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Ecology and Conservation of the Golden Langur, *Trachypithecus geei*, in Assam, India

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Abstract: The aim of this study was to understand plasticity and resilience in the behavioral ecology of one of India's most endangered primates, the golden langur (*Trachypithecus geei*) inhabiting forest reserves in Assam. Our survey revealed that golden langur populations in Assam are isolated; restricted to just pockets of suitable habitat. Their forests face severe human pressure mainly due to illegal logging, hunting, and widespread invasion for both commercial interests and by displaced refugees. An extensive survey using a stratified random walk transect method estimated a total population of 943 individuals living in 96 groups. About 40% of the langurs recorded were immature and the average group size was 9.8. Adult sex ratio was 1.5 to 5.0 adult female for each adult male. Four groups inhabiting forests with varying degree of disturbance were monitored using focal animal sampling for 1,728 hours during 12 months. Records on activity budgets, food and feeding behavior, and reproductive and ecological profiles indicated significant differences between them, attributed to differences in habitat quality. Small groups, isolation, proportionately few infants and juveniles, and habitats of increasingly poor quality are all parameters suggesting further decline in the golden langur population of the region. Conservation initiatives focusing on research, education, and community participation are show considerable success.

Key Words: Primates, northeast India, conservation, golden langur, demography, habitat quality, population ecology, community participation

Introduction

The golden langur, *Trachypithecus geei*, discovered in 1954, is known to occur in India between the River Sankosh in the west and the River Manas in the east, and from the Assam-Bhutan border foothills in the south to the inner Himalayan range in the north. Gee (1956) and Khajuria (1956, 1962), provided the first information on its morphology and distribution. Although described in the genus *Trachypithecus*, the golden langur has also been ascribed to the genus *Presbytis* (e.g., Mukherjee and Saha 1974; Roonwal and Mohnot 1977; Mukherjee 1978; Napier and Napier 1985) as well as *Semnopithecus* (e.g., Brandon-Jones 1984; Corbet and Hill 1992). It is a member of the capped langur, *T. pileatus*, group, and Corbet and Hill (1992) and Groves (1993) have suggested it might

even be best considered a subspecies of *T. pileatus*, although this has not been substantiated. Brandon-Jones *et al.* (2004) and Groves (2005) listed it as a full species distinct from *T. pileatus*.¹

There have been a number of surveys to establish the range and population status of golden langurs in India and Bhutan (Gee 1961; Wayre 1968; Mukherjee and Saha 1974; Mukherjee 1978; Subba 1989; Choudhury 1992; Wangchuk 1995). Although providing considerable data concerning their geographic distribution and many aspects of their behavior, none were systematic in their approach, and are limited as such in the sort of information required for their conservation. *Trachypithecus geei* has the highest legal protection under the Indian Wildlife Protection Act (1972) [now called the Wildlife (Protection) Amendment Act 2002], being listed in Sched-

¹ Although *T. geei* was first intentionally described by Khajuria (1956), Corbet and Hill (1992) recorded that it was inadvertently described earlier by Gee (1956), although Brandon-Jones *et al.* (2004) argued that the nature of Gee's description made it unavailable, and that Ali and Santapau, then editors of the *Journal of the Bombay Natural History Society*, who mentioned the name in the issue with Gee's article, were the true, if equally inadvertent, authors of the species group name. Groves (2005) ascribes authorship to Khajuria (1956).

ule I, which prohibits killing, trapping, capturing, and keeping them as pets (Srivastava 1999). Under the auspices of the Indo-U.S. Primate Project, Srivastava *et al.* (2001b) surveyed the entire known range of the species in western Assam. Their findings indicated declining populations. As a next phase of that study we collected data to examine the nature of the population changes and change in habitat quality. We also monitored focal populations inhabiting different habitats with varying degrees of disturbance to understand the long-term consequences on behavioral ecology and survival, which are essential for conservation management. Results on population and habitat change are presented here.

Methods

The conservation program for the golden langur had three components: research, education, and community participation. The survey and research were conducted in three stages: an extensive survey, an intensive survey, and the collection of long-term ecological and behavioral data from two populations, one of which we considered undisturbed (Koilamoila: Manas Reserve Forest) and the other under pressure from

human activities (Lalbithi: Chirrang Reserve Forest). As part of our community participation program we established a nongovernmental organization and self-help group, promoting community education and reforestation to ensure the survival of golden langurs and their habitat.

Extensive survey

The extensive survey was conducted to obtain a general picture of the status and distribution of the species and the rate of change in their populations. A survey carried out by the Indo-U.S. Primate Project in 1997 (Srivastava *et al.* 2001b) was used as a baseline, and we revisited the same transects during September–October 2001, using essentially the same methodology for vegetation assessment and age-sex classification. Additional surveys were conducted between November 2002 and March 2003, and in February 2004, in the areas that we were unable to survey in 2001. A team of four to seven people walked in the Manas National Park and the Ripu, Chirrang, and Manas reserve forests, covering more than 100,000 ha of forests. A stratified-random transect method was used (NRC 1981; Srivastava *et al.* 2001b). All observers were trained and performed a reliability test before undertaking

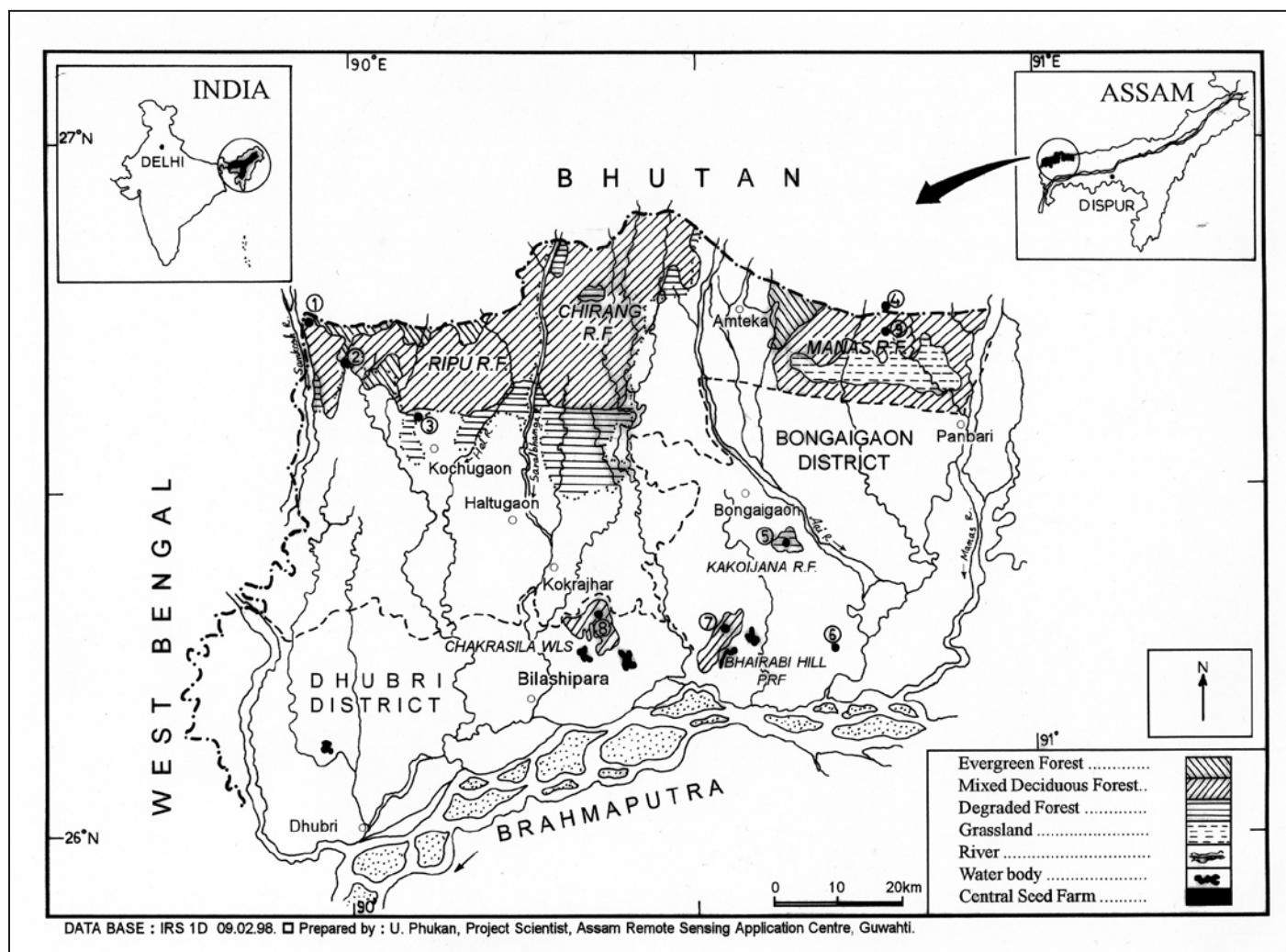


Figure 1. Distribution of golden langurs, and vegetation profile of their habitat in western Assam, India.

the survey. When primates were encountered, the observers recorded as much demographic data as possible, along with data on habitat.

Intensive survey

Two sites were selected following the initial survey, one at Manas Reserve Forest and the other in the Chirrang Reserve Forest, for intensive surveys in order to obtain complete counts for age-sex composition data on as many groups as possible. Two permanent, 4–5 km transects were prepared—one each in the different habitats of the Chirrang and Manas reserve forests—were monitored by four observers each month to record seasonal changes in demography. These transects were repeated six times each month ($n = 144$; total transects = 12 months \times 6 each month \times 2 habitats) to locate focal groups ($n = 19$) and record the demographic details.

Study sites

The Koilamaila study site in the Manas Reserve Forest (349.6 km²), and Lalbithi study site of Chirrang Reserve Forest (592.54 km²) are in the Aie Velley and Kachogaon forest divisions, respectively, near the town of Bongaigaon, Assam. These areas were first notified as reserve forests on 27 August 1881. The area was declared a World Heritage Site by UNESCO in 1985, and notified officially by the central government of India in 1999 (Fig. 1). The area has high degree of biodiversity because it is located between the Indian, Ethiopian, and Indochinese biogeographic regions. The habitat is tropical and subtropical evergreen to semievergreen forest, and tropical moist deciduous *Shorea robusta*-type forest. The dominant tree species are *Mesua ferrea*, *Castanopsis indica*, *Terminalia belerica*, *Sapium bacatu*, *Artocarpus chaplasi*, *Dillenia indica* and *Sterculia vilosa* (Champion and Seth 1968; Kanjilal 1997; Srivastava 1999). Height relative to ground classifies the forest biotope as ground cover, lower canopy (5–10 m), middle canopy (10–15 m), and top canopy (15–20 m and above). The annual temperature range is 15–35°C and the minimum and maximum annual rainfall are 1,200 mm and 4,000 mm, respectively, with an average relative humidity of 83%.

Habitat evaluation

At each location where primates were encountered and at 500-m intervals, habitat parameters were measured in 10-m-radius circular plots. A total of 514 plots were recorded. Due to the varying numbers of animals encountered, our sample size varied for each reserve forest; Ripu Reserve Forest ($n = 292$), Chirrang Reserve Forest ($n = 88$), Manas Reserve Forest ($n = 74$) and Manas National Park ($n = 60$). The canopy cover was recorded as the percentage of total canopy volume using the following scale: No canopy cover, 1–20%, 21–50%, 51–75%, and more than 75%. Canopy height; ground cover; dominant tree, shrub, herb species; and phenological states were recorded at 500-m intervals on each transect walked. The degree of encroachment by humans cultivating land within the forest, and estimates of

forest quality were recorded, as was any evidence of grazing or logging. Comparative assessments of habitat change were made by direct observation and as reported by the Forest Survey of India (India, Forest Survey of India 2003) using satellite images.

Twelve Modified Wittaker plots (Stohlgren *et al.* 1995) were established and monitored every month on predetermined dates (2–3 days). A total of 1,090 trees from 112 species (at least six trees of more than 20 cm girth at breast height from each species) were numbered and measured for their height, diameter at breast height, crown width, and crown density. We also established a variable line transect of 2 km and monitored it for three days every month to record the vegetation and the langur groups we saw there. Each marked tree was enumerated for different plant parts: leaf buds, young leaves, mature leaves, flower buds, flowers, unripe fruit, ripe fruit, and seeds (also see Kent and Coker 1994). The abundance of a given plant part was recorded as the proportion of total canopy volume using a 0 to 3 scale, referring to the value 1–25%, 26–50%, 50–75%, and more than 75%, respectively.

Results

Distribution

Fifty-four transects of approximately 4 to 12 km (total 410 km) were surveyed in the Ripu, Chirrang, and Manas reserve forests. An additional 28 km of transects were surveyed in Manas National Park. All animals located were in the three reserve forests named and in the western part of Manas National Park (Fig. 1). Golden langurs were not encountered in Manas National Park east of the River Manas. Our survey confirmed that golden langurs are not found outside their known ranges between the three rivers (Sankosh, Manas, and Brahmaputra) as was reported earlier by Gee (1956).

Group size and composition

A total of 943 individuals in 96 groups were recorded during the census. Of these, 567 were adults, indicating that about 40% of the animals located were immature. Group size and composition, and the populations in the three reserved forests and Manas National Park are presented in Table 1. The smallest group contained four individuals and the largest 19, with an average group size of 9.8. Of 943 individuals, 157 (16%) were adult males, 332 (35%) were adult females, 78 (9%) were unsexed adults, 376 (40%) were immature (202 juveniles and 174 infants), and the remaining individuals were not assigned any age and sex category. The adult sex ratio was 2.1 females per male (range, 1.5–5.0). The majority of groups had one adult male. We also encountered an all-male group with males of all age classes in Manas National Park. The composition of 11 groups in the Chirrang Reserved Forest and eight groups in the Manas Reserved Forest monitored on a monthly basis is shown in Table 2. The birth rate varied significantly with 0.43/female (Manas Reserve Forest) and 0.27/female (Chirrang Reserve Forest).

Population density

Golden langur group and individual densities were estimated from transect data for each reserve separately and compared with the information provided by Srivastava *et al.* (2001b) (Table 3). The greatest number of groups and individuals/km² were found in Chirrang Reserve Forest, and the lowest numbers were in Manas National Park. A negative relationship between group density and habitat quality as a simple measure of percentage of canopy cover (Tables 4 and 5) is evident, except in the Ripu Reserve Forest. This is also true when individual density is compared, again except for the Ripu Reserve Forest. This suggests that as the quality of habitat deteriorates, the number of groups and individuals increases. These findings are also true when data obtained from satellite images are used (Table 5, Data Source: IRS-1C & 1D LISS III; India, Forest Survey of India 2003).

Habitat quality

The political unrest in the area between the late 1980s and late 1990s has led to the present day deforestation crisis and all the reserve forests suffered from the so-called *tragedy of the commons*. Although commercial logging was banned by an interim order of the Supreme Court of India in the late 1990s, illegal encroachment and woodcutting using hand tools have severely affected these forests reserves (Srivastava *et al.* 2001b). Areas that were classified as dense forest during the 1997 survey were recorded with no canopy

cover or severe loss of canopy cover in the present study (for example, certain patches of Ripu Reserve Forest). Data obtained on canopy cover indicated that more than 60% of the area of Ripu Reserve Forest had less than 20% of canopy cover, Chirrang Reserve Forest had 40%, Manas Reserve Forest had 26%, and Manas National Park had 40%. Accordingly, using habitat parameters, logging, and grazing pressure Manas National Park and Manas Reserve Forest, Chirrang Reserve Forest, and Ripu Reserve Forest were classified as undisturbed (or least disturbed, with the highest degree of protection) to the most disturbed, in that order.

An analysis of 12 permanently marked Modified Whitaker plots with 1,090 trees of 112 species showed a plot diversity of 2.5 for undisturbed habitat and 1.9 for the disturbed habitat. The average diameter at breast height for all trees over 10 m was 0.86 m in the undisturbed habitat and 0.78 m in the disturbed habitat. Home range also varied, with 4.3 km² for undisturbed habitat to 1.2 km² for disturbed habitat.

We estimated the available suitable langur habitat for each of the four sites (three reserved forests and a national park) on the basis of habitat parameters (canopy cover, ground cover, average DBH and number of lianas) collected from sample plots independently. Table 5 provides information on the total area of the reserves, total forest cover, canopy cover, and availability of suitable golden langur habitat (for details on total forest cover and canopy cover, definitions, and district boundaries (see India, Forest Survey of India 2003).

Table 1. Group composition, size, and average group size at different locations.

Location	Area (km ²)	Adults			Juveniles	Infants	Total groups	Total	Average group size	Adult sex ratio
		Male	Female	?						
Ripu RF	605	62	142	39	64	69	41	376	9.2	1 : 2.3
Chirrang RF	593	69	106	26	91	65	35	357	10.2	1 : 1.5
Manas RF	350	19	49	10	32	29	14	139	9.9	1 : 2.6
Manas NP	500	7	35	3	15	11	6	71	11.8	1 : 5.0

RF = Reserved Forest, NP = National Park.

Table 2. Age/sex composition of groups monitored every month between November 2001 and December 2002, and September 2003 and February 2004 inhabiting disturbed and undisturbed forests.

Study population	Total groups	Total individuals	Average group size	Adults			Juveniles	Infants
				Male	Female	?		
Chirrang RF (disturbed)	11	119	10.8	19	51	10	26	13
Manas RF (undisturbed)	8	81	10.1	8	25	8	25	15

RF = Reserved Forest.

Table 3. Sample plots, group and individual densities at different locations during 1997¹ and 2001.

Location	Area (km ²)	Sample plots ¹	Density/km ² 1997 ¹		Sample plots	Density/km ² 2001	
			Group	Indiv.		Group	Indiv.
Ripu RF	605	328	6.2	46.5	292	2.8	25.8
Chirrang RF	593	112	7.2	64.3	88	7.9	81.1
Manas RF	350	130	1.8	20.2	74	3.8	37.6
Manas NP	500	120	1.0	8.2	60	2.0	23.7

¹ Data from Srivastava *et al.* (2001b); RF = Reserved Forest, NP = National Park.

Discussion

Golden langurs are land locked between three rivers (Manas, Sankosh, and Brahmaputra) and the Himalayan mountain ranges in the north. There they occupy moist evergreen, dipterocarp, riparian, and moist deciduous forests (Srivastava 1996, 1999). They are able to survive in degraded habitats dominated by secondary growth, and also outside of their natural range in Assam and Tripura (Srivastava 1996; Srivastava *et al.* 2001c; Gupta and Srivastava in press). However, 93% of the entire golden langur population, technically an island population, is confined to these forest reserves that have varying degree of disturbance. We estimate that not more than 1,500 individuals are now left in India. A larger population may exist in Bhutan, estimated at more than 4,340 individuals, but these figures are based on an extrapolation from 58.5 km² of a study area to a hypothetical 2,000 km² area of pristine broadleaf forest in the Black Mountain National Park (Wangchuk 1995). The total known suitable habitat of the golden langur in India is less than 500 km² (Table 5; Srivastava 2006). However, it has become increasingly clear, based on field studies on the different primate species, that they are not uniformly distributed in any given habitat and, rather, occupy pockets of suitable habitats within their range in what seems to us a quite uniform habitat. It is imperative, therefore, to obtain information on suitable habitats for any conservation initiative. Although the Ripu, Chirrang, and Manas reserve forests are important golden langur habitats, human pressures have increased instability and resulted not only in an overall decrease in the amount of suitable habitat, but also in discontinuities in the distribution of the remaining habitat (for example, Ripu Reserve Forest with several small clearings and a larger gap between Manas Reserve Forest and Chirrang Reserve Forest, see also Fig. 1). These findings further suggest that past and widespread golden langur populations are now reduced in size and split into a metapopulation. Habitats that are fragmented suffer increased edge effects, and populations become more vulnerable to adverse environmental conditions such as increased light and temperature or decreased humidity. Although Manas National Park receives the highest protection under the Wildlife (Protection) Amendment Act 2002, it contains only about 20 km² of suitable golden langur habitat for two reasons: the River Manas running through the park

is a barrier, restricting them to the western one-third of the national park, and most of the western part of the park is a grassland and therefore, managed (controlled burning almost every year) for other endemic and endangered species (e.g., pygmy-hog, hispid hare, gaur, water buffalo, tiger, and elephant). Complete protection of the Ripu, Chirrang, and Manas reserve forests is urgent. We believe it is important to upgrade the status and protection of the golden langur habitat, so that the metapopulation can be linked through forest corridors to prevent genetic fragmentation of the various populations.

Brooks *et al.* (2002) in their critical analysis of world Biodiversity Hotspots have shown that the habitat loss has resulted in an extremely large number of threatened species, with the probability of their extinction high in the absence of immediate conservation action. Primates are no exception. In a recent study at Borajan Reserve Forest of Assam, India, Srivastava *et al.* (2001c) demonstrated that forest degradation on a very small scale eroded 60% of a primate population (five species) within a span of four years between 1995 and 1998. Similar conditions are fast developing for these reserve forests with a combination of social disturbance, inadequate forest department resources, and political and population pressure resulting in their rapid degradation. For example, only 70 km² of suitable golden langur habitat remains in the 610 km² of the Ripu Reserve Forest. However, we believe there is still time to act and provide adequate protection, mainly by upgrading the legal status of the reserve forests and planning effective conservation strategies with active community participation and education.

Although the number of groups and individuals sighted did not vary significantly when the number of sightings was adjusted for the number of transects surveys (effort), it shows a declining trend from a total population of 1,064 (130 groups) estimated in the 1997 survey (Srivastava *et al.* 2001b) to 943 (96 groups) in the 2001 survey. The average number of groups sighted per sample plot was similar (0.19 group/sample) for both surveys, but the average number of individuals sighted per sample plot increased slightly from 1.54 individuals/sample in 1997 to 1.83 individuals/sample during 2001. The 2001 survey team obtained information from local residents (mainly from the Bodo community) and as such were possibly facilitating the location of langur groups.

Table 4. Percent of sample plots with indicated levels of canopy cover.

Habitat quality	Ripu RF	Chirrang RF	Manas RF	Manas NP
Number of plots ¹	292	88	74	60
No canopy cover	44.5	25.0	16.2	36.6
Canopy cover 1–20%	19.8	20.5	10.8	16.7
Canopy cover 21–50%	20.1	34.1	33.8	23.3
Canopy cover 51–75%	10.3	13.6	29.7	36.6
Canopy cover >75%	4.5	6.8	9.5	13.3

¹Samples were always taken at 500-m intervals. They were also taken at the point of contact with golden langurs; accordingly the number of sample plots differ from reserve to reserve. RF = Reserve Forest, NP = National Park.

Table 5. Total area, forest condition and habitat quality index (HQI) at different locations.

Protected area	Total km ²	Forested in 2003 ¹	Very dense forest ²	Moderately dense forest ³	Suitable langur habitat ⁴
Ripu RF	605				70
Chirrang RF	593	9165	205	709 ⁵	250
Manas RF	350	300	33	267	150
Manas NP ⁶	500	218	35	183	20

¹India, Forest Survey of India 2003 (Source: IRS-1C & 1D LISS III), ²Canopy cover over 70%. ³Canopy cover between 40–70%. ⁴Estimated from area surveyed and groups sighted. ⁵Ripu and Chirrang reserve forests combined. ⁶Langurs not found east of River Manas. RF = Reserved Forest, NP = National Park.



Figure 2. Golden langur, *Trachypithecus geei*.

Using the 1997 survey, Srivastava *et al.* (2001b) suggested a “sink effect” for the golden langur populations inhabiting these reserves. The populations are restricted to a small area due to the loss of suitable habitat. The authors also demonstrated that populations in undisturbed habitats live in smaller groups with lower population densities, and populations in disturbed habitats live in larger groups with higher densities because food is more clumped and unevenly distributed within the habitat. A similar trend was found in this study, providing further support for the idea that the disturbed habitats will ultimately erode, as in the case of Ripu Reserve Forest. There the individual and group densities were higher during 1997 surveys. The langurs have declined drastically, from 6.2 groups and 46.5 individuals to 2.8 groups and 25.8 individuals per km² in 2001 (Table 3). Srivastava *et al.* (2001b) also suggested that higher densities generate a higher probability of disease and pathogen spread, as in the case of zoo and captive animals. Nevertheless, it is unclear why the group and individual densities have increased for Chirrang and Manas reserve forests, even though the habitats have degraded during this period (for details see Tables 4 and 5). The only explanation we can offer at this time is that the populations have either moved from Ripu Reserve Forest to these

reserves (to the *sink*) or have developed higher growth and fertility rates, responding to isolation and the restricted area available. Understanding how habitat quality affects population processes remains a challenge.

The low population size and group size of the golden langurs are comparable to some of the other critically endangered langurs of the world, such as the golden-headed langur (*Trachypithecus poliocephalus*), Delacour’s langur (*T. delacouri*), and the Tonkin snub-nosed langur (*Rhinopithecus avunculus*) (for review, see Srivastava *et al.* 2001b). The ratio of adults to immatures varies between locations, with half of the population being immature at Koilamoila (Manas Reserve Forest) and only 32% immature in Lalbhati (Chirrang Reserve Forest). This probably reflects different levels of habitat quality and protection. These findings indicate the need to upgrade the Red List categorization of the golden langur to Critically Endangered (IUCN 2006). Although under India’s Wildlife (Protection) Amendment Act of 2002 golden langurs are listed in Schedule I, which prohibits their persecution, hunting, and capture for any reason, sporadic hunting incidences have been reported in the area for meat or for sports.

However, the long-term effects in terms of the nutritional costs on survival and reproduction are not known. The ability of golden langurs to survive on few fast-growing exotic plantation species (Srivastava *et al.* 2001a) and the relative facility with which they can establish themselves in new areas (Gupta and Srivastava, in press) could be used as a management tool to increase the resource base for forest restoration and plantations. The information on staple food plants provided us with the opportunity to prepare a comprehensive reforestation and restoration program. Long-term data on the metapopulation of golden langurs in relation to habitat destruction are needed to estimate demographic rates and shapes of recruitment functions. An assessment of fecal glucocorticoid levels as a measure of environmental stress, interindividual variability of the timing of puberty and corresponding hormonal and behavioral changes will provide vital clues to predict future population trends. Analysis of the nutritional content, secondary components, and toxicity of the plant materials eaten by these langurs will also help underline the effects of habitat change on reproductive success.

Community Participation

Intensive long-term research on the dynamics of ecosystem is necessary to enhance holistic management plans. Research provides the basic data to help prevent and lobby against the uncontrolled destruction and exploitation of natural ecosystems. Nevertheless, we have also learned that baseline research is not enough to conserve any threatened species or its habitat, because human pressures are mounting on all these ecosystems. Participation at all levels is needed to translate the basic research and theoretical solutions into a reality. Our efforts in this regard have shown very encouraging results.



Figure 3. Golden langur, *Trachypitecus geei*.

Establishment of New Horizons

The field researchers and assistants trained to collect systematic ecological and behavioral data during the project were encouraged to form a nongovernmental organization (NGO) to further the goal of community participation in the conservation of golden langurs and their habitats. The move initiated by project researchers Mr. Edison Naezary and Maheswar Moshahary with the help of Mr. Rajen Islari, and Mr. M. Brahma and local community resulted in the formation of *New Horizons*, an NGO dedicated to conserving golden langurs. This group not only initiated a nursery for the propagation of golden langur food plants but also started a massive reforestation program in the Chirrang and Manas Reserve Forest. They also began a self-help group for women to take part in a weaving project. The group was further joined by other five NGOs to be members of the Manas Biosphere Conservation Forum, which is now coordinated by Community Conservation Inc. (Community Conservation 2006).

Education

In order to motivate local communities to participate in our conservation initiatives it was imperative to provide research findings in Bodo, the local language. Educational material in the form of booklets, posters, and leaflet in the regional language were published and distributed free for an awareness campaign. A leaflet, "An Appeal: Save Manas Biosphere Reserve" on helping the Manas Biosphere reserve and what people can do to protect it was produced. This was issued on the occasion of the 47th Wildlife Week of India. Another leaflet, "Save Golden Langurs," was also published. A booklet and a poster highlighting the uniqueness of golden langurs and their status and distribution was printed in Bodo, the language of most of the residents within the reserve forests.

Reforestation program

The reforestation program built on an earlier initiative to establish nurseries at Koylamoila and Lalbiti. A participatory scheme was adopted for a reforestation program to

improve conservation education and planting those species that are the staple diet of langurs and also of value to the local communities.

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