the population decline by prompting tribal villagers to recount population size. We show that structural measurements of the forest and distance to human habituation do not adequately explain the presence or absence of gibbons in different parts of the reserve, and report that the decline of gibbons as experienced by the tribal villagers does correspond well with the observed decline in gibbon habitat.

Study Area

The Dampa Tiger Reserve (23°20' to 23°47'N and 92°15' to 92°30'E) in western Mizoram was chosen as the study area after a preliminary investigation on the protected areas of Mizoram (Raman *et al*. 1998; Gupta and Sharma 2005). The main considerations were that this reserve has a mosaic of habitats with varying degrees of anthropogenic influence, from open *jhum* fallow lands to primary undisturbed forests, resulting in a high degree of forest fragmentation (Fig. 1). The 500-km² reserve was notified as a sanctuary in 1985 and subsequently afforded a Tiger Reserve status in 1994. Its westernmost border follows the Khawthlangtuipui River, which forms the international border with Bangladesh. The reserve covers mountainous terrain with elevations from 250 to 1100 m above sea level. Situated on the Tropic of Cancer, Dampa experiences a seasonal climate with relatively mild winters (December to February, average temperature of 15°C), a warm summer and a distinct rainy season from May to October.

The area is covered in tropical evergreen and semi-evergreen forests, as well as tropical moist deciduous forests, and at higher elevations, above 700 m above sea level, sub-montane forests. The low, moist valleys have evergreen vegetation characterized by species like *Michelia champaca*, *Dipterocarpus turbinatus*, and *Terminalia chebula*. The higher slopes are characterized by species such as *Castanopsis indica*, *Schima wallichii*, *Mesua ferrea* and occasionally *Quercus* sp. On the steep western slopes the forest is more open with many deciduous species (for example, *Lannea coromandelica*, *Sterculia villosa* and *Gmelina arborea*) and large patches of *Dendrocalamus longispathus* bamboo, and expanses of open grassland on rocky surfaces on the highest slopes. Dampa's natural vegetation thus contains a cross-section of habitats from grasslands, successional habitats, and open forests to dense, lofty, primary evergreen forest.

The reserve provides a habitat for several endangered species such as tiger (*Panthera tigris*), clouded leopard (*Neofelis nebulosa*) and Asiatic elephant (*Elephus maximus*). It is especially rich in primates with, apart from the western hoolock gibbon, capped langurs (*Trachypithecus pileatus*), Phayre's langur (*T. phayrei*), rhesus macaque (*Macaca mulatta*), Assamese macaque (*M. assamensis*), northern pig-tailed macaque (*M. leonina*), stump-tailed macaque (*M. arctoides*), and Bengal slow loris (*Nycticebus bengalensis*).

Methods

Habitat use

The senior author, with the aid of two assistants, worked in the reserve from 10 December 2010 until 7 May 2011. It was not possible to visit the south-western parts of the reserve as logistical and linguistic reasons prevented us from working closer to the Bangladesh border. We set up 35-ha plots in 15 locations (35 ha is approximately the home range size of western hoolock gibbons: Feeroz and Islam 1992) to assess the presence of gibbons, and measure vegetation. Each plot was surveyed for five days, for a median duration of 18.8 hrs (interquartile range (IQR) 17.7–19.7 hrs) and covering 19.9 km (19.3–20.3 km). We established whether or not gibbons were present, and if so, their group sizes and composition. In each plot we estimated the canopy continuity (as a percentage) and, using a handheld GPS, the distance from the plot to the nearest village. We quantified disturbance by assessing the presence of trails (none or a single trail was scored as 0, multiple trails, up to 7, scored as 1), presence of cut tree stumps (absent 0, present 1), traces of non-timber forest collection (absent 0, present 1), presence of forest camps (absent 0, present 1), presence of *jhum* (absent 0, present adjacent to the plot 1). These were summed to arrive at a disturbance level score (from 0 to 5). We compare plot characteristics (canopy continuity, distance to village and disturbance levels) between plots with and without gibbons. We use non-parametric statistics, reporting medians and interquartile ranges (IQR), and accepting significance when $P<0.05$ in a two-tailed test (Siegel 1956).

Historic decline

We conducted village interviews in two forest management ranges—Teirei on the western and northern side (three villages: Teirei, Damparengpui, Tuipuibari) and Phuldungsei in the south-east (four villages: Phuldungsei, Lallen, Saithah,

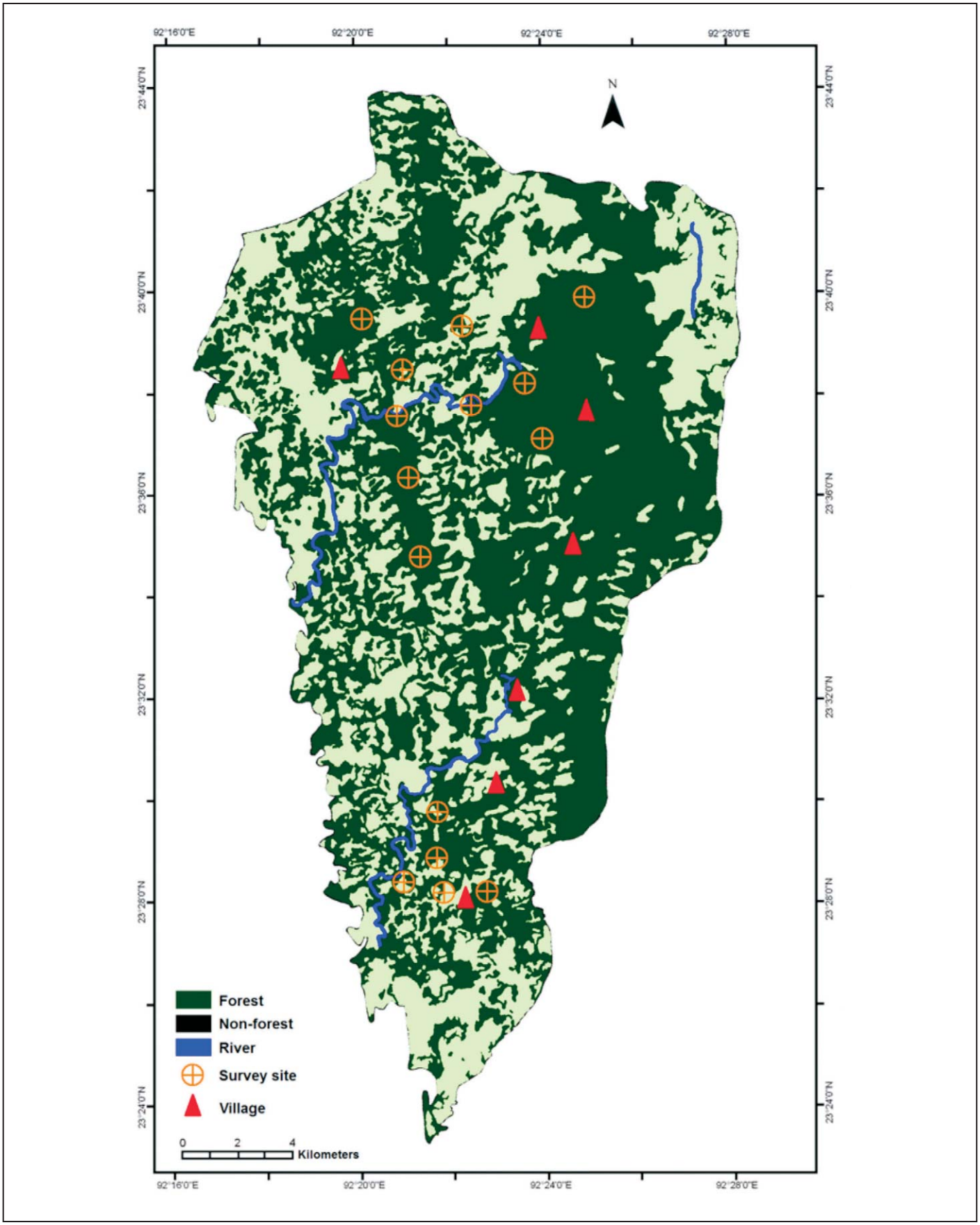

Figure 1. Dampa Tiger Reserve, in western Mizoram, India, showing habitat types suitable for gibbons (closed evergreen and semi-evergreen forest, open evergreen and semi-evergreen forest, closed and open moist deciduous forest) in dark green, habitats unsuitable for gibbons (bamboo, shrub forest, current and abandoned *jhum*, and villages) in pale green, and the survey sites (circles for gibbon surveys and triangles for village surveys). Modified from satellite imagery provided by the Mizoram Remote Sensing Application Centre.

and Kawnmawi)—with the aim of establishing changes in gibbon abundance over time (for locations of the villages inside the reserve see Figure 1). In Teirei, the villagers belong to the Bru tribe whereas in Phuldungsei they were Mizo. We focused on the elder villagers with, by their own account, a good knowledge of the forest and its fauna, resulting in a clear bias towards males. In both ranges a similar number of interviewees were selected with similar ratios of men to women, and of a similar age (Teirei, 25 men and one woman, median age 56 years; Phuldungsei: 23 men and four women, median age 55 years). Interviews were conducted in the Mizo language (Phuldungsei and parts of Teirei) by the senior author, or, with the aid of an assistant, in the Bru language (parts of Teirei). Each interview was conducted in the interviewee's house, and to ensure independence, each interviewee was questioned separately (Lammertink *et al.* 2003).

We asked interviewees about their perception of the population sizes of gibbons within their management ranges, in three predefined classes: >100, between 50 and 100, and <50, in three time periods. As the most distant time period we selected the late 1960s to early 1970, this being defined (and remembered by most interviewees) by a period of civil unrest (*Buai Kum*); the second time period covered the mid-1970s to the mid-1990s, defined as the period after the civil unrest but prior to the declaration of the area as a Tiger Reserve in 1994; the third time period was the present, defined as 2011 or one or two years prior. Interviewees born between 1966 and 1980 were only asked about possible changes between the latter two time periods.

We obtained detailed vegetation maps of the study area prepared by North Eastern Space Applications Centre (NESAC), Meghalaya and Mizoram Remote Sensing Application Centre (MRSAC), Mizoram, based on satellite images from the years 1978, 1989, and 2005 (MRSAC 2008). The satellite images covered over 80% of the reserve (416 km² of about 500 km²), including all of the regions we worked in. For analysis we distinguished all forest types used by gibbons into two major categories: Closed Evergreen/Semi-Evergreen Forest, Open Evergreen/Semi-Evergreen Forest, Closed Moist Deciduous Forest and Open Moist Deciduous Forest as *Forest* (habitable by gibbons) and deforested and regenerating forest in early stages of succession (Forest Blank; Scrub Forest), slash-and-burn agriculture (Current *Jhum*; Abandoned *Jhum*), bamboo patches (Bamboo) and Villages as *Non-Forest* (Inhabitable by gibbons)

Results

Habitat use

We found nine groups of gibbons, with a median group size of 3 (range 2–4), with no more than one group present in each of the plots. Each group contained one adult male, one adult female, and up to two young and the total number of gibbons we recorded was 31. There was a clear relationship between the distance from the plot to the nearest village and canopy continuity (Kendall's T = 0.44, n = 15, P<0.05) and disturbance level (T = 0.60, n = 15, P<0.005) as well as between canopy continuity and disturbance level (T = 0.85, P<0.001): plots at greater distances from villages had more continuous canopies and significantly less signs of human disturbance.

While most of the gibbons were found in what appeared to be 'good' forest, there was no significant difference between plots with or without gibbons in terms of nearest distance to the village (gibbons present: median distance 4.0 km (IQR 3.0–4.5 km, n = 9), gibbons absent: median distance 3.3 km (IQR 3.0–3.5 km, n = 6; Mann Whitney U, P = 0.33), canopy continuity (gibbons present: median canopy continuity 80% (IQR 70–90%, n = 9), gibbons absent: median canopy continuity 68% (IQR 60–70%, n = 6; Mann Whitney U, P = 0.27) or disturbance levels (gibbons present: median disturbance level score 2 (IQR 0–4, n = 9), gibbons absent: median disturbance level score 4 (IQR 2–5, n = 6; Mann Whitney U, P = 0.34).

Historic decline of gibbons and their habitat

The perceived change in abundance of gibbons was very similar in the two forest ranges. Referring to the period of civil unrest in the late 1960s and early 1970s, in Teirei 20 out of 24 and in Phuldungsei 18 out of 19 of the elder interviewees thought the population of gibbons in their area was larger than 100 individuals, with the remaining five estimating it at somewhere between 50 and 100 individuals. For the period after the civil unrest but prior to gazettement as a Tiger Reserve all interviewees were unanimous in their belief that the population was somewhere between 50 and 100 individuals. In Teirei eight and in Phuldungsei nine interviewees considered the present population to number between 50 and 100 individuals, but the remaining interviewees all were of the opinion that there were less than 50 gibbons in their part of the reserve. While the majority of interviewees agree that the population of gibbons in Dampa had declined, in four of the villages at least half of the interviewees were of the opinion that the population size had stabilized since gazettement as a Tiger Reserve in 1994.

Regarding the time period during which the decline took place, more interviewees pointed at a decline prior to gazettement of the area as a Tiger Reserve than after, with however, the majority of interviewees indicating a continuous decline (Table 1). No clear pattern emerged with respect to the spatial distribution of the decline with, for instance, no apparent differences between reports from villages in the two forest ranges (western and northern vs. south-east). While few interviewees were able to identify a single cause for the decline of gibbons in the reserve, the overall consensus was this was the combined result of fire (from *jhum* cultivation or other causes), reduction of the available habitat, and hunting, exacerbated by an increase in the human population.

The perceived decline of the gibbon population by the villagers living in the different parts of Dampa Tiger Reserve matched well with the recorded decline in gibbon habitat as

Table 1. Perceived changes in population sizes of hoolock gibbons (*Hoolock hoolock*) in seven villages in two forest ranges in Dampa Tiger Reserve (gazetted in 1994) between the late 1960s to the present. "Elder interviewees" were those born before 1965, and "All interviewees" included 10 interviewees born between 1966 and 1980.

Forest range	Village	Elder interviewees (43)		All interviewees (53)	
	(Elder, all)	Continuing decline	Early decline (<1996)	Late decline (>1996)	Stable since gazettement
Teirei	Teirei (7, 7)	57	0	43	0
	Tuipuibari (10, 10)	40	50	10	50
	Damparengpui (7, 10)	85	15	0	30
Phuldungsei	Phuldungsei (7, 9)	85	0	33	0
	Kawnmawi (6, 6)	33	67	0	67
	Lallen (2, 6)	100	0	33	33
	Saithah (4, 6)	25	75	33	50

calculated from the vegetation maps. The extent of forest used by gibbons decreased from 63% of the mapped parts of the reserve in 1978 to 59% in 1989 to 50% in 2005.

Discussion

We recorded nine groups of western hoolock gibbons, totaling 31 individuals, in different sections of the Dampa Tiger Reserve. The only other population estimates available for the reserve were provided by Gupta and Sharma (2005) who, based on a 15-day survey mostly in the Teirei forest range, estimated Dampa to contain 10 groups, and by Molur *et al*. (2005) who estimated 20 individuals (about six groups) to be present. However, judging from Figure 1, which shows the combined total habitat available for gibbons in the reserve, and taking into account the extent of forest we actually managed to survey, we consider it more than likely that additional groups occur there. We expect the largest number of undetected groups to be present in the westernmost part of the reserve, close to the border with Bangladesh, as there the forest fragments are amongst the most remote and are not accessible by road.

We found no clear differences in terms of canopy continuity, distance to the nearest village or habitat disturbance levels between plots with and without gibbons. Indeed, while some of the groups inhabited some of the best forests in the reserve, others were found in the more disturbed sections, and conversely, we failed to detect gibbons in one part of the reserve where the forest appeared to be perfectly suitable for gibbons. We find this pattern consistent with a reduction in numbers (and local extinction) of gibbons due to habitat loss but especially hunting (either current or in the recent past).

We found a high degree of concordance between the decline in gibbon habitat recorded through satellite imagery (from 63% suitable for gibbons in 1978 to 50% in 2005, in a more or less linear fashion) and the decline in gibbon numbers as recalled by tribal villagers. Soliciting information from villagers can lead to a better understanding of the attitudes and perceptions of people towards biodiversity conservation including complex issues researchers may miss when conducting an ecological study. When interpreted with care, interview data can provide good insights regarding the (local) status of threatened primates (Parker *et al.* 2008; Meijaard *et al*. 2011). Our approach was a general one, without giving precise time periods but referring to key events (civil unrest, establishment of the area as a Tiger Reserve) instead. Nor did we force interviewees to estimate numbers they have no ability or authority to estimate (see Asquith 2001). We purposely laid a greater emphasis on the elder villagers, as they indeed have experienced the decline first-hand, and by targeting seven villages from distinctly different parts of the reserve, we managed to capture the spatial component of the decline as well. A general consensus emerged that several decades ago, gibbons numbered over one-hundred individuals after which they experienced a decline that was either progressive until the present day, or that may have ceased with the gazettement of the areas as a reserve. All interviewees agreed that at present the total gibbon population is less than 50 individuals. While this may be more a reflection of the gibbon population in the part of the reserve they were familiar with than true gibbon numbers, they do in fact match well with findings of the present study and that of Gupta and Sharma (2005). While local traditions of hunting and *jhum* cultivation are slowly fading, pressures in this regard are still felt especially from the southern parts of the reserve and from across the Bangladesh border. One of the positive outcomes of our study is that gibbons in Dampa are indeed able to persist outside the most pristine sections, and that a large number of villagers felt that the decline of western hoolock gibbons had ceased since the gazettement of the area as a reserve.

Based on our study, we argue that future work with western and eastern hoolock gibbons needs to be interdisciplinary, focusing not only on the biology of the gibbons, but also addressing human-wildlife interactions, understanding the dependency of people on forests, and trying to charter conservation objectives. We do need more quantitative data on the dynamics of human disturbances, in particular hunting, as this may be fundamental to understanding the current distribution patterns and explaining the local extinction of gibbons in the region. In the absence of these data, we would argue against relying too much on community-based forest preservation initiatives as opposed to strict nature reserves, as here it is more challenging to control hunting.

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Authors' addresses:

Samuel V. Pachuau, H/No M-67, Armed Veng, Aizawl-796007, Mizoram, India, and Department of Anthropology and Geography, Oxford Brookes University, Oxford OX3 0BP, UK. E-mail: <Sam_vlg16@yahoo.co.in>, **Qamar Qureshi**, Department of Landscape Level Planning and Management, Wildlife Institute of India, Dehradun-248001, Uttarakhand, India, E-mail: <qnq@wii.gov.in>, **Bilal Habib**, Department of Animal Ecology and Conservation Biology, Wildlife Institute of India, Dehradun-248001, Uttarakhand, India. E-mail: <bh@wii.gov.in>, and **Vincent Nijman**, Department of Anthropology and Geography, Oxford Brookes University, Oxford OX3 0BP, UK. E-mail: <vnijman@brookes.ac.uk> (corresponding author).

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