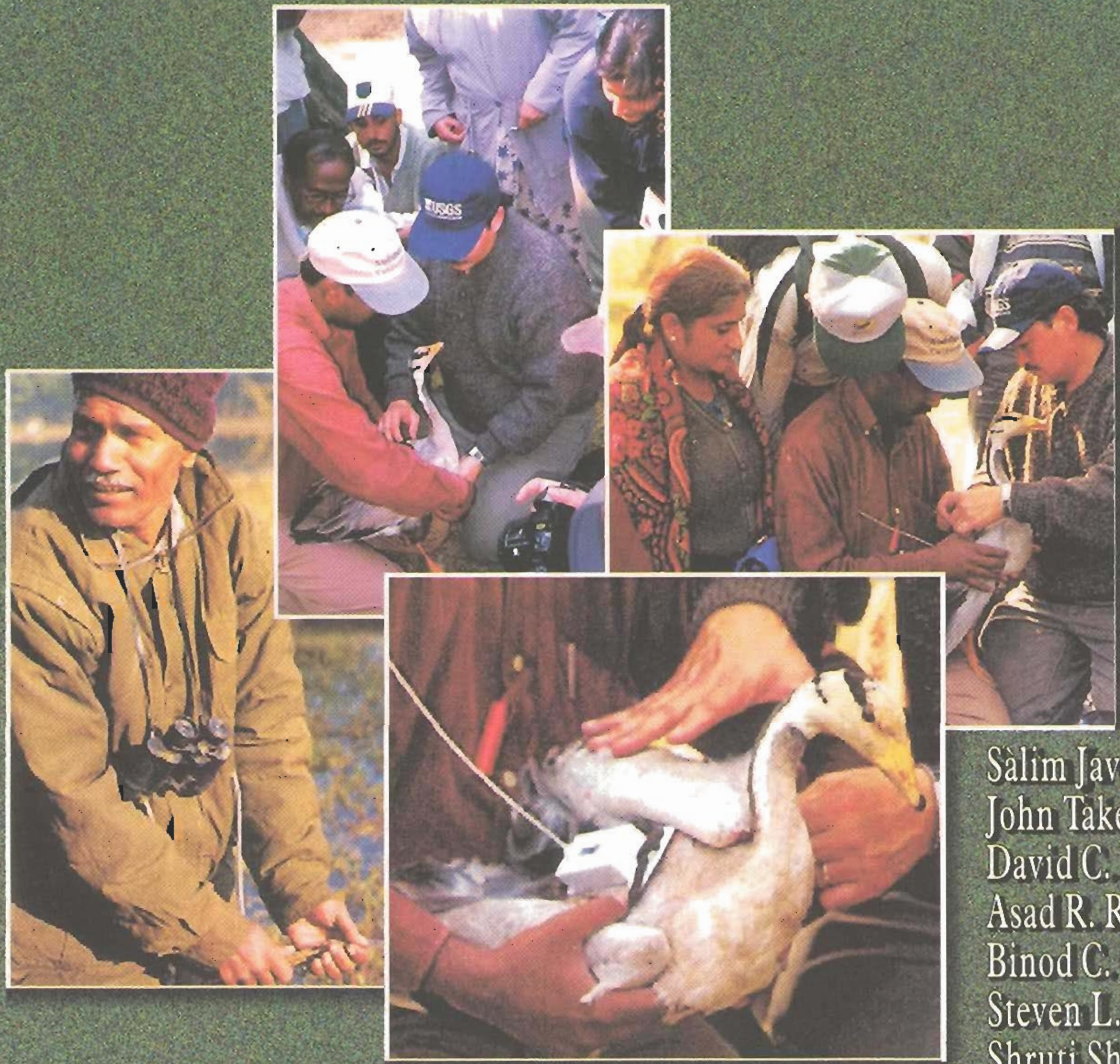
DOCUMENTING TRANS-HIMALAYAN MIGRATION USING SATELLITE TELEMETRY

A report on the capture, deployment and tracking of bar-headed geese (*Anser indicus*)



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Ministry of Environment & Forests

U.S. Fish & Wildlife Service

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Cover Photographs: PTT deployment on bar-headed goose in Keoladeo National Park, India.

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Indian Institute of Science	*Collaborating Agency*
Wild Bird Society of Japan	*Collaborating Agency*

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FOREWORD

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Endowed as it is with diverse bio-climatic regions and habitats, India has been a home for some magnificent wildlife: both resident and migrant. While much of our natural history and ecological studies have been addressed to the resident wild fauna, it is only in recent years our biologists and managers have started looking at migratory fauna. As a signatory to the Convention on Migratory Species (CMS) and several bilateral treaties with our neighbouring countries, India is committed to cooperate and collaborate in studies related to Trans-boundary migration of wildlife. Satellite Tracking of Siberian and common cranes from Russia to India in collaboration with Russian, Japanese and American scientists is a good example of such cooperation.

Within our resources and human resource capabilities, we in India have been addressing such studies with traditional tracking and monitoring methods. However, in our efforts to keep ourselves in tune with the modern technologies in this subject area, we have been fortunate to have the support and collaboration of the US Fish & Wildlife Service. The US Fish & Wildlife Service have been lending their technical know how to Indian Biologists and Managers in the field of wildlife research and management for the last 3-4 decades. As always, also in the field of migration studies, the US Fish & Wildlife Service have pro-actively collaborated with the Ministry of Environment and Forests for conducting a training workshop on the use of satellite tracking technology which was organised in December, 1999 by the Wildlife Institute of India along with the Bombay Natural History Society (BNHS), Aligarh Muslim University (AMU), Indian Institute of Science (IISc) and Salim Ali Centre for Ornithology and Natural History (SACON). The US Fish & Wildlife Service had also obtained the services of several eminent scientists from the US Geological Service. The Wild Bird Society of Japan very kindly donated the satellite transmitters, which were used for tracking the migratory bar-headed goose from India to Tibetan Plateau in Western China.

I am happy that this effort has not only empowered our wildlife scientists and managers to use this technology in future but also has set the trend for adopting newer technologies in this field. While placing my appreciation on record of the services rendered by the US Fish and Wildlife Service, I also wish to congratulate all the participating agencies for successfully conducting this workshop. The report compiled by the Aligarh Muslim University scientists and coordinated by the Wildlife Institute of India will be an additional asset for the collaborating organisations who may use it for obtaining support for their future studies in this field. I hope this report will have a wide circulation to the potential users of this technology.

(S C Sharma)
Addl. Director General of Forests (Wildlife)

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Many people helped in the organization of this workshop. We thank the Ministry of Environment and Forests, Government of India and the US Fish & Wildlife Service for being main sponsors of this workshop. The Wild Bird Society donated the two PTT's for the workshop. We wish to thank the US Geological Survey for providing expertise and facilities at its Anchorage and Vallejo stations to complete the analysis and writing work. The workshop was jointly organised by the Wildlife Institute of India, Department of Wildlife Sciences, Aligarh Muslim University, Bombay Natural History Society, Salim Ali Centre for Ornithology and Natural History, the Indian Institute of Science, Bangalore and the Rajasthan Forest Department. We wish to thank the respective heads and staff of these organizations for their support. We are thankful to all the staff of the Wildlife Institute of India, Dehradun and the Rajasthan Forest Department for their support during the technical session and field demonstration. We also thank Space Application Centre, Ahmedabad for organizational support.

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The Indian programme was brought under the JTA due to the support from Department of Ocean Development (DOD), Delhi and National Institute of Oceanography (NIO), Goa. We particularly thank Dr. B.N. Krishnamurthy, Advisor DOD, Dr. L.V.G. Rao of NIO, Goa, Dr. S.A.S. Naqvi of DOD and Dr. Sateesh Shenoi of NIO Goa for their efforts and cooperation. We also thank G. Martinelli, U. Koeppen, D. Orthmeyer and Mary Bishop for their comments and to Tahmima Shafiq and Faiza Abbasi for their help in the preparation of this report.

We would also like to extend our appreciation to Ali Hussain, Mohammad Qasim and Akhtar of BNHS for their help in the field and to all the delegates who participated in the workshop. We also acknowledge the technical expertise and assistance provided by WII staff, particularly Dr. Navneet Gupta. Finally, we thank the field staff at Keoladeo National Park, Bharatpur for their support.

EXECUTIVE SUMMARY

With a population of less than 50,000 individuals, the near-threatened bar-headed geese (*Anser indicus*) winters in central Asia from Pakistan to Myanmar. Nearly two-thirds of the population winters in India. Bar-headed geese are reputed to be the highest flying migratory bird in the world and have been sighted crossing the Himalaya above Mt. Everest (> 9,000 m). However, their migration route from wintering to breeding areas has never been documented.

In the first satellite telemetry study conducted on geese in the Indian subcontinent, we examined the local distribution and spring migration of two bar-headed geese marked in the winter of 1999-2000 at Keoladeo National Park (27.217°N, 77.533°E) near Bharatpur, India. During winter, the satellite-marked geese primarily roosted in the shallow marshes in the center of the Park and occasionally used surrounding agricultural fields. One transmitter ceased functioning after 105 d in mid March prior to the spring migration. The second goose migrated on 24 March, with a brief stopover at the Ganges River (27.970°N, 78.690°E) near Kasganj, Uttar Pradesh. On 25 March, it flew 504 km across the Himalayan mountain ranges to the Lamqog Kanbab River, Tibet (29.882°N, 83.470°E). The bar-headed goose staged there for 8 days before migrating to the west side of Taro Tso (31.238°N, 83.974°E) a lake near Lunggar, Tibet. The geese remained there through the breeding season (May-June).

We suggest that bar-headed geese migrate over the Himalaya across a broad front, with the route documented in this study showing an example of one route from northern India. Conservation of this species will depend on identification and protection of critical wintering, migration, and breeding habitats and improved monitoring surveys to determine population trends. We recommend that studies should include marking at several wintering areas, including eastern Tibet, to determine the amount of geographic variation evidenced in different bar-headed goose populations.

As this tracking effort was part of an International Workshop, our effort has not only provided first hand information on the trans-Himalayan migration of the bar-headed geese, but has also demonstrated the use of the technology to a large number of potential users in the Indian sub-continent.

INTRODUCTION

1. INTRODUCTION

Animal movement and migration studies have made significant progress with the use of telemetry. Conventional radio-telemetry has been used in numerous studies in different regions. However, the use of this technology is restricted to species with limited range of movement. Applying this tool for long distance migrants is usually unsatisfactory. Other challenges such as hilly terrain or dense vegetation, where getting signals and following animals often become major constraints. These problems and the need to track long distance migrants, particularly birds, led to the development of other technologies with greater spatial coverage, accuracy and ease in tracking. Satellite telemetry technology has overcome many of these problems and has become a very useful tool. There is a greater recognition of the use and benefits of this technology among biologists, managers and various conservation organizations.

Satellite tracking technology has been used extensively in the Western Hemisphere. However until recently, in the Indian sub-continent the use of this technology was limited to one study in 1994 when three Eurasian cranes (*Grus grus*) were fitted with Platform Terminal Transmitter (PTTs) in Keoladeo National Park, Bharatpur and tracked to their Siberian breeding grounds (Higuchi *et al.,* 1994). It took almost six more years for the next international collaborative project to emerge within India. This project, started in winter 1998-99, was the first long-term project using satellite tracking in India (Higuchi *et al.*, 1999). Other than these two studies, no effort has been made previously to demonstrate the use of this technology and its application in the Indian subcontinent.

1.1 BACKGROUND

The need to hold a workshop where satellite telemetry technology could be demonstrated to potential users was identified nearly ten years ago. However, the workshop was not conducted until 1999 with the support of the Ministry of Environment, Government of India. With interest shown by leading wildlife organizations and individuals throughout the country the first such demonstration of technology took place in December 1999 when a week long workshop was held at the Wildlife Institute of India, Dehradun. This report is an outcome of the workshop's successful culmination when two bar-headed geese (*Anser indicus*) were captured and fitted with PTTs to track their spring migration.

The Ministry of Environment and Forest, Government of India, in collaboration with the United States Fish & Wildlife Service, sponsored a regional workshop titled "Application of Satellite Telemetry for Wildlife Research and Management". The workshop was organised by the Wildlife Institute of India (WII), Dehradun, jointly with the Bombay Natural History Society, Mumbai (BNHS), Department of Wildlife Sciences, Aligarh Muslim University, Aligarh, Indian Institute of Science (IISc), Bangalore and Salim Ali Centre for Ornithology and Natural History (SACON), Coimbatore.

1.2 SATELLITE TELEMETRY WORKSHOP

The workshop was meant for participants from India and neighbouring countries and aimed at introducing this technology to wildlife research and management personnel. The technical sessions were held from 13-15 December 1999 at the Wildlife Institute of India, Dehradun, followed by a field demonstration of PTT deployment at Keoladeo National Park, Bharatpur. Although the initial plan was to demonstrate the use of this technology at three different sites for three different interest groups (Bhitarkanika Wildlife Sanctuary in Orissa for marine turtles and at a reserve in the Karnataka for elephants), due to logistics and lack of PTT's for turtles and elephants, the field demonstration on these two groups were deferred. All participants of the workshop were taken to Bharatpur for demonstration on bar-headed geese.

1.2.1 Technical session

The three-day technical session addressed a broad range of topics. This included history and review of the satellite tracking technology, design options for the Platform Transmission Terminals (PTT's) and improvement in the size and shape of the transmitters. Various harnessing considerations such as transmission cycle options, hardware and software requirements, introduction to the Argos System, PTT deployment, real-time Argos data acquisitions, data access and interpretation and GIS options were also discussed in great detail during the three day technical session (Appendix I).

Resource persons (Appendix II) also discussed various financial considerations, such as PTT costs, Argos tariffs and data costs. The penultimate session was attributed to interest group discussion. Interest groups were formed among the delegates based on their area of interest and work. The four interest group presentations focused around developing priority species lists where the technology can be effectively used, the collaborating individuals and agencies and funding opportunities. The concluding session was devoted to networking and potential project ideas (Appendix I).

SATELLITE TELEMETRY

2.1 EVOLUTION OF SATELLITE TELEMETRY

Satellite tracking technology in wildlife studies was identified as an important tool as early as in 1970 when an elk (*Cervus elaphus*) was marked and tracked in Wyoming (Craighead *et al.,* 1972). The technology became more popular in the last decade largely due to reduction in weight, refinement in size and shape of the PTT and harness methods. Since the deployment of a 160 g transmitter on a Sandhill Crane in 1989 (Nagendran 1989) the technology has made substantial progress. Mita and Kanmuri (1994) have developed a 25-gram PTT. The current sets of transmitters weigh from as little as 20 g.

Continued investment on research and development and subsequent weight reduction and improved performance of PTT's were possible due to the unlimited opportunity the technology offered to track long distance avian migrants. Size and weight of avian satellite transmitters is crucial for the use and success of the technology. Development of satellite transmitters or the Platform Transmitter Terminal (PTT) has continued towards manufacturing smaller transmitters (Fuller *et al.,* 1995). This has resulted in use of Satellite Tracking on different groups of birds, such as seabirds (Jouventin and Weimerskirc 1990), bald eagles (*Haliaeetus leucocephalus*), Eurasian cranes (Higuchi *et al.,* 1994), white-naped cranes (*Grus vipio*) and hooded cranes (*Grus monacha*) (Higuchi *et al.,* 1992 and Higuchi *et al.,* 1994b).

Standard very-high-frequency (VHF) radio transmitters have been used for several decades to track numerous species including mammals (marine and terrestrial), birds, reptiles and amphibians. However, VHF transmitters have a detection range of less than 10 km, which precluded studies on species in remote areas with limited access. Since the early 1970s, development of satellite telemetry has created a major technological advance in conservation studies by enabling researchers to track remote and trans-border species. The first platform transmitter terminal (PTT) used to track wildlife by satellite was deployed on a large mammal (Craighead *et al.,* 1972), but in the early 1980s, Stikwerda *et al.,* (1986) developed the first bird-borne PTT. Early generation PTTs for birds weighed more than 100 grams and were deployed on large birds such as swans, cranes and eagles (Fuller *et al.,* 1995, Nagendran 1992, Higuchi *et al.,* 1994 and Higuchi *et al.,* 1996). As the weight of PTTs decreased, studies were initiated on smaller species in groups such as seabirds and waterfowl, including the far eastern curlew (*Numenius madagascariensis*).

Satellite technology has been used extensively to study migratory birds across many regions through the 1990s; however, in the Indian sub-continent, the use of this technology has been limited. This modern technology has been used in the Indian sub-continent only twice before, even though the use of conventional radio-telemetry has made significant progress in this region. In 1994, two Eurasian cranes were successfully tracked from Keoladeo National Park, Bharatpur. An ongoing project on "Satellite tracking of

Large Wetland Birds" conducted by Hiroyoshi Higuchi, Salim Javed and Mini Nagendran is the only other effort. Under this project two Eurasian cranes, have been successfully tracked from Kutch in Gujrat. Nine more birds, Eurasian and demoiselle cranes will be captured and marked in the year 2000-2001.

2.2 TRANS-HIMALAYAN MIGRATION

India is a winter terminus for several species of birds in central Asia (Ali & Ripley, 1987, Grimmet *et al.,* 1999). For many species breeding in northern areas and traveling to the south for the winter, the Himalayan mountain range is a formidable barrier to migration. For example, satellite telemetry studies have shown that the houbara (*Chlamydotis undulata*) migrates around the range (O. Cumbreau, unpubl. data), but such a circular route greatly increases the distance and duration of their migration compared with a trans-Himalayan route. However, Donald (1952) and Swan (1961, 1970) noted the presence of several different species of birds flying at elevations well above 5,000 m to cross over the Himalayas.

One migratory species in particular, the bar-headed geese (*Anser indicus*), is known for its ability to cross this formidable barrier. Mountaineers scaling Mt. Everest reported having seen bar-headed geese flying over Everest (Swan 1970) at a height estimated at over 9,000 m. Numerous studies (reviewed in Butler & Bishop, 2000) have been undertaken to examine the physiology of captive bar-headed geese to determine how they achieve sustained flight in such a rarified atmosphere. Compared with other geese, this species has a higher myoglobin concentration at the onset of migration (Saunders & Fedde, 1991) and a slightly modified hemoglobin structure that increases the binding affinity of oxygen (Zhang *et al.,* 1996). However, none of these studies have examined the actual routes and timing of their migration in the wild.

2.3 WHY BAR-HEADED GEESE?

The estimated world population of bar-headed geese is less than 50,000 individuals, but 17,000 or nearly half of the birds counted in surveys, winter in India (Mundkur & Taylor, 1993). Bar-headed geese are known to be the highest flying migratory bird in the world and have been sighted crossing the Himalaya above Mt. Everest (> 9,000 m). However, their migration route from wintering to breeding areas has never been documented. Bar-headed geese have a discontinuous breeding range restricted to selected wetlands on the high plateaus of central Asia and wintering grounds spanning the Indian subcontinent from Pakistan to Myanmar (Ali & Ripley, 1987; Miyabayashi & Mundkur, 1999). Given their limited numbers and uncertain distribution, their conservation status has been listed as near threatened (del Hoyo 1992, Collar *et al.,* 1994, Grimmet *et al.,* 1999).

Unfortunately, the ecology and distribution of this species is little studied, primarily because they are found in remote trans-border regions of central Asia that have limited access to ornithologists. In fact, the breeding grounds for the bar-headed geese wintering in India are not documented. It is also not certain whetber the birds that breed in Ladakh winter in India. Thus, as a demonstration project for the first satellite telemetry workshop in India, hosted by the Ministry of Environment and Forests, Government of India and the U. S. Fish and Wildlife Service, we deployed two satellite transmitters donated by the Wild Bird Society of Japan on bar-headed geese at Keoladeo National Park (hereafter KNP) to examine their winter distribution and spring migration.

Selection of bar-headed geese for demonstration was also based on logistics, ease of capture, and their winter abundance at KNP. Also, because the species is not listed in either Schedule I or Schedule II of the Wildlife Protection Act (1972), the bar-headed geese was an ideal candidate for demonstration tracking. Moreover the bar-headed geese had merit as a candidate for education, as an ordinary nature lover or a layperson is more familiar with this species because of its frequent occurrence in wetlands during winter.

FIELD DEMONSTRATION

3.1 STUDY AREA

KNP (27.217°N, 77.533°E) is located near Bharatpur in the state of Rajasthan, 50 km west of Agra and 178 km northeast of Jaipur (Fig. 1). It is located at low elevation (<150 m), within the natural floodplain of the Gambhir and Banganga Rivers, with a boundary demarcated by a masonry wall separating it from 18 adjacent villages. The central 8-km^2 wetland is divided into units by earthen dykes with dams and floodgates controlling water levels (Ali & Vijayan, 1986), and the remaining 21-km^2 units consist of a variety of upland habitats. The vegetation of Bharatpur is a mixture of xerophytic and semi-xerophytes species consisting predominantly of *Acacia nilotica, Prosopis cineraria* and *Salvadora oleoides.* The flora is intensively studied by Prasad *et al.,* (1996).

Prasad *et al.,* (1996) have classified the wetland plant species into six categories; free floating (*Spirodela polyrhiza, Lemna perpusilla* and *Eichhornia crassipes*); rooted with floating leaves (*Nymphaea pubescens, Nymphaea nouchali* and *Nyphoides cristatum*); unanchored submerged (*Ceratophyllum demersum, Utricularia aurea* and *Utricularia stellaris*); rooted submerged (*Hydrilla verticillata, Najas minor* and *Potamogeton crispus*); emergent amphibious (*Eleocharis dulcis, Scirpus littoralis* and *Ipomea aquatica*) and marshland plants such as *Caesulia axillaris, Eclipta prostrata* and *Echinochloa colonum.*

The Park has been divided into 15 blocks. The wetland blocks are L, D, K, E, N and F but the plant species composition differs in each block depending upon the water level. *Hydrilla verticillata, Najas minor, Potamogeton nodosus, Nymphea pubescens, Spirodela polyrhiza, Wolffia globosa, Lemna perpusilla* and *Azolla pinnata* are the main species that occur in these blocks. These species are confined to the deepest areas with open water and loose muddy bottom. *Paspalum distichum, Ipomea aquatica, Pseudoraphis spinescens* and *Scirpus littoralis* are the species forming associations mostly in comparatively shallow water areas and in moist soil. Extensive patches of *Paspalum distichum* occur in such areas. Most precipitation occurs in June through October when water levels rise to 2 m, drop slowly during the winter months and quickly during March to June (Middleton, 1989).

KNP is one of the best-studied national parks of India. It was developed as a waterfowl sanctuary in 1899 by Maharaja of Bharatpur and used for game hunting from 1902 to 1967 (Vijayan, 1988). When India became a party to the Ramsar Convention in 1980, KNP was one of two wetlands in the country (the other was Chilka Lake, Orissa) to be named as a Ramsar site, and then was raised to the status of a National Park in 1981. KNP is also a United Nations world heritage site.

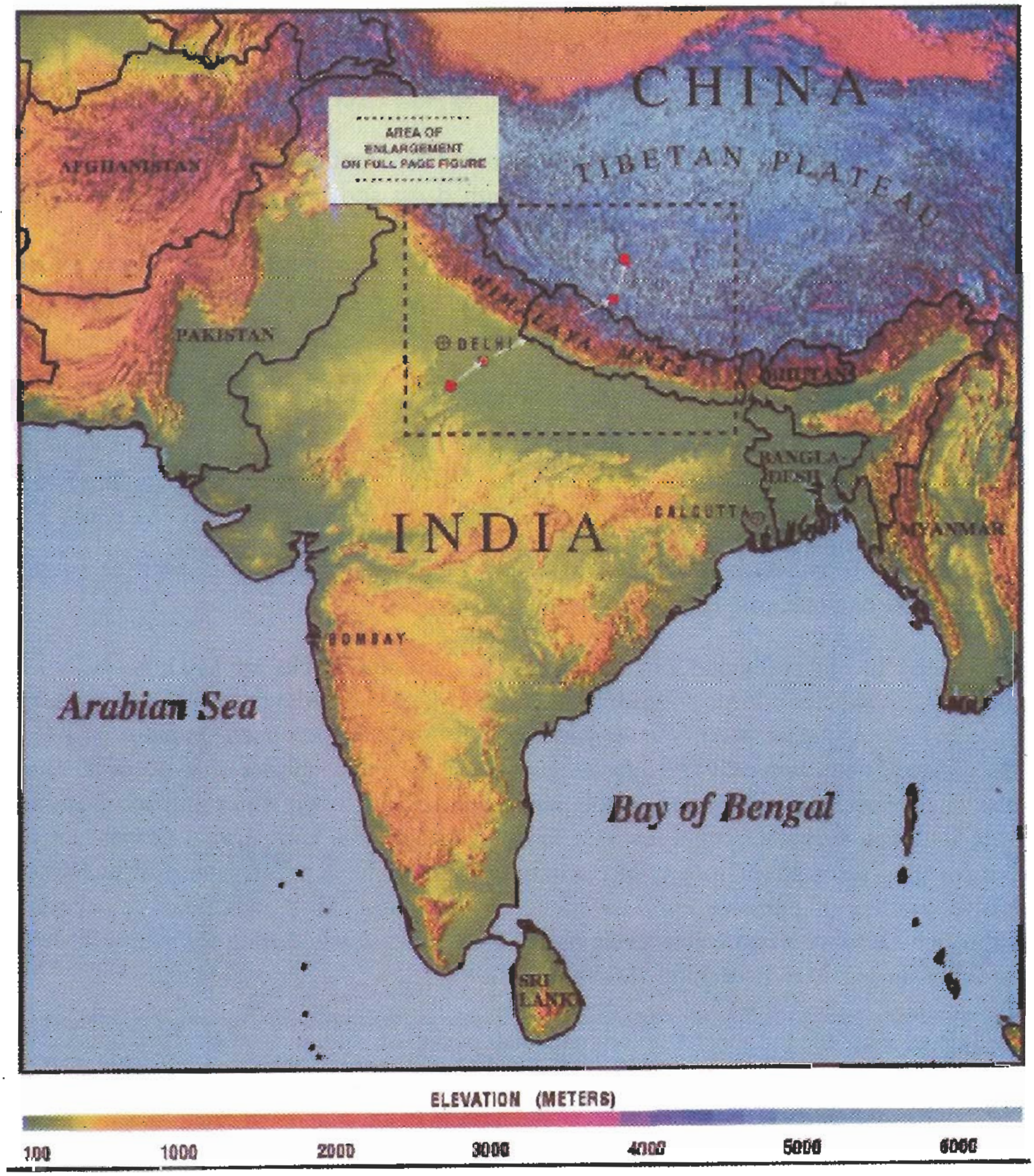

Figure 1: Location of the study area and color index to its elevation. Keoladeo Ghana National Park is located south of New Delhi at the leftmost red circle.

3.2 CAPTURE AND MARKING

Two bar-headed geese were captured and marked on 18 December 1999 and 6 February 2000. Trappers used traditional Indian techniques to capture the geese by hiding leg-noose lines at the edge of the wetland. Trappers have very effectively used the traditional leg noose technique to capture cranes and geese in India. To minimize stress due to capture, birds are very carefully handled and transmitters are quickly deployed. Soon after catching, birds are examined for external injury or abnormality. If no such evidence is apparent the process of deployment begins. One person holds the bird in its normal standing posture to avoid any damage to the bird. The whole process of examination and deployment is completed in 25-30 minutes time, allowing a quick release of the bird at the capture site. Special care is taken to release the bird with no predators, particularly raptors in the vicinity. Although the birds initially show some reaction to the deployed PTT by pecking on it a few times, but very soon they get used to it. Studies on Petegrine Flacons in Alaska (S. Ambrose and E.A. Rexstad, unpublished data) did not find any significant annual variation in adult survival over the year in PTT marked birds. However it is always better to ground track the birds for the initial few hours after release and record movement and behaviour.

The geese were fitted with 45 g satellite transmitters (T2050), manufactured by Nippon Telegraph and Telephone Company, Japan. Given the average body weight of the geese as 2000 g, the 45 g transmitter will be less than 3 per cent of the body weight. Transmitter weight, roughly about 3 per cent of the body weight is considered ideal for most of the species. The PTT was deployed using a standard backpack harness (Dwyer, 1972) made of Teflon ribbon. The Teflon ribbon was sewn together with dissolvable thread so that the transmitter would drop off after 6-8 months. This is ideal, as the battery would deplete by that time, given the duty cycle. The sides of the transmitter were painted red on the geese marked in February (#11753) to visually distinguish it from the other PTT-marked geese (#11754). Each transmitter was programmed to send a signal every 60 s on a 6 h on: 12 h off duty cycle to extend the battery life over 119-170 d. Locations of marked geese also were recorded during regular surveys of KNP from 8 February 2000 through 3 April 2000, and sightings were transferred onto a map overlaid with a 400 m × 400 m grid.

3.3 SATELLITE TELEMETRY LOCATIONS

PTT signals were received by three U.S. National Oceanic and Atmospheric Administration polar-orbiting weather satellites circling 850 km overhead about every 100 min. Locations were calculated by Doppler shifts in frequency by the French aerospace affiliate, Service Argos (Toulouse, France). Data made available by Argos were sent by electronic mail to the study investigators or acquired on the Internet. The messages were compiled and concatenated at the Alaska Biological Science Center (U.S. Geological Survey, Anchorage, AK, USA) on a Unix workstation and processed into datasets (SAS Inst., 1994) for analysis with customized programmes.

For interpreting the broad-scale migration locations of transmitter #11753, higher-quality location classes (n=89) were accepted, and lower quality locations (n=103) were subjected to systematic plausibility tests of direction, distance, and rate of movement between locations (D. Douglas, unpubl. method). This procedure removed 24% (n=25) of the lower quality locations. For interpretation of local-scale wintering distribution at KNP, only the 2 highest Argos location classes (2, 3) were used (n=44, #11753; n=61, #11754). Spatial interpretation was conducted with ArcInfo and Arcview geographic information system software (ESRI, Inc., Redlands, CA, USA), digital thematic maps, and Landsat-7 satellite browse imagery (U. S. Geological Survey, EROS Data Center, Sioux Falls, SD, USA). Service Argos provided an index of quality with each location. Figures included color indices of elevation, vegetation, and ice cover.

3.4 BAR-HEADED GEESE POPULATION DATA

We compiled available surveys at KNP to examine the peak count of bar-headed geese wintering in the Park. Annual counts were conducted by the Park staff and biologists. We calculated a trend line comprised of 3-year moving averages. We also extracted population counts for bar-headed geese from Asian Waterfowl Counts (Lopez & Mundkur, 1997) reported in wetlands from 16 different states in India.

RESULTS

4.1 TRANSMITTER PERFORMANCE

We obtained a total of 423 satellite locations from December through June for the two PTT-marked geese (Table 1). The first PTT (#11754) was deployed in December and the transmitter ceased to transmit on 17 March (n=137 d). This bird was last sighted prior to the spring migration on 2 April with 20 geese in the "K" block at KNP. The second PTT (#11753) was deployed in February and lasted for 88 days. The transmitters were stored for several months and field-tested prior to deployment. This may have resulted in a shorter field lifespan than was originally projected.

Table 1 Summary of events for the two PTT marked bar-headed geese (Anser indicus)

Events	*ID 17753*	*ID 11754*
Date of Marking	06 Feb 2000	18 Dec 1999
Last Sighting	23 Mar 2000	02 Apr 2000
Last Location	22 Jun 2000	15 Mar 2000
Last Message	22 Jun 2000	16 Mar 2000
Operational Days	137 days	88 days
Total Overpasses	259	275
Total Messages	1059	1108
Total Locations	92	228
Location Class		
Z	12	1
B	22	43
A	29	46
0	34	23
3	9	27
2	35	34
1	45	49

4.2 WINTER DISTRIBUTION OF BAR-HEADED GEESE IN KEOLADEO NATIONAL PARK

We examined the distribution of the two PTT-marked geese wintering at KNP. We limited the dataset to the best Argos accuracy classes (Class 2-3, approximate 150-350 m accuracy) because we had a large dataset for each geese. The geese were located roosting in the middle of the wetland habitat (Fig. 2), especially in blocks "K" and "L" where they commonly feed on grasses including *Paspalum distichum* (Middleton, 1992). On occasions, both the geese used areas beyond the Park boundary also, primarily to agricultural areas to the east. Additionally, the 184 direct sightings of the geese inside the Park, confirmed the general accuracy of the telemetry locations. Of the 184 sightings we obtained 117 sightings for bird #11753 and 67 for bird # 11754. Inside the park, bird # 11753 largely used block "L" while the bird with PTT ID # 11754 mostly used block "K" (Table 2), an example of strong site fidelity for individual wetland units.

Table 2 Summary of ground locations of the two bar-headed geese in Keoladeo National Park during winter

Months	*ID 17753*		*ID 11754*	
	Locations	*Block*	*Locations*	*Block*
February	99	L	33	K
March	18	L	31	K
April	0	L	3	K

4.3 SPRING MIGRATION AND BREEDING AREA

Winter migration movements of the geese coincide with the food availability at KNP (see Middleton 1992). Following the end of the monsoon rains in October, the wintering habitat improves through December but declines through April (Fig. 3, lower inset). Bar-headed geese typically arrive later than many other species, in November, and depart in March and April (Owen 1980).

On 23 March 2000, #11753 left the wintering area at KNP and flew northeast <150 km to a stopover site on the banks of Ganges River, 25 km west of Kasganj, Uttar Pradesh (Table 3). After <18 h the geese resumed migration. Crossing the Himalaya it flew northeast for 504 km at (>29 km/h) to the Lamqog Kanbab River, 10 km south of Paryang in the U-Tsang region on the Tibetan Plateau. The geese traveled over the Himalayas in less than 24 h, possibly flying along Karnali River Valley before crossing between two 7,000 m peaks.

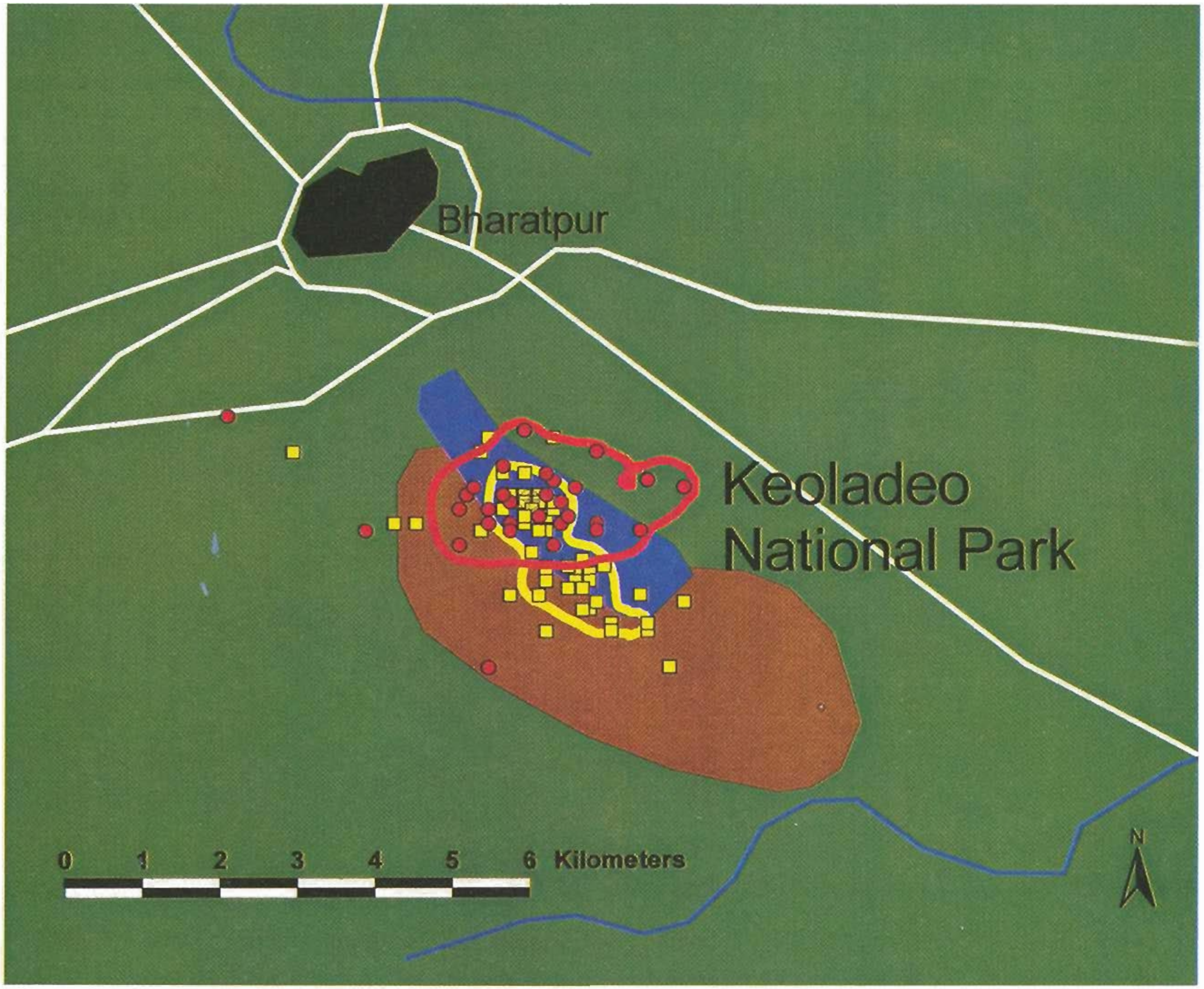

Figure 2: Keoladeo National Park, Bharatpur, India. Points show the distribution of wintering locations (accuracy class 2-3) for two bar-headed geese marked with satellite transmitters. Different symbols represent the different individuals (red circle = 11753, yellow square = 11754).

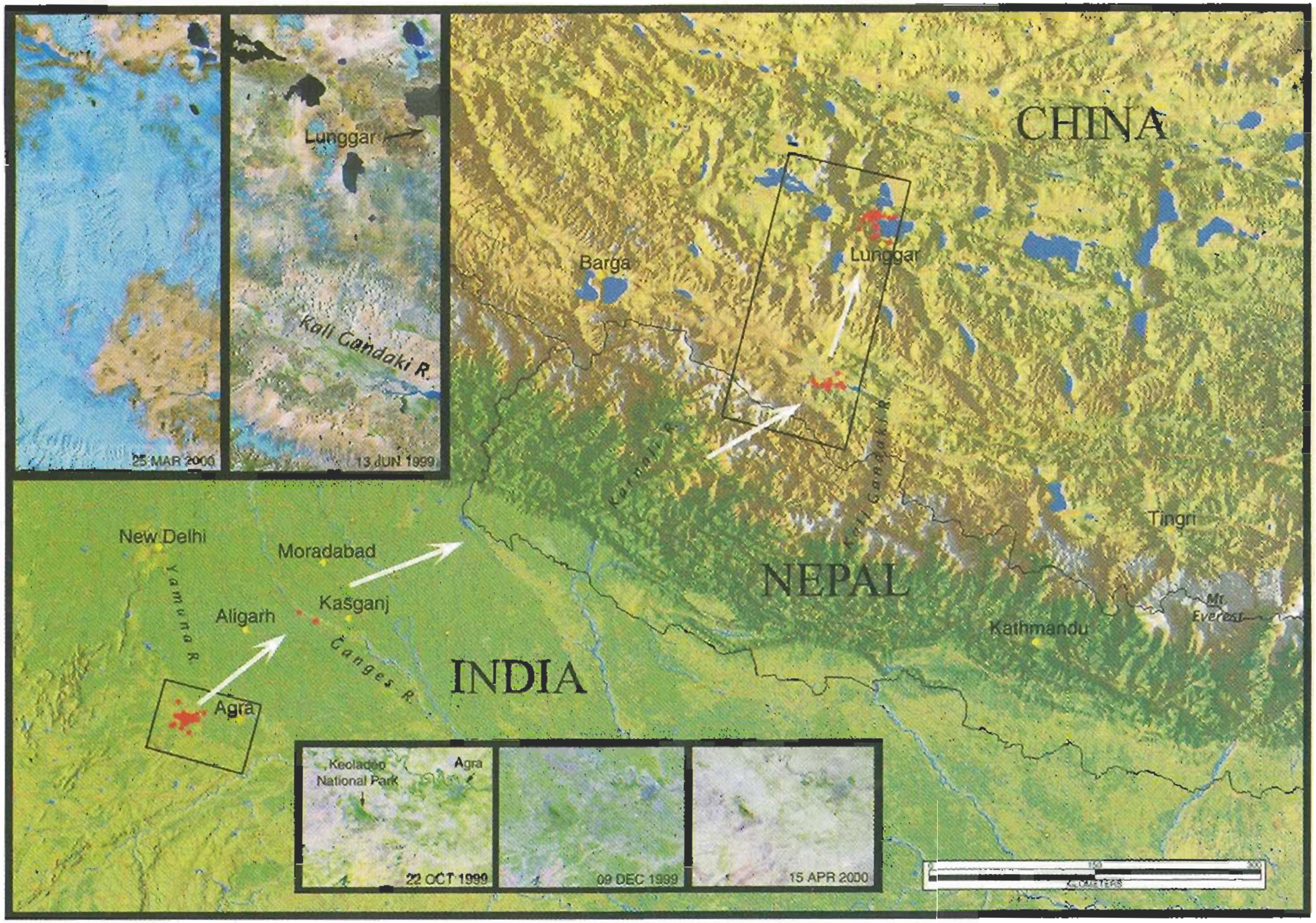

Figure 3. The spring migration and possible breeding area of a bar-headed goose marked at Keoladeo Ghana National Park (KNP), Bharatpur, India. Red circles indicate different locations, although some circles overlap. White arrows describe the general migration route from KNP to a stopover area near Kasganj, India (24 Mar), a staging area near Parang, Tibet (25 Mar) and a possible breeding area near Lunggar, Tibet (3 Apr).

Table 3 Description of capture, migration, stopover and staging sites for Bar-headed geese (Anser indicus) ID 11753. The table also gives distance covered between sites, speed, time taken to reach the site and direction of migration

Date	*Site Name*	*Site Description*	*Coordinates*	*Distance (km)*	*Speed (km/h)*	*Time (h)*	*Angle*	*Locations*
23.03.2000	KNP	Wintering	27.217N, 77.533 E	–	–	–	–	133
24.03.2000	Ganges River	Stopover	27.970N, 78.690 E	141.6	7.4	19.1	46.6	3
25.03.2000 -01.04.2000	Lamqog Kanbab River	Staging	27.970N, 78.690 E	504.1	28.8	17.5	64.4	10
03.03.2000 22.06.2000	Taro Tso Lake	Breeding	27.970N, 78.690 E	134.0	3.8	35.1	24.5	46

A Landsat image of the neatby lakes (Fig. 3, upper inset) taken on 25 March 2000 showed that the perimeter of many nearby lakes was frozen. The geese staged on the river Paryang from 25 March to 2 April (Table 3). The lake had probably thawed (see Fig. 3, upper inset) when the bird moved 134 km north to the west edge of the Taro Tso Lake near Lunggar. It remained there from 3 April until 22 June when the transmitter ceased functioning.

4.4. POPULATION SURVEYS

We found survey data on bar-headed geese at KNP for 13 years between 1983 and 2000 (Fig. 4). The peak counts were highly variable, but averaged 773 + 442 (SD) individuals. The statewide survey results for bar-headed geese in India (Table 4), summarized from the Asian Waterfowl Count, also indicate highly variable numbers (CV = 125%) with a peak of 16,600 individuals, but the majority (>81%) were counted in only four states: Assam, Karnataka, Orissa, and Rajasthan (Lopez & Mundkur, 1997).

Figure 4 Population surveys of bar-headed geese wintering at Keoladeo Ghana National Park, Bharatpur, India, 1983-2000. Bars indicate annual peak counts, the line shows the trend from 3-year moving average

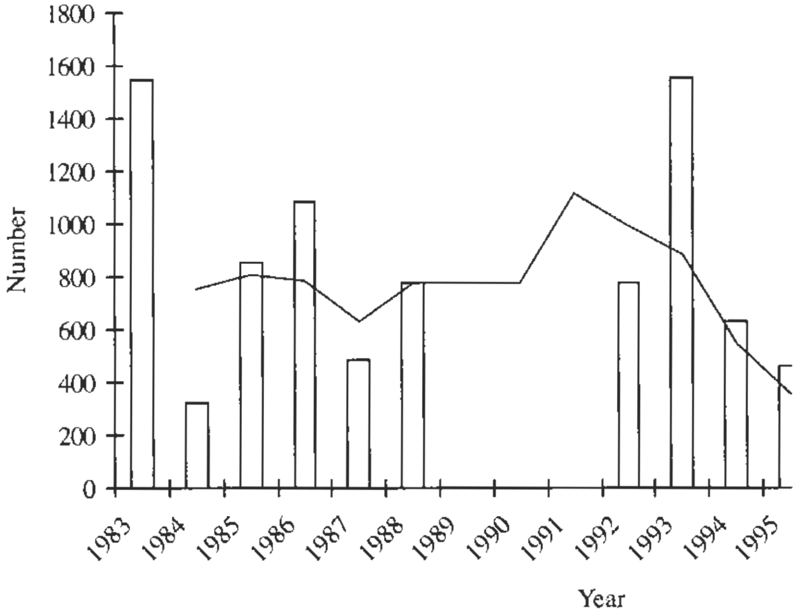

Table 4 State-wise status of bar-headed Geese (Anser indicus) in India based on Asian Waterfowl Count data (Lopez & Mundkur 1997). Names in bold are important for future monitoring programme and conservation of wintering population of bar-headed geese. Dash indicates no count data

States	*1994*	*1995*	*1996*	*Mean*
Andaman & Nicobar Islands	–	–	–	–
Andhra Pradesh	670	637	228	511
Arunachal Pradesh	–	–	–	–
Assam	**4085**	**21**	**4640**	**2915**
Bihar	–	–	263	87
Delhi	–	–	–	–
Goa	–	–	–	–
Gujarat	285	154	–	146
Haryana	–	54	–	18
Himachal Pradesh	–	–	1200	400
Karnataka	**3686**	**1321**	**3934**	**2980**
Kerala	–	–	–	–
Madhya Pradesh	67	–	–	22
Maharashtra	189	–	–	63
Manipur	–	–	–	–
Orissa	**2510**	**3960**	**2021**	**2830**
Pondicherry	–	–	14	4
Punjab	3	–	–	1
Rajasthan	**3435**	**967**	**245**	**1549**
Tamil Nadu	–	67	20	29
Tripura	–	–	–	–
Uttar Pradesh	166	232	–	132
West Bengal	–	36	12	168
Total	**16606**	**8194**	**13835**	**12878**

DISCUSSION

5.1 TRANS-HIMALAYAN MIGRATION AND POSSIBLE BREEDING AREA

Our study has documented a trans-Himalayan migration route of a satellite-marked bar-headed goose wintering in northern India (Fig. 2, 3). Geese may fly at 100 km/h (Bloekpoel, 1974) or more, but the short period (Table 2: 17.5 h) between locations during the migration indicated that the PTT-marked goose flew directly across the range. The goose landed in a snow-free river valley in the Tibetan Plateau where it staged before adjacent lakes thawed. Demoiselle cranes (*Anthropoides virgo*) tracked from Mongolia during the fall migration of 1996 (Kanai *et al.,* in prep.) staged near the same riverine area as the geese in our study, suggesting that this habitat may be used by many migratory waterbird species. Both species staged on along the river drainage that includes the Lamqog Kanbab and Kali Gandaki Rivers, before and after their trans-Himalayan flight. In addition, several thousand demoiselle cranes have been observed flying nearby over Jomsom, Nepal during the fall (Kanai *et al.,* in prep.).

We also may have identified a breeding area for bar-headed geese wintering in India. We obtained 46 locations for the PTT-marked goose on the shore of Taro Lake, and this is typical of the preferred habitat for this colonially nesting species (Owen, 1980; Ming & Dai, 1999). Breeding geese have been reported in nearby areas (<250 km) of the Tibetan Plateau to the southwest of Lunggar (Lu, 1997). In addition, the goose was located here during May and June when bar-headed geese are reported to breed (Owen, 1980; Grimmet *et al.,* 1999). Whether this area represents a breeding area for a sizeable proportion of the birds from India or simply a small colony requires additional study.

5.2 MIGRATORY STRATEGIES OF BAR-HEADED GEESE

Some goose populations, such as lesser snow geese (*Anser c. caerulescens*) from Wrangel Island, Russia follow a single major route to their staging area on the Yukon-Kuskokwim Delta of Alaska during the fall migration (Ely *et al.,* 1993). Greater white-fronted geese (*Anser albifrons*) from Japan funneled through Kamchatka during the spring (Kurechi *et al.,* 1995). In contrast, bar-headed geese wintering in India probably migrate across a wide front.

Swan (1970) reported that bar-headed geese migrated over Mt. Everest in the western Himalaya. Our study suggests that some individuals wintering in India migrate across the Himalaya near the Karnali River. In Kashmir, Donald (1952) observed skeins of bar-headed geese at sundown, flying over the Seoj Plateau near Bhadarwa and near the Bhal Pudhree Pass near Seoj in Chamba, likely passing on to the Pangong Lakes. He observed these geese flying at high elevations and suggested they flew over the mountains rather than following rivers. A recent study on bar-headed geese marked with satellite transmitters in Kyrgysztan in 1998 (U. Koeppen *et al.,* in prep.) showed that their migratory route extended to wintering areas in eastern Pakistan, a previously undescribed wintering area. According to their results, they suggested there may be regular wintering areas west of 70° E.

Bar-headed geese have been reported to both breed and spend the winter in western Tibet (Bishop *et al.,* 1997; Lu 1997). Different populations likely exhibit geographic variation in their migratory behavior which has been documented in studies of radio-marked greater white-fronted geese (*Anser albifrons*) on the Pacific coast of North America (Ely & Takekawa, 1996). However, it is unclear whether the population in western Tibet is nonmigratory or if a leapfrog migration (Swarth, 1920) has evolved in this species. Additional marking of the population in western Tibet would clarify their ttue migratory behavior.

5.3 POPULATIONS OF BAR-HEADED GEESE

5.3.1 Winter distribution

Historic records and counts for wintering bar-headed geese (Bishop *et al.,* 1997) and band returns from five birds (see Miyabayashi & Mundkur, 1999) show their distribution extends from Pakistan to Myanmar. In China, the western Tibetan Plateau is the major wintering area (Bishop *et al.,* 1997). In India, the bird is reported to breed in Ladakh and is a common winter visitor throughout northern and northeastern India, especially in Rajasthan and Assam (Ali & Ripley, 1987). It is found in Kaziranga National Park and Pani Dihing Sanctuary in Assam (Choudhury, 1997). It migrates south to Chilka Lake, Orissa where it was very common in eatly 1940s (Benthall, 1947). It is a regular visitor in Karnataka (Krishnan, 1987). In Gujarat, the bird has been a rare visitor to Kutch and Saurashtra (Khachar, 1971; Himmmatsinhji & Bapat, 1989).

5.3.2 Abundance and Trends

Perennou *et al.* (1994) estimated that there were <50,000 bar-headed geese, but that their numbers were increasing (see Callahan and Green 1993). However, there are conflicting views about the population trend of this species. Recent increases in survey effort and better coverage may confound population trends. Yakovlev (1997) suggested numbers in Kyrgyzstan had decreased from the 1950s to the 1990s. Swan (1970) noted that bar-headed geese were declining in the 1960s, and Owen (1980) suggested that counts were decreasing in the 1970s. About 25% (13,000-14,000) of the world population winters in Tibet (Bishop *et al.,* 1997) at altitudes ranging from 3,570-4,480 m. Bishop et al. (1997) found that although numbers have remained relatively stable in Tibet in the 1990s, they have declined considerably in other parts of China where the geese are hunted. Roberts (1991) reported that numbers of bar-headed geese observed at Manchar Lake, Pakistan by Salim Ali in 1926 were in the thousands, <400 by 1972, and none in the late 1980s. Miyabayashi and Mundkur (1999) compiled counts for the world population and found <36,000 individuals (<19,000 in southern Asia) and estimated there were only 12,000 breeding pairs.

In India, numbers of bar-headed geese are highest in Assam, Karnataka, Orissa, and Rajasthan (Table 4). Counts in Rajasthan at KNP have varied from 257 to 1,582 individuals (Fig. 4; Vijayan, 1991), but the surveys have been highly variable and show no consistent increasing trend. This is possibly due to inconsistent coverage of waterbodies in each state during the annual Asian Waterfowl Count. A large number of bar-headed geese are found at Kaziranga National Park (>750) and Pani Dihin Sanctuary (>1,000) in Assam (Choudhury, 1997). Counts at Chilka Lake in Orissa have shown that the population in the area has decreased, but birds may have changed their wintering grounds to Bhitarkanika (Dev, 1997).

To improve the quality of information and regular monitoring of the wintering population of bar-headed geese in India, we suggest that an annual geese count should be initiated. In areas such as KNP where bar-headed geese are abundant (up to 48% of the total state count in 1994-1995), consistent surveys should provide a good index to population change. In each area, surveys should be conducted on a single day to prevent duplicate counts. Data should be collected during mid-day when geese are most likely to concentrate at roost sites. Initially these counts should concentrate on areas within the four states with the largest numbers (Table 4) of bar-headed geese.

5.4 CONSERVATION THREATS

5.4.1 Hunting

Social changes may affect breeding populations. Formerly, Buddhists revered geese in Tibet and afforded them considerable protection (Swan, 1970). On their breeding grounds and in parts of their wintering grounds on the Tibetan Plateau, bar-headed geese were very tame (Ludlow, 1951; Swan, 1970), but hunting is now common in Tibet (Bishop *et al.,* 1997). Although hunting is prohibited under the Wildlife Protection Act of 1972 in India, bar-headed geese are extremely wary because they are subject to illegal hunting (Grimmet *et al.,* 1999). Large numbers are captured in nets with live decoys in northeastern India (Choudhury, 1997). Bar-headed geese are vulnerable outside current protected areas such as at the single spring stopover area we documented on the Ganges River, so it is essential to provide them with greater protection at these areas.

5.4.2 Habitat loss and degradation

Bar-headed geese, like many other migratoty waterbirds wintering in India, face threats because of continued loss and degradation of wetlands. There are nearly 170 major wetlands in India covering approximately 580,000 km^2 of the land area (Anonymous, 1993). However, a significant portion of these wetlands is not protected. Of the 93 key wetlands in India, nearly 45 per cent are moderately to highly threatened (Scott & Pole, 1989). Threats to wetlands include reclamation for agricultural, industrial, and urban expansion, and over-exploitation of wetland resources (Foote *et al.,* 1996). Use of wetlands by rural poor is a major source of disturbance and alteration of wetland habitats. Bar-headed geese typically avoid disturbed areas near habitation and roads (Middleton, 1992).

Poor enforcement and lack of protection for innumerable small wetlands, wayside ponds, and river stretches used by migratory birds during the fall and spring migration also threaten the long-term health of the bar-headed geese population. Protection measures in several protected areas need improvement (Choudhury 1997). To accord greater protection to these birds, a protection programme should be implemented that includes migration areas along their migratory flyways.

Finally, species such as bar-headed geese are at risk from pesticide contamination. Vijayan (1991) documented elevated levels of Eldrin and Dieldrin in sarus cranes (*Grus antigone*). The dieldrin levels in sarus cranes were higher than the lower limit of the diagnostic lethal level of dieldrin (4-5 ppm) in the brain. As the mortality of all the birds around Bharatpur occurred during winter, which coincides with application of eldrin and dieldrin to protect the wheat and mustard crops from termites. This may have implications for the bar-headed geese and other winter migrants that use adjacent crop fields for feeding. Similar mortality was also observed in snow geese feeding on eldrin contaminated rice seeds in Texas. Gole (1996) noted that geese often share the same feeding habitats as these cranes, and they may be exposed to the same contaminants.

5.4.3 Conservation of bar-headed geese and the promise of satellite telemetry

Baseline information from monitoring would provide crucial data on population trends that will support necessary research and management intervention. A network of biologists and amateur bird watchers support various activities related to bird conservation such as the Asian Waterfowl Count (AWC) and the recently launched Important Bird Areas (IBA) programme. A long-term conservation programme should involve strengthening the current network of organizations and individuals in India interested in bar-headed geese to develop an improved monitoring programme.

Our study was the first attempt to apply satellite telemetry to study the migration of waterfowl in India and to determine the spring migration and breeding areas of bar-headed geese. Although we were successful, our study clearly represents a pilot effort in the understanding of this species. The project has served as a hypothesis-generating exercise to further examine the ecology of the bar-headed geese. A logical follow-up study would be to examine a larger sample of marked individuals, captured in the major wintering areas of India. From such a study, we might obtain better information about different migration routes and timing, as well as evidence of distinct breeding and wintering populations. Ongoing advances in satellite transmitters, including hourly global positioning system (GPS) locations and altitude sensors (P. Howey, pers. comm.), will provide the tools needed to describe the exact migration flight patterns of the bar-headed geese. These advances in technology should lead to improved conservation for this species.

LESSONS LEARNT AND PROSPECTS

This project marked the first successful attempt to satellite track bar-headed geese in India. The tracking of one of the geese has achieved twin objectives. It has demonstrated the use and benefit of this technology to potential users in the Indian subcontinent. On the other side, it has provided information establishing the migration route of the bar-headed geese that winter in India. We do not wish to make far-reaching conclusions, based on tracking of one bird. There is clearly a need to repeat this work in India with a much larger sample size. This will allow further confirmation of our preliminary findings.

The successful tracking of bar-headed goose and Eurasian cranes has ushered a new beginning in wildlife tracking studies in India. We hope that in future projects this technology will be utilized, offering unlimited opportunities for studying movement and migration pattern for species where ground tracking is difficult or impossible.

6.1 TECHNOLOGY TRANSFER

The workshop not only demonstrated the use and application of the technology, but also allowed the transfer of technology, which is an important achievement in itself. With reputed and very experienced scientists from USA and other countries (Appendix II) the delegates obtained first-hand experience of using the technology and its potential benefits. This was possible because of the initiative from the US Fish & Wildlife Service.

6.2 COLLABORATION AND NETWORKING

The satellite telemetry workshop has also allowed various leading organizations and individuals to come together. If number of applicants and collaborators are any indicators, this workshop must serve as a role model in collaboration and networking. The workshop was very successfully organized by the Wildlife Institute of India, Dehradun in joint collaboration with Bombay Natural History Society, Mumbai, Department of Wildlife Sciences, AMU, Aligarh; Indian Institute of Science, Bangalore; Salim Ali Centre for Ornithology and Natural History, Coimbatore. The Ministry of Environment and Forests Govt. of India, New Delhi, and the U.S. Fish and Wildlife Service cosponsored the workshop with technical assistance from the U.S. Geological Survey. The Wild Bird Society of Japan generously donated the two PTTs. This workshop has successfully demonstrated the role of national and international collaboration.

6.3 CONCLUSION

Latest and cutting edge technologies such as these not only provide academic incentives to users, but also bring in other benefits. The ease, efficiency and spatial coverage not only unravels various mysteries of migration and movement but allows us in charting strategies for conservation of species, some of which may be critically endangered. For the Siberian cranes, it may be too late, but for many other species this is the right start.

Avian species such as the Great Indian Bustard (*Choriotis nigriceps*), the Lesser Florican (*Sypheotides indica*), Bengal Florican (*Eupodotis bengalensis*), the Demoiselle Crane (*Anthropoides virgo*), Blacknecked Crane (*Grus nigricollis*), Adjutant Stork (*Leptoptilos dubius*), Long-billed (*Gyps indicus*) and Whitebacked Vultures (*Gyps bengalensis*) are some of the important candidates for future studies using satellite telemetry.

We hope that this effort to organize and demonstrate the use of technology has not only enthused the user but also the persons in Central and State forest departments and governments. A synergy between the two is critical for the future of satellite tracking in India. With the Ministry of Environment paving the way for organizing this workshop, we hope that future research projects will get quick clearance from the Ministry and respective State governments. One of us (SJ) has tremendously benefited from a positive attitude and expeditious processing of application for fieldwork on cranes in Gujarat. A recently signed protocol by the Indian and Russian governments has identified bird migration studies using satellite telemetry as one of the key areas for future collaborative research between India and Russia. This will give much needed boost to satellite telemetry studies in India.

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APPENDIX 1

Programme of Technical Session

DATE	TIME	TOPIC	FACILITATOR/ SPEAKER
13/12/99 Inaugural Session			
	0830-0930	Registration and Tea	
	0930-0940	Welcome and Workshop Introduction	B.C. Choudhury
	0940-0950	Address by Director, WII	S.K. Mukherjee
	0950-1000	Inaugural Address by Guest of Honour	
	1000-1015	Objectives and Organization of the Workshop	Steve Landfried
	1015-1030	**Tea Break**	
13/12/99 Technical Session I	PRINCIPLES OF SATELLITE TRACKING		
	1030-1045	Participant Introductions	B.C. Choudhury
	1045-1130	History of Wildlife Migration Studies and Satellite Tracking	Mark Fuller & Consultants
	1130-1215	The Argos System and Satellite Imaging in Wildlife Research	Dave Douglas & Consultants
	1215-1300	Wildlife Tracking Hardware Options-Radios, GPS, Satellite Transmitters (PTTs)	Sam Merrill & Consultants
	1300-1330	Special Interest Group Formation (Birds, Wolves, Elephants, Sea Turtles, Data Analysis, and Education)	B.C. Choudhury Indian Resource Persons (Asad Rahmani, R. Sukumar and Salim Javed)
	1330-1430	**Lunch Break**	
13/12/99 Technical Session-II	PRACTICAL CONSIDERATIONS WITH SATELLITE TRACKING		
	1430-1510	Hardware Design Parameters: Species Specific Constraints	John Takekawa and Consultants
	1510-1550	Harnessing Issues	Jack Frazier and Consultants
	1550-1630	Transmission, Duty Cycle, and Accuracy Issues	Dave Douglas, Olivier Combreau and Consultants
	1630-1645	**Tea Break**	

DATE	TIME	TOPIC	FACILITATOR/ SPEAKER
	1645-1715	Panel: Lessons from the past	All Consultants & Indian Resource Persons
	1715-1815	Small Groups: Brainstorming for Project Development	Consultants Led Focus Groups
	1815-1830	Sharing Ideas	Steve Landfried
	1830-2000	Videos, Migration Websites and Interpersonal Networking	Resources available
	2000-2100	**Dinner**	
14/12/99 Technical Session-III	CASE STUDIES		
	0900-0925	Raptor and Crane Tracking	Mark Fuller
	0925-0950	Bar-headed Geese & Shorebirds	John Takekawa
	0950-1015	Marine Turtle Tracking	Jack Frazier
	1015-1040	Elephant Tracking	Fred Koontz
	1040-1055	**Tea Break**	
	1055-1130	Houbara Bustard Tracking	Oliver Combreau
	1130-1200	Wolf Tracking-Alternate Strategies (VHF, GPS, and Satellite Telemetry)	Sam Merrill
14/12/99 Technical Session-IV	COST BENEFIT ANALYSIS AND ALTERNATIVES TO SATELLITE TRACKING		
	1200-1230	Financial Aspects of Satellite Tracking	Dave Douglas and Consultants
	1230-1330	Panel: Wildlife Tracking Options (Tags, Radios, Radar and GPS)	All Consultants & Indian Resource Persons
	1330-1430	**Lunch Break**	

DATE	TIME	TOPIC	FACILITATOR/ SPEAKER
14/12/99 Technical Session-V	TRACKING DATA ANALYSIS AND EDUCATIONAL OPPORTUNITIES		
	1430-1530	Real Time Data Accessing and Analysis Demonstration	Dave Douglas
	1530-1615	Educational Opportunities Associated with Satellite Tracking	John Takekawa & Steve Landfried
	1615-1630	Integrating Options	Dave Douglas, Consultants and Indian Resource Persons
	1630-1645	Tea Break	
	1645-1700	Wildlife Tracking in the Subcontinent: Moving Forward	B. C. Choudhury & Salim Javed
	1700-1800	Project Development Discussions	Consultant Led Focus Groups
	1800-1900	Groups share Potential Project Ideas	Steve Landfried & B. C. Choudhury
	1900-2000	Videos, Migration Web Sites and Networking	Please Volunteer
	2000-2200	Dinner	
15/12/99 Field Visit	0600-1100	FIELD VISIT TO RAJAJI NP (Breakfast in field)	B. C. Choudhury
	1100-1200	Tea Break	
15/12/99 Concluding Session	1200-1330	NETWORKING FOR TRACKING, FIELD STUDIES AND FUTURE PLANNING	B.C. Choudhury & R. Sukumar
	1330-1430	Lunch Break	
	1430-1500	Summing up—Where do we go from here?	Steve Landfried/ B. C. Choudhury
	1500-1530	Vote of Thanks	B.C. Choudhury
	1530-1830	Departure for Delhi	

SPECIAL INTEREST GROUP	
Birds	**Implementing Agencies/Individuals**
Great Indian Bustard	BNHS, IUCN/SSC Bustard Group, Birdlife Institute, RSPB, NARC Forest departments of different states
Lesser Florican	Ravi Sankaran, BNHS, SACON, Assam Forest Department, Bird Conservation Nepal, Assam Valley Wildlife Society, Department of National Parks and Wildlife Conservation, Nepal and State Forest Departments.
Bengal Florican	BNHS, AMU, USF&WS, World Working Group on Birds of Prey.
Whitebacked Vulture	Raptor Research Foundation, Peter Mundy BNHS, AMU, USFWS, World Working Group on Birds of Prey and State Forest Departments.
Longbilled Vulture	Raptor Research Foundation, Peter Mundy, Goutam Narayan and State Forest Departments.
Greater Adjutant Stork	BNHS, Aaranyak Nature Club, Department of Zoology, Gauhati University, Stork Sp. Group Hiloljyoti Singha and State Forest Departments.
Demoieselle Crane	Salim Javed, AMU, WBS Japan, Meenakshi Nagendran, Hiroyoshi Higuchi, ICF and State Forest Departments.
Common Crane	Salim Javed, AMU, WBS Japan, Meenakshi Nagendran, Hiroyoshi Higuchi, International Crane Foundation and State Forest Departments.
Pallas Fishing Eagle	World Working Group on Birds of Prey, Raptor Research Foundation, B. Meyburg, M. Fuller, R. Naoroji and State Forest Departments.
Objectives	
	• To determine migration routes, stopover sites and distribution.
	• To determine dispersal pattern of young birds.
	• To device conservation strategies in (unknown) wintering/non-breeding sites.
	• To determine potentials for spread of disease (vultures).
Possible Funding Agencies	
	• US Fish & Wildlife Service
	• Wildlife Bird Society of Japan
	• WINROCK Foundation

	• Darwin Initiative
	• Environmental Research & Wildlife Development Agency
	• Swarosky
	• Peregrine Fund
	• National Geographic
	• RSPB
	• Shell
	• NGOs/Zoos in US
	• Forest Department of States
Reptiles	
Olive Ridley Sea Turtle	• B. C. Choudhury, Bivash Pandav, WII
	• Tracing the Migratory Route
	• Identifying the Non-breeding Area of Olive Ridley Sea Turtle in Orissa, India
Mammals	
Wolf (Dr. Y.V Jhala, WII)	• Prey Predator Relationships in Ladakh
Objectives	
	• Study of animal migratory/nomadic movement of prey and predators.
	• Study the seasonal and annual ranging patterns and home ranges.
	• Co-relate resource availability (vegetation and prey) and ranging patterns.
	• Assess the influence of human and livestock use of areas to wildlife resource use.
	• Usefulness of PTTs to address above objectives
Put PTT's on two wolves in Ladakh:	• Duty cylces
	• Successful hits
	• Accuracy issues
	• Life of collars
Lions (Dr. Ravi Chellam, WII)	• Research on sociability of Lions
	• Develop technology for field testing a combination of GPS + Capture + Satellite uplink Collars

APPENDIX II

The Resource Persons and Technical Support Personnel for the Workshop

1. Dr. Steve Landfried (Wisconsin)	Workshop Co-ordinator (US Side)
2. Mr. David Douglas (US Geological Survey, Alaska)	Argos Data Analysis
3. Dr. Mark Fuller (US Geological Survey, Idaho)	Raptors, large Birds
4. Dr. John Takekawa (US Geological Survey)	Bar-headed geese/Cranes
5. Dr. Jack Frazier (Smithsonian Institution, Virginia)	Marine turtles
6. Dr. Fred Koontz (Wildlife Preservation Trust International)	Elephant/Mammals
7. Mr. Sam Merrill (Minnesota Department of Natural Resources)	Wolves
8. Dr. Olivier Cumbreau (Environmental Research & Wildlife Development Agency	Bustards

The Indian Facilitators/Instructors

1. Mr. B.C. Choudhury (Wildlife Institute of India, Dehradun)	Workshop Co-ordinator (India) & Resource person Marine turtles
2. Dr. R. Sukumar (Indian Institute of Science, Bangalore)	Elephants
3. Dr. Asad Rahmani (Bombay Natural History Society, Mumbai)	Birds
4. Dr. Salim Javed (Aligarh Muslim University, Aligarh)	Birds

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Cooperating Agencies and Institutions

Rajasthan Forest Department
Keoladeo Ghana National Park
Smithsonian Institution/National Zoological Park
Steven Landfried Consultants
Wildlife Preservation Trust International
Space Application Centre
Environmental Research and Wildlife Development Agency