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Rapid Assessment of Proposed Reintroduction

Sites for the Manipur's Brow-antlered Deer or Sangai

Manipur's brow-antlered deer or sangai, is one of the most threatened species of deer found as a single, small and isolated population the Keibul Lamjao National Park (KLNP), Manipur. The major factors affecting its survival are its poor genetic status, deteriorating habitat conditions, lack of connectivity with the surrounding landscapes and mortality due to poaching and diseases. For its continuous existence in the wild, the best strategy is to create a second population at a suitable site that guarantees its long-term survival. Five sites with ecosystem components similar to those of KLNP, comprising wetlands (locally called Pat) and forest areas were surveyed. A qualitative ecological and disturbance scoring matrix was used to assess these sites. Pumlen Pat with adjoining Thongam Mondum Reserve Forest was identified as the best site for reintroduction of Sangai, which can be managed as a conservation reserve for the sustainable development of the area.

Key words: Reintroduction, Manipur's brow antlered deer, Floating meadows, Sangai, Second home.

Assessment of sites in Manipur for reintroduction of Sangai.

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Introduction

Among the Indian cervids, the Manipur's brow-antlered deer or sangai (*Rucervus eldii eldii*)is the most threatened. The sangai is also considered to be one of the most endangered and localized mammalian sub-species restricted to the Keibul Lamjao National Park (KLNP), Manipur. It was deemed extinct until a small population of Sangai was rediscovered in 1953 and conservation efforts were made. Thereafter, the population showed an increasing trend and by 2008 the population in the wild was around 100 individuals (Hussain and Badola, 2013). The characteristic feature of KLNP is the floating meadows locally known as "*phumdi*", a heterogeneous mixture of soil and decaying vegetation in which Sangai lives. The threat to this species can largely be attributed to its population being single, isolated and small, with deteriorating habitat condition owing to changes in the hydrology of Loktak Lake, anthropogenic pressures, lack of connectivity with the surrounding landscape for dispersal and incidences of mortality due to poaching and diseases. The construction of Ithai Barrage on the Manipur River has resulted in hydrological changes in the lake (Hussain *et al*., 2006). Earlier, the meadows used to settle down during lean seasons and get replenished with soil and nutrients. Presently, they float continuously resulting in thinner meadows that are unable to support the weight of the Sangai (Hussain and Badola, 2013). Additionally, water pollution and eutrophication in the lake (Tuboi, 2013) are leading to rapid proliferation of the meadows, but these erratically formed meadows are thin and hence are of no significant value to the sangai. The dependence of the local communities on the park resources for their livelihood imposes tremendous pressure on the park. The preferred forage species of the sangai are *Leersia hexandra*, *Oryza rufipogon*, *Capillipedium* spp., *Persicaria perfoliata*, *Oenanthe javanica* and *Imperata cylindrica* (Tuboi *et al.,* 2012; Tuboi and Hussain, 2016). These are extracted heavily by the local communities.

The existing population of the sangai has grown from a founding population of a meager 14 individuals (Ranjitsinh, 1975) and in all likelihood is going through a genetic bottleneck. An earlier study has shown that the genetic diversity of both the wild and captive populations is low (Hussain and Badola, 2013). In this context, the constraints imposed by space, as the park has lost its connectivity with the surrounding habitat, is a limiting factor for the sangai because there is very little chance of natural recolonization of the species into the sink. The establishment of a second home for sangai seems to be the most appropriate strategy for its conservation.

In the light of the foregoing discussion, the establishment of a second population of sangai was suggested by Hussain and Badola (2013). Thus, the aim of this study was to assess and identify potential areas for reintroduction of Sangai to create a second population in the wild within Manipur and to make a contribution to our understanding of this species for better conservation.

Material and Methods

Study Area

Reintroduction using wild-born or captive-raised animals to re-establish a population of threatened species is one of the strategies to assure the continued existence of a species in a given landscape. In the present context, sites in which sangai are known to have been found historically were identified, and the habitats therein were surveyed for suitability as potential second home of the sangai. Five sites were identified on the basis of landownership in the Manipur valley. These sites were Ikop Pat, Pumlen Pat (and the adjoining Thongam Mondum Reserve Forest), Langol Reserve Forest, Sambei Purum Reserve Forest and Heingang Reserve Forest (Fig. 1).

Ikop Pat/Lake

Ikop Pat, located 40 km from Imphal in Thoubal District, lies between latitudes 24°31'N and 24°40'N and longitude 93°52'E and 93°57'E. It has an area of 6.005 km² and is surrounded by three villages. The lake receives water from precipitation and indirectly from the Manipur River, which runs along its western shoreline. The lake is eutrophic, mainly due to agricultural and fishing practices around the periphery, as indicated by the high pH (8.0), BOD (4.26 mg/l), COD (16.45 mg/l), nitrogen (3.47 mg/l), phosphorus (1.42 mg/l), potassium (12 mg/l), total coliform count (350/100 ml) and fecal coliform count (210/100 ml). The floral diversity includes 26 plant species belonging mainly to the families Poaceae and Nymphaeaceae, some of which are important food species of the sangai (Tuboi and Hussain, 2016). The economically important plants, such as *Trapa natans*, *Euryale ferox*, *Echinochloa stagnina*, *Nymphaea* spp., *Ipomea aquatica,* extracted by the local people for commercial purposes, are declining due to overexploitation by the locals and polluted water. The biomass value of the important plant species ranges from 366.4 to 877.8 g/m² and production values of total plants ranges from 0.15 to 4.53 g/m²/day (Envis Centre Manipur, 2008).

Pumlen Pat/Lake and adjoining Thongam Mondum Reserve Forest

The Pumlen Pat is the second largest freshwater wetland in Manipur with an area of 58.06 km², surrounded by 14 villages. Thongam Mondum Reserve Forest, adjacent to the lake, with an area of 9.9 km², is included in the proposed site as a part of Pumlen Pat, making the total available area for the reintroduction of the sangai as 67.96 km². The area lies between latitudes 24°20'N and 24°35'N and longitudes 93°50'E and 94°0'E in Kakching District at an elevation of 767 m amsl at a distance of 40

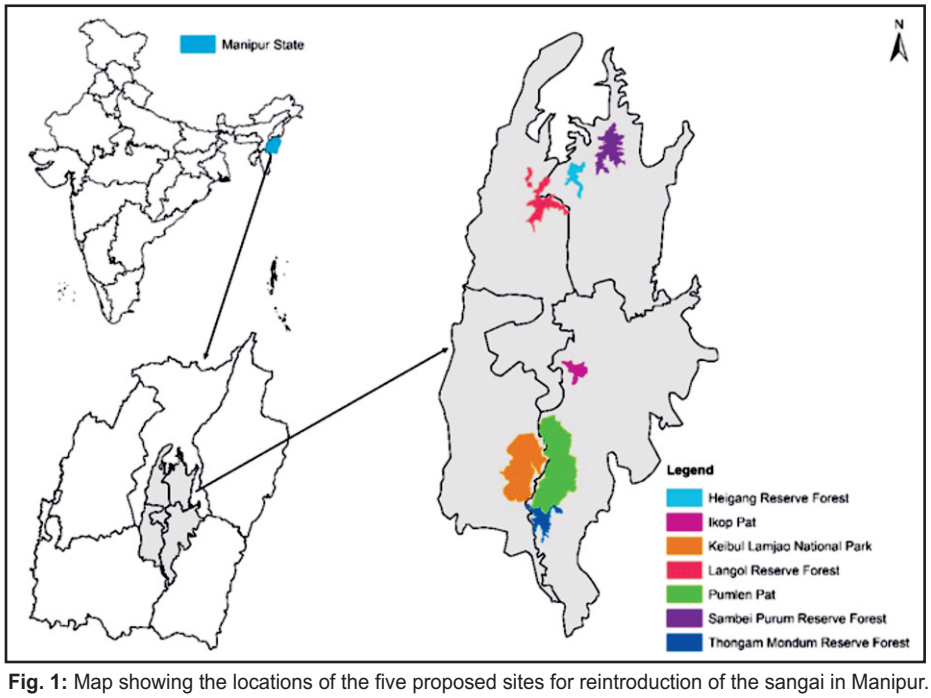

Fig. 1: Map showing the locations of the five proposed sites for reintroduction of the sangai in Manipur.

km from Imphal city and the far east of KLNP. It is closely associated with other satellite wetlands such as Kharung Pat in the north, Loktak in the west and Lamjao Pat in the east during the rainy season. The lake receives water from precipitation and surface runoff from the denuded hills in the southeast and agricultural fields to the north. It receives water indirectly from the Sekmai River through Khoidum Pat on the northern side and from the impounded Manipur River.

The high levels of BOD (3.82 mg/l), nitrogen (1.86 mg/l), phosphorus (1.08 mg/l), potassium (10 mg/l), total coliform count (220/ 100 ml) and fecal coliform count (170/100 ml) indicate that the lake water is eutrophic (Envis Centre Manipur, 2008). A total of 75 plant species belonging to 29 families, of which the families Poaceae, Polygonaceae and Nymphaeaceae are dominant, have been identified in the lake. The presence of preferred forage species of the sangai among these plants makes this site ideal for reintroduction in the context of food availability. Other mammals of conservation concern found in the area are the hog deer (*Axis porcinus*) and the long-tailed goral (*Naemorhedus caudatus*).

Langol Reserve Forest

Langol Reserve Forest (LRF) and Langol Extension Reserve Forest (LERF) are isolated hill ranges in the northern part of Imphal Valley. LRF lies between latitudes 24°48'N and 24°50'N, and longitudes 94°53'E and 94°57'E, and LERF lies between latitudes 24°52'N and 24°54'N, and longitudes 94°53'E and 94°54'E. The Government of Manipur declared Langol a reserve forest in 1933, but there has been no improvement in the condition of the forest. LRF has an area of 19.22 km², with an extension of 2.05 km². It is drained by the Imphal River, the Nambul River and the Luwangee River of Imphal Valley. It is the only reserve forest near Imphal and serves as a carbon sink for the city. As the city expands, Langol Hill Range now bears the burden of the increasing pressure of urbanization, with many settlements, institutions and hospitals being established around the hill range. Encroachment is thus rampant in the area, and an area of about 53.58 ha (0.5 km^2) in LRF and about 23.31 ha (0.23 km^2) in Sadar Hills East Range have been encroached (Singh, 2011).

Sambei Purum Reserve Forest

Sambei Purum Reserve Forest (SPRF) falls within Imphal East District and covers an area of 19.40 km². It is situated at a distance of 18 km from Imphal city and lies between latitudes 24°53'N and 24°57'N, and longitudes 93°59'25″E and 94°2'26″E. It is separated from Heingang Reserve Forest by a highway that runs along the eastern and western sides of Heingang and SPRF, respectively. It is drained by the Iril River and is surrounded by 22 villages with Meitei, Kuki, Naga and Muslim communities. The common tree species found in SPRF are *Pinus roxburghii*, *Castanopsis hystrix*, *Emblica officinalis*, *Schima wallichii*, *Rhus succedanea* and *Lithocarpus dealbatus*. The common shrubs and grasses include *Lantana camara*, *Mikania micrantha*, *Imperata cylindrica*, *Cyperus difformis*, *Panicum* spp., *Osbeckia stellata* and *Cynodon dactylon.*

Heingang Reserve Forest

Heingang Reserved Forest (HRF) is located in Imphal East District, and National Highway 2 runs alongside it. It is situated at a distance of 6 km from Imphal city and lies between latitudes 24°51'N and 24°55'N, and longitudes 93°56'E and 93°56'E. The reserve forest, with an area of 9.71 km², is also surrounded by wetlands and agricultural lands on the southern and eastern boundaries, which act as a buffer between the human settlements and the reserve forest. It is drained by the Imphal River and the Kongba River. A total of five villages, with mainly Meitei and Muslim communities, surround the reserve forest. Rapid urbanization and an increased population have resulted in encroachment of the reserved forest's land for housing, agriculture and timber extraction for commercial purposes. Resource exploitation in terms of vegetable and firewood collection is also prevalent. To the southwestern and eastern sides of the forest lie small wetlands owned by the local people. These wetlands are highly degraded due to overexploitation for fish farming. The plant species composition of these wetlands are similar to that of KLNP, and species such as *Zizania latifolia*, *Leersia hexandra*, *Cyperus* spp., *Setaria* spp., *Nymphaea stellata*, *Alternanthera philoxeroides* and *Eichhornia crassipes* are found in these wetlands. The Heingang Marjing sacred grove, with an area of ca. 7.08 ha, is located in Heingang village.

Methods

Field assessment

Considering the basic resource requirements of the sangai such as food, cover and, water, and the requirement of undisturbed areas, an assessment of the five proposed reintroduction sites was conducted over a period of one month in 2011. In the course of this assessment, data on habitat availability, food plants and water availability were collected. Since the local communities living around the area also play a crucial role in the conservation of the sangai, socio-economic data and data on the dependence of the local communities on the natural resources of the surroundings were collected. The activities of these communities, such as hunting and fishing that pose a threat to the survival of the sangai in the area were recorded. Other factors that can be detrimental to a reintroduction program, such as the presence of human and livestock populations were documented. The representatives of the respective settlements were interviewed, and their attitude and opinion towards wildlife conservation were examined. The suitability of each site for reintroduction was evaluated on the basis of the scores obtained on an ecological matrix and a disturbance matrix.

The role of local people in maintaining or conserving natural ecosystem of a particular area is crucial and indispensable. Therefore, a qualitative disturbance matrix was generated on the basis of the various activities of the people living in and around the reserve sites that affected the stability of the sites directly or indirectly.

Qualitative scoring matrix

A qualitative scoring matrix was developed on the basis of the observations made during the assessment (Table 1).

Table 1: Qualitative scoring matrix for assessment of proposed reintroduction sites for sangai in Manipur.

Sl. No.	Parameters	Code	Scoring
1	Forest area (ha)	Absent	-
		<1000	1
		>1000	2
2	Wetland area (ha)	Absent	-
		<500	1
		500-1500	2
		>1500	3
3	Food plant availability	Low	0
		High	1
4	Water availability	Yes	1
		No	0
5	Villages (number)	<5	2
		5-15	1
		>15	0
6	Human population (number)	<5000	1
		>5000	0
7	Livestock (number)	<500	2
		>500	1
8	Degradation status	High	0
		Low	1
9	Fishing	High	0
		Low	1
10	Resource extraction	Low	1
		High	0
11	Hunting	Absent	1
		Present	0
12	Tourism regulation	Absent	0
		Present	1
13	Attitude of local communities	Positive	1
		Negative	0
14	Level of urbanization	Low	1
		Medium	0
		High	-1
15	Pollution	High	0
		Medium	1
		Low	2
16	Disturbance during breeding season	High	1
		Low	2

The scoring matrix was divided into an ecological matrix and a disturbance matrix. The ecological matrix was based on qualities such as the availability of area, water and food. The disturbance matrix was based upon the anthropogenic pressure on the site and the opinion of the people. The site with the highest score was identified as the best site for reintroduction among the five proposed sites.

Results

Site characteristics

Among the five sites, the largest available area is that of Pumlen Pat alongwith adjoining Thongam Mondum Reserve Forest (67.98 km²), followed by LRF (21.27 km²), SPRF (19.40 km²), HRF (9.71 km²) and Ikop Pat (6.005 km²) (Table 2). Pumlen Pat has the largest available wetland area (58.06 km²). There is an additional hill range, the Thonga Mondum Reserve Forest, with an area of 9.90 km². Ikop Pat comprises only wetlands, with no dry land, whereas SPRF and LRF consist of only forests, with no wetland habitat. HRF, on the other hand, has a forest area of 6.62 km² and a wetland area of 1.25 km².

The largest human population was in SPRF, followed by Pumlen Pat. The smallest population was in Ikop Pat. In LRF, the population of the National Game Village and the Langol Housing Complex was excluded from the estimated population. The livestock population was greatest in SPRF (1100), followed by HRF (590) and was the least in Ikop Pat (150). In all the five sites, habitat degradation in terms of deforestation, pollution and over exploitation of resources was observed. Except for SPRF and LRF, water was available at all the three sites. The disturbance in terms of human interference and livestock population was observed to be high at all the proposed sites. Human interference was mainly in the form of vegetable extraction; encroachment for housing, farming and road construction; fishing (at Ikop Pat, Pumlen Pat and HRF); and timber and firewood collection in the reserve forests. There were potential threats such as habitat degradation due to overexploitation of resources, encroachment, poaching and traditional hunting at LRF, SPRF and HRF. The attitude of the local people towards the reintroduction of sangai was positive, but people

expressed their reluctance to forego the access they had to the natural resources of the area as these resources form their main source of livelihood (Table 2).

Plant species such as *Zizania latifolia*, *Leersia hexandra*, *Capillipedium* spp., *Alternanthera philoxeroides* and *Setaria* spp., which constitute the important forage plants of the sangai in KLNP, were abundant in the wetlands of HRF, Pumlen Pat and Ikop Pat. Food plants of the sangai found in SPRF and LRF were *Imperata cylindrica*, *Cyperus* spp., *Saccharum munja* and *Capillipedium* spp.

Scoring matrix

According to the ecological matrix, Pumlen Pat ranked the highest, indicating it is the best site for reintroduction in terms of ecological factors such as the area of the wetland and availability of water and food. Among the five proposed sites, Pumlen Pat has the highest wetland area, with an additional forest area as well. Since the lake also shares with KLNP the characteristic feature of floating meadows, food plants of the sangai are also present. HRF emerged as the best reintroduction site after Pumlen Pat due to the availability of suitable wetland habitats and floating meadows with adequate availability of forage species. HRF is followed by Ikop Pat as the next viable site for reintroduction, but it is smaller, and no hard ground is available. Ikop Pat was followed by SPRF and LRF. SPRF and LRF lack wetland areas within their boundaries. Hence, availability of water and food plants was minimal (Table 3).

Number of settlements, human population, degree of resource extraction, pollution, urbanization, livestock, tourism and activities such as hunting were considered in assessing the anthropogenic pressure. On the basis of these factors and considering other disturbance factors such as proximity to urban area, Pumlen Pat was identified as the most suitable site for reintroduction of sangai. Although HRF had the highest score in the qualitative matrix, it was less suitable than Pumlen Pat because of its close proximity to the national highway that runs to its west and a state highway on the eastern side. The close proximity to highways may result in rapid urbanization, which will be detrimental for the long-term survival of the sangai. The opinion and attitude of the local panchayat or village head was more or less positive at all the sites. This positive attitude could be harnessed in support of sangai conservation (Table 4).

Discussion

Increasing anthropogenic pressure and climate change have increased the risk of extinction for rare and endangered species in the wild. One effective way to conserve these rare and endangered species is through reintroduction. Reintroduction of a species remains a critical part of conservation (Seddon *et al*., 2007). For many species, past reintroduction efforts have had low success rates because of lack of information on the biological and ecological attributes of the species, poor release-site selection, ignorance about human social behavior at the site and failure to deal effectively with the

Table 2: Characteristics of the proposed sangai reintroduction sites in Manipur.

Characteristics	Ikop Pat	Pumlen Pat	LRF	SPRF	HRF
Available area (km²)	6.005	67.98	21.27	19.40	9.71
Forest area (km²)	0	9.90	21.27	19.40	6.62
Wetland area (km²)	6.005	58.06	0	0	1.25
Cultivated area (km²)	0	0	0	0	1.47
Number of villages	3	14	12	22	5
Number of livestock	150	450	350	1100	590
Water availability	Yes	Yes	No	No	Yes
Factors causing disturbance	Fishing, vegetable collection, encroachment	Fishing, vegetable collection, agriculture, encroachment	Firewood and vegetable collection, encroachment	Firewood and vegetable collection, encroachment	Firewood and vegetable collection, encroachment
Possible threats	Anthropogenic pressure, poaching	Anthropogenic pressure, poacing	Anthropogenic pressure, encroachment, hunting	Anthropogenic pressure, encroachment, hunting	Anthropogenic pressure, encroachment, hunting
Attitude of local communities	Positive	Positive	Positive	Positive	Positive

LRF, Langol Reserve Forest; SPRF, Sambei Purum Reserve Forest; HRF, Heingang Reserve Forest

Table 3: Qualitative ecological scoring matrix for the proposed sangai reintroduction sites in Manipur.

Proposed sites	Forest area (ha)	Wetland area (ha)	Food plant availability	Water availability	Ecological score
Ikop Pat	-	2	0	1	3
Pumlen Pat	1	3	1	1	6
LRF	2	-	0	0	2
SPRF	2	-	0	0	2
HRF	1	1	1	1	4

LRF, Langol Reserve Forest; SPRF, Sambei Purum Reserve Forest; HRF, Heingang Reserve Forest.

Table 4: Qualitative disturbance scoring matrix of the proposed reintroduction sites of the sangai in Manipur.

Proposed sites	Degradation status	Fishing	Resource extraction	Hunting	Tourism regulation	Response	Villages	Human population	Livestock	Level of urbanization	Pollution	Disturbance during breeding season	Disturbance score
Ikop Pat	0	0	1	1	-	1	2	1	2	1	1	1	11
Pumlen Pat	0	0	0	1	0	1	1	0	2	1	1	1	8
LRF	0	-	0	1	-	1	1	0	2	-1	0	1	5
SPRF	1	-	0	0	-	1	0	0	1	0	1	1	5
HRF	1	1	1	0	1	1	2	1	2	1	1	2	14

LRF, Langol Reserve Forest; SPRF, Sambei Purum Reserve Forest; HRF, Heingang Reserve Forest.

factors that have caused the species to get extinct at a site or landscape (Sutton, 2015).

The state of Manipur comprises Manipur valley and the surrounding hill tracts. The state is ranked 24th in terms of geographical area. However, there is a striking difference in the distributional pattern of the human population in the state, with the highest human density being around Manipur valley, where two-thirds of the population lives in about 8% of the area in the state. Thus, finding flat land suitable for the reintroduction of sangai, comprising a combination of wetlands, drylands and hillocks, is almost impossible.

In the face of this growing demand for land due to the increasing population and subsequent development of Manipur valley, the Manipur Forest Department was able to identify five sites in the valley that could be developed as a second home for the sangai within its distribution range. An intensive ecological and social survey of these five sites was carried out by the authors of the present work, and the choice was narrowed down to two sites, *viz.* HRF and Pumlen Pat and adjoining Thongam Mondum Reserve Forest.

Before this study, the process of advocacy for a second home for the sangai was almost negligible. Subsequent to the Endangered Species Recovery Programme (ESRP) of the Ministry of Environment, Forest and Climate Change (MoEF & CC), taken up under Compensatory Afforestation Fund Management and Planning Authority (CAMPA), intensive advocacy and lobbying for a second home of the sangai was taken up by the Wildlife Institute of India (WII). The HRF, one of the sites identified for reintroduction, was allotted for the conservation and breeding of the Manipuri Pony (*Equus*sps). Thus, Pumlen Pat, along with Thongam Mondum Reserve Forest, is the only area available for creating a second home for the sangai in Manipur. In the 6thmeeting of the Manipur State Board for Wildlife, the honorable Chief Minister of Manipur in principle approved the development of Pumlen Pat and Thongam Mondum Reserve Forest as a reintroduction site for the sangai by declaring them a conservation reserve and advised the Forest Department of Manipur to initiate the process.

The landscape of Pumlen Pat comprises four small hillocks, the smallest hillock being Hapcha. The slightly larger Chinjao is in the centre, the largest hillock, Chingkok chingmei, lies to the west, and Tokpaching is on the eastern side. Tokpaching is inhabited by the local people. The people living around Pumlen are dependent on the lake for their livelihood. Resource extraction in the form of fishing and vegetable collection is a source of income for the people. As such, they are reluctant to forego their activities in the absence of alternate livelihood sources even though their response to the reintroduction of the sangai was positive. Encroachment for fish farming and agriculture is also a common occurrence. The presence of Mondum Mahadeva (a temple) on Thongam Mondum Hill, to the south of the lake, is also a source of disturbance. The number of visitors is large, especially on Sundays and on full moon days. The temple has become a favored tourist spot where the locals sell vegetables and fishes collected from the lake.

During 2017–2018, intensive ecological studies were conducted at KLNP, and a series of consultative meetings were held with the local communities and other stakeholders, including representatives from government departments and legislators. Together, these studies and meetings have improved our understanding of the ecological and social attributes hindering the conservation of the sangai. Several livelihood, veterinary and medical camps conducted at KLNP and Pumlen Pat helped build the trust of the local communities. Under the ESRP, WII has initiated a conservation-breeding program for reintroducing the sangai at Pumlen Pat (WII, 2018).

Conclusion

An understanding of the influence of natural and anthropogenic factors on populations of wild ungulates is of fundamental importance for their conservation management. Among the five sites assessed, Pumlen Pat has the largest wetland area. It also has floating meadows, and water and food are available. There is an additional forest area as well, the Thongam Mondum Reserve Forest. Thus, Pumlen Pat and the adjoining Thongam Mondum Reserve Forest is the most feasible among the surveyed sites. The area is an extension of KLNP since their habitat characteristics are similar. During 2017–2018, a series of consultative meetings and workshops were conducted that involved multiple stakeholders at different levels of governance for advocating the establishment of a second population of the sangai. The Government of Manipur has in principle agreed to establish a second population of the sangai at Pumlen Pat and Thongam Mondum Reserve Forest and has directed the Forest Department of Manipur to initiate the process to declare this area a conservation reserve under Section 36A of the Indian Wild Life (Protection) Act, 1972. Unless the Manipur Government takes up immediate action, it is likely that we may also lose this area to increasing land demand.

मणिपुर के ब्रो-एन्टलर्ड डीयर अथवा संगाई के लिए प्रस्तावित पुर्नवास स्थलों का त्वरित मूल्यांकन

चोंगपी टुबोई, रूचि बडोला एवं सैयद एनुल हुसैन

सारांश

मणिपुर का ब्रो-एन्टलर्ड डीयर अथवा संगाई केबुल लमजाओं राष्ट्रीय पार्क, मणिपुर में पाए जाने वाले हिरन की सबसे संकटग्रस्त प्रजातियों में से एक है। मुख्य संकटों में इसका कमजोर आनुवंशिक स्तर, आवास स्थलों का ह्रास मानवजनित दबाव, आसपास के भूदृश्यों के साथ संयोजकता का अभाव तथा शिकार एवं रोगों के कारण मृत्यु शामिल है। मणिपुर में एक उपयुक्त स्थल में एक द्वितीय आबादी जो संगाई की दीर्घकालीन उत्तरजीविता की गारंटी दे, का सृजन करने पर विचार करते हुए आर्द्र भूमियों (जिसे स्थानीय रूप से पाट कहा जाता है) और वन क्षेत्रों को मिलाकर केबुल लमजाओं राष्ट्रीय पार्क के समान पारिस्थितिकीय तंत्र घटकों के साथ पाँच स्थलों का सर्वेक्षण किया गया : इन स्थलों का मूल्यांकन करने के लिए एक गुणात्मक पारिस्थितिकीय एवं विक्षोभ स्कोरिंग मैट्रिक्स का उपयोग किया गया। पुमलैन पाट जो थोंगम मोंडुम आरक्षित वन के पास है, को संगाई पुनर्वास स्थल हेतु सर्वोत्तम पाया गया, जिसे सतत् विकास हेतु संरक्षण क्षेत्र (Conersation Reserve) के रूप में प्रबन्धित किया जा सकता है।

References

Envis Centre Manipur. (2008). State of Environment Reports and its issues with database management. Government of Manipur, Directorate of Environment.

Hussain S.A. and Badola R. (2013). Conservation ecology of Sangai (*Rucervus eldii eldii*) and its wetland habitat, Manipur. A study report. Wildlife Institute of India. **1:** 321.

Hussain S.A, Singsit S., Angom S., Kipgen K. and Vaiphei N. (2006). The brow-antlered deer of Manipur *Cervus eldii eldii*, McClelland 1842: A review of its status, ecology and conservation. *Indian Forester,* **132**(12): 40-50.

Ranjitsinh M.K. (1975). Keibul Lamjao Sanctuary and the brow-antlered deer- 1972 with notes on a visit in 1975. *J. Bombay Natural History Society*, **72** (2): 243-255.

Seddon P.J., Armstrong D.P. and Maloney R.F. (2007). Developing the science of reintroduction biology. *Conservation Biology*, **21**(2): 303-312.

Singh K.J. (2011). Langol Hill Range, the carbon sink of Imphal City. Kangla online. http://kanglaonline.com/2011/10/langol-hill-range-the-carbon-sink-of-imphal-city/

Sutton A.E. (2015). Leadership and management influences the outcome of wildlife reintroduction programs: findings from the Sea Eagle Recovery Project. PeerJ 3:e1012; DOI 10.7717/peerj.1012

Tuboi C. (2013). Assessment of water quality and biomass productivity of the tropical floating meadows of Keibul Lamjao National Park, Manipur. Ph.D.thesis. Saurashtra University, Rajkot, Gujarat, India.

Tuboi C., Angom S., Babu M.M., Badola R. and Hussain S.A. (2012). Plant species composition of the floating meadows of Keibul Lamjao National Park, Manipur. *NeBio*, **3**: 1–11.

Tuboi C. and Hussain S.A. (2016). Factors affecting forage selection by the endangered Eld's deer and hog deer in the floating meadows of Barak-Chindwin Basin of North-east India. *Mammalian Biology*, **81**: 53–60.

WII. (2018). Action plan for conservation breeding of Sangai. Wildlife Institute of India. 20 pp.

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