Home range, habitat use and food habits of re-introduced gaur (Bos gaurus gaurus) in Bandhavgarh Tiger Reserve, Central India

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Research Article

Home range, habitat use and food habits of re-introduced gaur (*Bos gaurus gaurus*) in Bandhavgarh Tiger Reserve, Central India.

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Abstract:

Gaur, which became locally extinct before 1995 in Bandhavgarh Tiger Reserve (BTR), Central India, is an endangered animal per Schedule – I of the Indian Wildlife Protection Act (1972). A re-introduction program was therefore created to rebuild the gaur population in BTR, both to enhance the long-term survival of the species and to restore natural biodiversity. After re-introduction, the home range, habitat use and food habits of gaur (*Bos gaurus gaurus*) were studied in BTR, India, from January 2011 to January 2012. Nineteen gaurs (five males - three radio-collared and 14 females - nine radio-collared) were re-introduced from Kanha Tiger Reserve to Bandhavgarh Tiger Reserve in January 2011. The reintroduced gaurs were monitored periodically through ground tracking and satellite GPS fixes. The mean annual group size of gaur was estimated at 7.3 ± 0.76 (SE). The overall estimated summer, monsoon and winter home ranges of gaur were 290 km^2, 137 km^2 and 155 km^2 (Minimum Convex Polygon) respectively. The overall individual male home ranges varied from 135 to 142 km^2, and overall individual female home ranges varied from 32 to 169 km^2. Radio collared locations were plotted on a classified (LISS III) habitat map of Bandhavgarh Tiger Reserve to evaluate the habitat use and availability in each season. Habitat preference was computed using Bonferroni confidence interval method, compositional analysis and Ivlev's index. In summer, gaur largely preferred grassland (P<0.0001), whereas in monsoon and winter, gaur preferred bamboo mixed forest (P<0.0001). Gaur avoided open mixed forest (P<0.0001) and agricultural land in all three seasons. Data on food habits were collected through opportunistic sightings. In total, gaur fed on 68 plant species. The present study has reported first-time information on ranging patterns of reintroduced gaur and their degree of preferences for different vegetation and terrain types across seasons, which will be very useful to the park administration for future conservation of this endangered species and for habitat intervention.

Key words: Reintroduction, gaur *(Bos gaurus gaurus),* home range, habitat use, food habits, Bandhavgarh Tiger Reserve.

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Introduction

Gaur (*Bos gaurus gaurus*), family Bovidae, is one of the large wild ungulates of Asian jungles. Gaur is an endangered animal per Schedule – I of the Indian Wildlife Protection Act (1972). It is included in Appendix I of the Conservation on International trade in Endangered Species of Wild Fauna and Flora (CITES) and categorized as Vulnerable by the International Union for Conservation of Nature and Natural Resources (IUCN). Gaur is the tallest living ox [1], and one of the four heaviest land mammals (elephant, rhino and wild buffalo are the other three). Adult gaur bulls weigh 600-940 kg and stand 1.6 to 1.9 m at shoulder [2]. The adult cows are about 10 cm shorter in height [3] and weigh about one fourth less than the adult males [4]. Formerly gaur were distributed throughout the forested tracts of India and South Nepal, east to Vietnam and south to Malaya [5]. According to Ranjitsinh [6] the estimated population of gaur in India is between 12,000 and 21,000. Sankar et al. [7] estimated the gaur population in India to be approximately 23,500. Presently gaur occur in 101 existing and 27 proposed Protected Areas (PA's) of India covering 15 states. Tropical Moist Deciduous and Tropical Dry Deciduous forests are the dominant vegetation types within the present distribution limits of gaur [7].

The gaur population in India co-occurs with elephants (*Elephas maximus*) throughout its present distributional range, except in the Central Indian highlands, where elephants have become extinct [8]. Presently gaur are distributed in more or less isolated pockets, largely corresponding to the major mountain systems of the Western Ghats, the Central Indian highlands and the North-Eastern Himalayas, including the hills south of Brahmaputra. As ecosystem landscapers, gaur play an important role in the moist and dry deciduous forests in India, as they have a major impact on the physical structure of habitats, rates of ecosystem processes and the diversity of communities [9]. Also, mega-herbivores like gaur are important modifiers of ecosystem structure and function because they can trigger trophic cascades [10-11], increase spatial heterogeneity, accelerate successional processes [12] and influence nutrient cycling and primary productivity [13].

The last small population of gaur (30 to 32 individuals) migrated out of the Bandhavgarh Tiger Reserve (BTR) in 1995. This population was considered to be the only population north of the Narmada River, in Central India. The local extinction of gaur from the park also resulted in loss of biodiversity and decline in tourist numbers in the park [14]. Since BTR also has a considerable population of tigers (n~50), it was important to have gaur in the park as a prey species of tiger [14].

For the last two decades, captive breeding, reintroduction and translocation programs have become increasingly important conservation tools [15-16], although there are two important obstacles to re-establishing species: first, understanding the fundamental ecological requirements and life histories of species of concern [17], and second, identifying appropriate areas for reintroduction or restoration, given that degradation or modification can render native habitats unsuitable [18-19]. A study [20] showed that young rhino males do not adapt quickly to a new environment and hence are susceptible to high mortality, whereas adult and near adult males and females adapt faster. Another factor in the success of reintroductions is whether animals remain where they are released [21]. There are few reintroductions of mega-herbivores and herbivores reported, *viz.,* reintroduction of bison (*Bison bison*) into the rocky mountain parks of Canada [22], elk (*Cervus canadensis*) in America [23], reindeer (*Rangifer tarandus*) in Finland [24], white rhinoceros (*Ceratotherium simum*) in Botswana [25] and Asiatic One-horned Rhinoceros (*Rhinoceros unicornis*) in Dudhwa Tiger Reserve, Uttar Pradesh [26].

The re-introduction program to re-build the gaur population in Bandhavgarh Tiger Reserve (BTR) translocated and reintroduced an initial population of 20 animals, with subsequent supplementation of 30 more animals; the sex ratio was 60% females and 40% males. The simulations of gaur population viability analysis (PVA) showed that the probability of survival of reintroduced gaur in BTR is 0.9400

(0.023 SE). This program is the first successful mass trans-location of gaur in its entire distributional range. Following re-introduction of gaur in BTR, the present study was conducted from January 2011 to January 2012 with the following objectives: a) to estimate the home ranges of gaur in different seasons, b) to understand the habitat use and habitat preference of gaur in different seasons and c) to estimate the food habits of gaur.

Methods

Study area

Bandhavgarh Tiger Reserve lies on the extreme north-eastern border of the Madhya Pradesh state and the northern flanks of the eastern Satpura Mountain range (23°30' 08" to 23°47'05" N and 80°11'43" to 80°47'05" E). BTR consists of two conservation units: Bandhavgarh National Park (442.842 km^2) and the Panpatha Wildlife Sanctuary (245.842 km^2). The altitude of the park varies between 410 m and 811 m. The terrain is of rocky hills rising sharply from the swampy and densely forested valley in the low land. BTR lies within the tropical zone, having three distinct seasons. The area is characterized by well-defined winter (November-February), summer (March- June) and monsoon-post monsoon (July- October). During the study period, the lowest temperature reported was 2.2 °C in winter, and the highest was 44 °C in summer. Average rainfall is 1,173 mm, most of which occurs during the monsoon [27].

Vegetation of BTR falls under five categories [28]: moist peninsular low level sal (*Shorea robusta*) forest ($3C/C_{2e}$), northern dry mixed deciduous forest ($5B/C_2$), dry deciduous scrub (DS_1), dry grassland ($5/DS_4$) and West Gangetic moist mixed deciduous forest ($3C/C_{3a}$). Wild herbivores found are chital (*Axis axis)*, sambar (*Rusa unicolor)*, barking deer (*Muntiacus muntjak)*, nilgai *(Boselaphus tragocamelus)* and chinkara (*Gazella bennettii)*; large carnivores are tiger *(Panthera tigris)* leopard *(Panthera pardus*) and dhole (*Cuon alpinus*). The scavengers/ omnivores consist of striped hyena *(Hyaena hyaena)*, golden jackal (*Canis aureus*), wild pig *(Sus scrofa)* and sloth bear *(Melursus ursinus)*. Other small carnivores such as jungle cat (*Felis chaus*), rattle (*Mellivora capensis*), common mongoose *(Herpestes edwardsi*), ruddy mongoose (*H. smithi*), palm civet (*Paradoxurus hermaphroditus*) and small Indian civet (*Viverricula indica*) are also found. Primates such as common langur *(Semnopithecus entellus)* and rhesus monkey *(Macaca mulatta)*, and rodents/lagomorphs such as porcupine (*Hystrix indica)* and rufous-tailed hare *(Lepus nigricollis ruficaudatus)* occur in the park.

There are 15 villages (with human population of 6160 and livestock population of 11042) located inside the Tiger Reserve, of which seven are located in National Park and are due for relocation. Large numbers of domestic buffaloes (*Bubalus bubalis*) and a few domestic brahmini cattle (*Bos indicus*) are kept in the villages.

Capture and translocation of gaur

The action plan was prepared by the Madhya Pradesh Forest Department which envisaged capture and reintroduction of 20 gaur (15 adult females and 5 adult males) from KTR to BTR, Madhya Pradesh. It was proposed that after careful monitoring of the initial reintroduced stock, reintroduction of 30 more gaur to Bandhavgarh would be undertaken within two years to maintain a viable population of approximately 50+ animals [14].

Nineteen gaur, five males (three sub adults, two adults) and 14 females (one yearling, six sub adults, seven adults) were captured from KTR between 21st January and 27th January 2011 and re-introduced into BTR. Of these, 12 animals were fitted with radio collars: two adult males with GPS/satellite collars

and 10 individuals with VHF collars (one male and nine females). A holding Boma (enclosure for large herbivores; *Swahili* term, Mozambique) was designed at KTR where the immobilized animal would be released before eventually being loaded in the transport truck. The Boma was constructed of steel sections 2.5 m high by 3 m long made out of 50 mm x 75 mm x 3 mm rectangular hollow tubes. The Boma had three sliding gates 1.5 m wide and 2.5 m high sliding on a 3 m rail. The Boma had a loading ramp, which was a 3 m section made of solid pressed steel at 2.5 m height. The steel sections of the Boma beyond the sliding gate were covered with agri-mesh all the way up to the entrance of the truck. Since gaur are forest dwelling animals, this was done to give them a sense of having a space to hide in. Branches with foliage were hung on the wires running across the Boma. The Boma was divided into two compartments using bamboo mats and sliding gate, providing food, water and salt in the last compartment. Transport trucks and containers were designed according to the animals' needs. A stretcher was specially designed for carrying immobilized animals from the site of capture to the vehicle. A suitable site with good vegetation, cover and water was selected for the soft release of gaur at the borders of Tala and Magdhi ranges at BTR. The reintroduced gaur were released in a power-fenced 50 hectare plot in BTR. On 20th March 2011 the reintroduced gaur were released into the wild.

Home range

The radio-collared gaurs were monitored periodically through ground tracking, using "homing in" and "triangulation" techniques [29-31]. The satellite data up-link in both the satellite collars ceased functioning, one in August 2011 and the other in October 2011. Thereafter the gaur were tracked by VHF signals (ground tracking). The Minimum Convex Polygon (MCP) technique was used to determine the home-ranges of the gaur [32-34]. The interpretation and comparison of home-range size were measured by 100% MCP. The use of MCP was justified because of the sample size in a one year study period, and the temporally clustered nature of fixes that resulted in autocorrelation of results [35]. Accurate analyses using Fixed Kernel methods would not be suitable with this data set because they generally require larger samples with a more even distribution of the locations to maintain accuracy [36]. Minimum Convex Polygon (MCP) technique is one of the oldest techniques for home range estimation, comparable among species globally, and its inclusion as one or more methods of range calculation is therefore valuable [32-34]. Program CALHOME [37] and ArcGIS 9.2 (ESRI 2006) were used to estimate the home ranges of gaur. Home ranges of each individual in different seasons were estimated in the present study. Since gaur is a group living animal, the home ranges were also grouped by males and females to understand their overall seasonal home ranges.

Habitat use

All the radio telemetry locations from 12 radio-collared gaur were analyzed to evaluate the habitat use patterns. Season-wise gaur locations were plotted on the classified Landsat ETM+ imagery of BTR. On each collared location, the major vegetation and terrain type were recorded. Seven vegetation types were classified from Landsat ETM+ imagery: sal (*Shorea robusta*) forest, bamboo forest, open mixed forest, mixed forest, riparian forest, grassland and agriculture land [38]. Three major terrain types were categorised in the study area, *viz.,* flat, gentle slope and steep slope. Habitat use by gaur was estimated as the percent of locations found in each vegetation and terrain type. The 100% MCP home range represents the total area within which an animal has the opportunity to choose different vegetation types. Therefore, the availability of different vegetation types (percentage area) to a gaur was computed within its 100% MCP home range in a GIS domain [39]. Subsequently, habitat use (vegetation and terrain) of gaur in each season was computed using Bonferroni simultaneous confidence intervals and

Chi-square test [40], and the result was further validated by the preference rank of different vegetation types through compositional analysis [38] and Ivlev's electivity Index [41]. The analytical methods (Bonferroni simultaneous confidence intervals and compositional analysis) were conducted using the program RSW (Resource Selection Analysis Software for Windows) [42]. Each gaur was considered as a sample for statistical analysis [43].

Food habits

Data on food habits of gaur were collected by opportunistic sightings in all seasons whenever the animals were located using radio-telemetry. After direct observation through binoculars (8 X 40), on-site inspections were made to identify the food plants and parts eaten by gaur in the field. Total time spent for recording food habits data was 146 hrs in summer, 139 hrs in monsoon and 161 hrs in winter.

Results

Group size and composition

The group size of gaur varied from 1 to 19 individuals. The two gaur bulls (GM3 and GM5) were found solitary on many occasions (n=138) in all seasons (summer, monsoon and winter) and would join the family groups for a span of 10-15 days. The mean annual group size of gaur was estimated as 7.3 ± 0.8 (SE). The mean group size of gaur in summer was 9.5 ± 0.8 (SE), in monsoon 7.6 ± 1.4 (SE) and in winter 5.3 ± 1.2 (SE).

Home range of gaur

In total, 3972 locations of radio collared gaur were obtained, of which 1579 locations were males and 2393 locations were females (March 2011 to January 2012). The number of radio collared locations obtained and home ranges of individual gaur are given in Appendix 1. The month-wise utilized area (in km^2) by the gaur is given in Fig. 1.

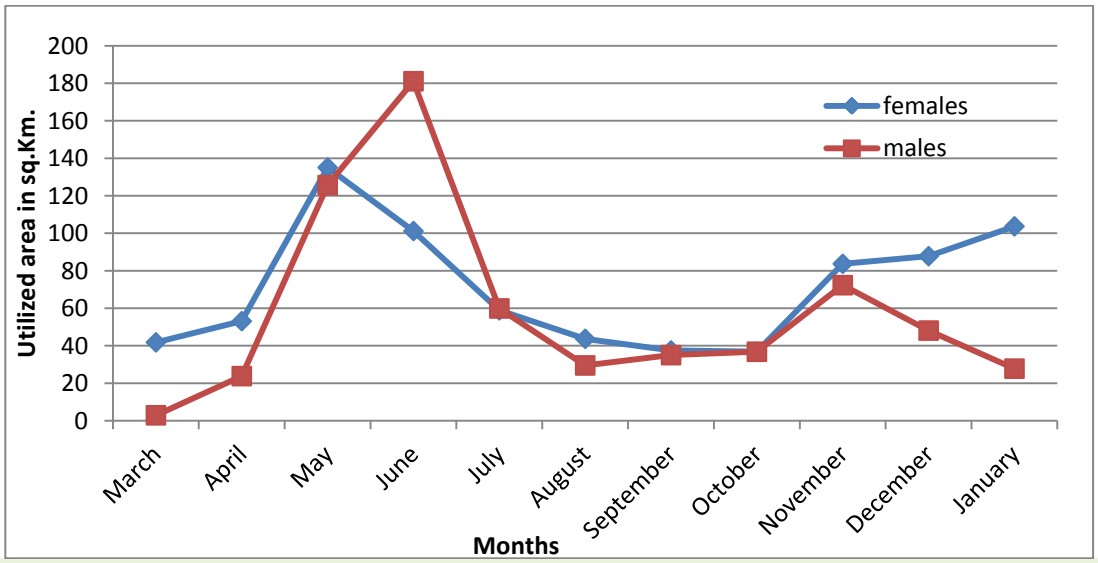

Fig. 1. Month-wise area of utilization of gaur in Bandhavgarh Tiger Reserve (March 2011- January 2012).

The estimated summer, monsoon and winter home ranges of the gaur were 290 km^2, 137.1 km^2 and 155 km^2 respectively. The overall home ranges of the males and females during the study period (March 2011 to January 2012) were 255 km^2 and 200 km^2, respectively, and the home-range overlap was 186 km^2 (Fig. 2). The summer (March 2011-June 2011) home ranges for males (n= 559) and females (n= 1338) were 231 km^2 and 161 km^2, respectively. In monsoon and post-monsoon (July 2011 to October 2011) the home ranges of males (n= 607) and females (n= 828) were 111 km^2 and 136 km^2 respectively. In winter (November 2011 to January 2012) the home ranges of males (n= 227) and females (n= 413) were 98 $km^2$and 152 km^2 respectively (Fig. 3). The overall individual male home ranges varied from 135 to 142 km^2 and overall individual female home ranges varied from 32 to 169 km^2.

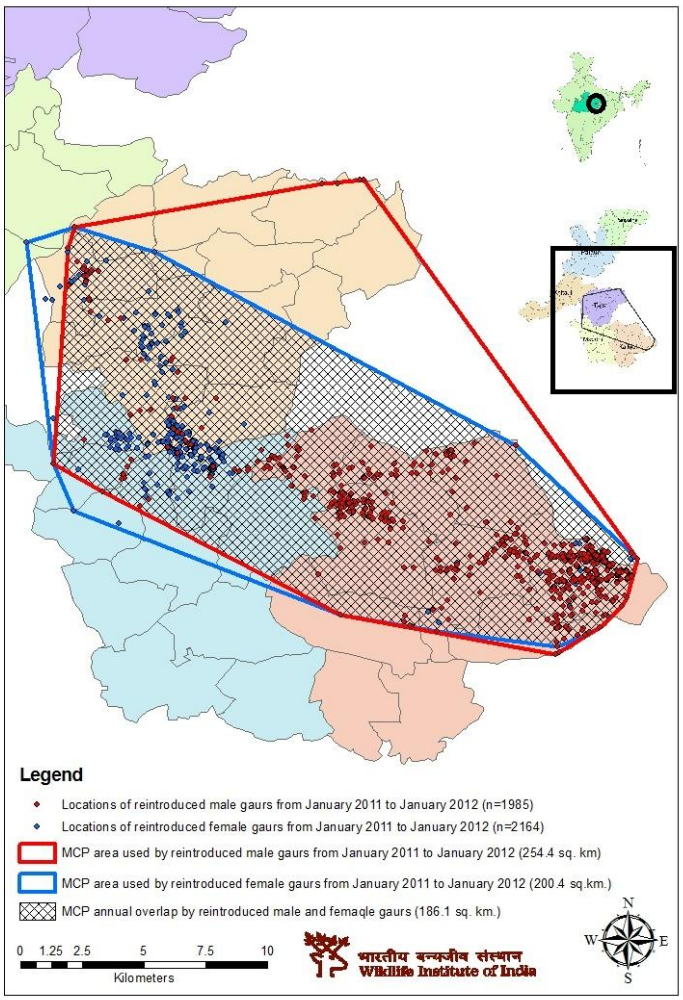

Fig.2. Overall home range of male and female gaur and their area of overlap in Bandhavgarh Tiger Reserve (March 2011- January 2012).

Natality and Mortality

There were four births during the study period, of which three calves survived. In total four animals died, of which two were collared females that died naturally. A sub-adult female was killed by a tiger on 4th June 2011. An un-collared female went missing from the park on 27th March 2011.

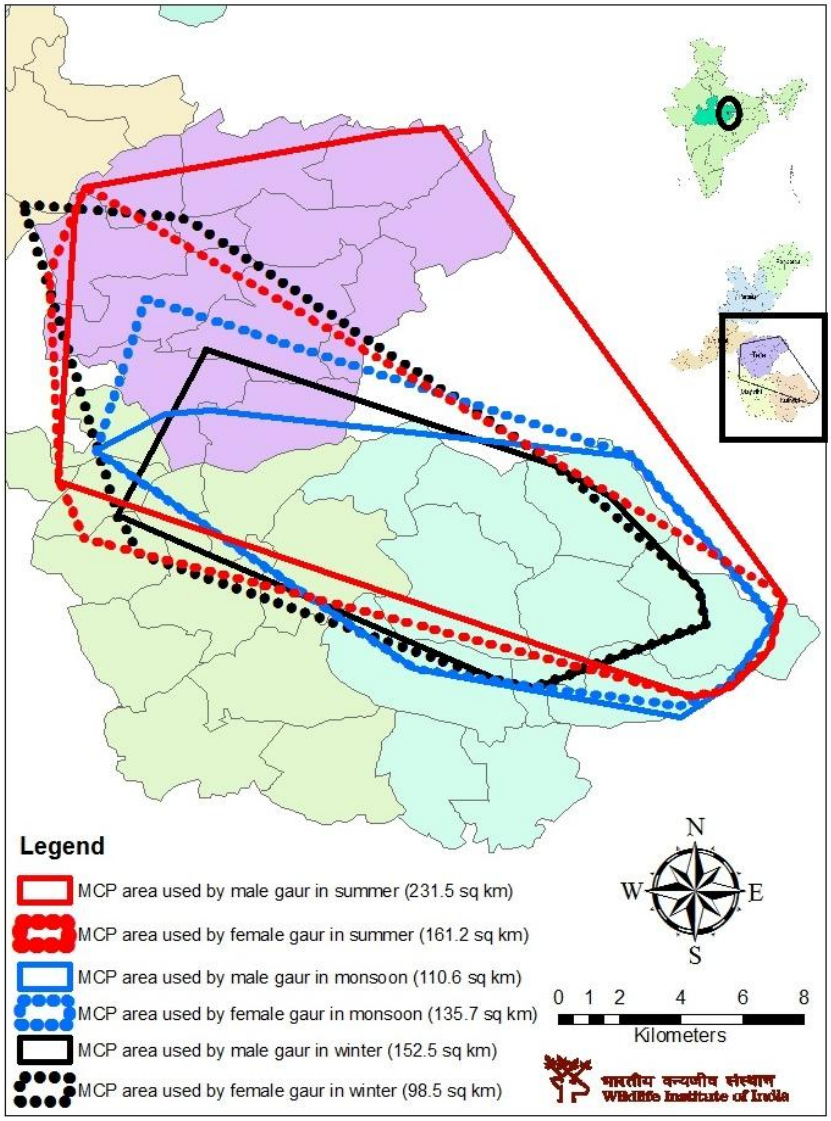

Fig. 3. Locations and home range of gaur season-wise (summer, monsoon and winter) in Bandhavgarh Tiger Reserve.

Habitat use by gaur

In summer, gaur used grassland ($P<0.001$) and sal forest ($P<0.001$) habitats more than their is availability; mixed forest ($P<0.001$), open mixed forest ($P<0.001$) and agricultural land ($P<0.001$) were less used than their availability; bamboo forest and riverine forest were used in proportion to their availability ($X^2=62.6731$, df= 6, $P<0.0001$, $\lambda= 0.0054$; Bonferroni simultaneous confidence intervals and Chi-square test) (Appendix 2). The summer habitat preference of gaur was in the following order: grassland> sal forest> bamboo forest> riparian forest> mixed forest> agricultural land> open mixed forest. In monsoon, gaur used bamboo forest ($P<0.001$) more than its availability; mixed forest ($P<0.001$), open mixed forest

(P<0.001) and agricultural (P<0.001) land less than their availability; grassland, sal forest and riparian forest were used in proportion to their availability (X^2=54.2351, df= 6, P<0.0001, λ= 0.028; Bonferroni simultaneous confidence intervals and Chi-square test) (Appendix 2). The monsoon habitat preference of the gaur was in the following order: bamboo forest >grassland> sal forest> mixed forest> riparian forest> open mixed forest> agricultural land. In winter, gaur used bamboo forest (P<0.001) more than its availability; grassland (P<0.001), sal forest (P<0.001), open mixed forest (P<0.001) and agricultural land less than their availability; mixed forest and riparian forest were used in proportion to their availability (X^2=33.0898, df= 6, P<0.0001, λ= 0.016; Bonferroni simultaneous confidence intervals and Chi-square test) (Appendix 2). The winter habitat preference of gaur was in the following order: bamboo forest> mixed forest> riparian forest> sal forest> grassland> open mixed forest> agricultural land. Ivlev's electivity Index provided identical results as compositional analysis for ranking of preference of different habitats by gaur in BTR (Appendix 3).

Gaur mostly used flat terrain (65%) compared to gentle slope (28%) and steep slope (7%). The use of undulating terrain by gaur increased in monsoon and winter compared to summer. The use of terrain with a gentle slope went up from 25% in summer to 45% in winter. Gaur used flat terrain mostly in summer (71%) followed by monsoon (63%) and winter (51%). The steep slope was used by gaur mostly in monsoon (12%) followed by winter (4%) and summer (4%).

Food habits

In total 68 plant species were consumed by gaur (Appendix 4). Among the food plants eaten the number of tree species were maximum (n=28) followed by grass (n=21), herbs (n=10), shrubs (n=6) and climbers (n=3). The number of tree species in the diet of gaur was considerably higher in summer (n=22) than in monsoon (n=11) and winter (n=9). On the other hand, the number of grass species consumed by gaur was higher in monsoon (n=14) than in summer (n=10) and winter (n=9). Five incidences of de-barking of sal (*Shorea robusta*) and three incidences of de-barking of mahuwa (*Madhuca indica*) by the gaur were recorded in peak summer.

Discussion

The group size of gaur may range from 1 to 16 animals [1, 7, 44-46] and occasionally up to 40 individuals [47-48]. In Pench Tiger Reserve the observed mean group size of gaur was highest in winter (5.6 ± 0.42), followed by monsoon (4.6 ± 0.29) and summer (3.9 ± 0.14), and significant differences in the group sizes between summer and monsoon were reported [7]. In Mudumalai Tiger Reserve, the overall mean group size of gaur was 9.8 ± 7.6, while in dry season it was 8.7 ± 6.2 and in wet season it was 10.2 ± 7.9 [49]. In Parambikulam Wildlife Sanctuary the mean group size of gaur was 6.0 [50]. In the present study there was no significant difference observed in the gaur group size in different seasons. Hence, it can be assumed that different seasons played a negligible role in determining group size of gaur in BTR.

It was observed that the relocated gaur initially (March 2011 to June 2011) utilized an area of 290 km^2 after their reintroduction, and subsequently their ranges were reduced to 160 km^2 after exploration of new areas. In Pench Tiger Reserve, the home range of male gaur was 12.6 km^2 and 7.6 km^2 in summer and monsoon respectively, while in the present study, the home ranges of male gaur were much larger. The home ranges of female gaur in Pench Tiger Reserve were 7.2 km^2 and 13.8 km^2 in summer and monsoon respectively, while in the present study, the home ranges of female gaurs were much higher. The observed smaller home ranges of gaur males and females in all seasons in Pench Tiger Reserve may be attributed to the availability of food resources and water through the year [7]. In BTR, gaur were found to utilize grasslands more during summer and bamboo forest more in monsoon and winter. Gaur

is a generalist feeder but prefers to browse in dry season and predominantly graze in monsoon [49]. Riparian forest was used by the gaur according to its availability in all the seasons, because a number of perennial streams and artificial waterholes are found in riparian forests which serve as the major source of water in the Park. Open mixed forest was avoided by gaur in all seasons, as it lacks food resources and water. Agricultural land was avoided by gaur in all seasons because of anthropogenic disturbance. In Kanha Tiger Reserve gaur frequently used the meadows and low-lying areas during most part of the year except monsoon, when the animals moved up and dispersed into the hills [47]. In Bandhavgarh also the gaur used areas with steep slope more in monsoon than in summer and winter.

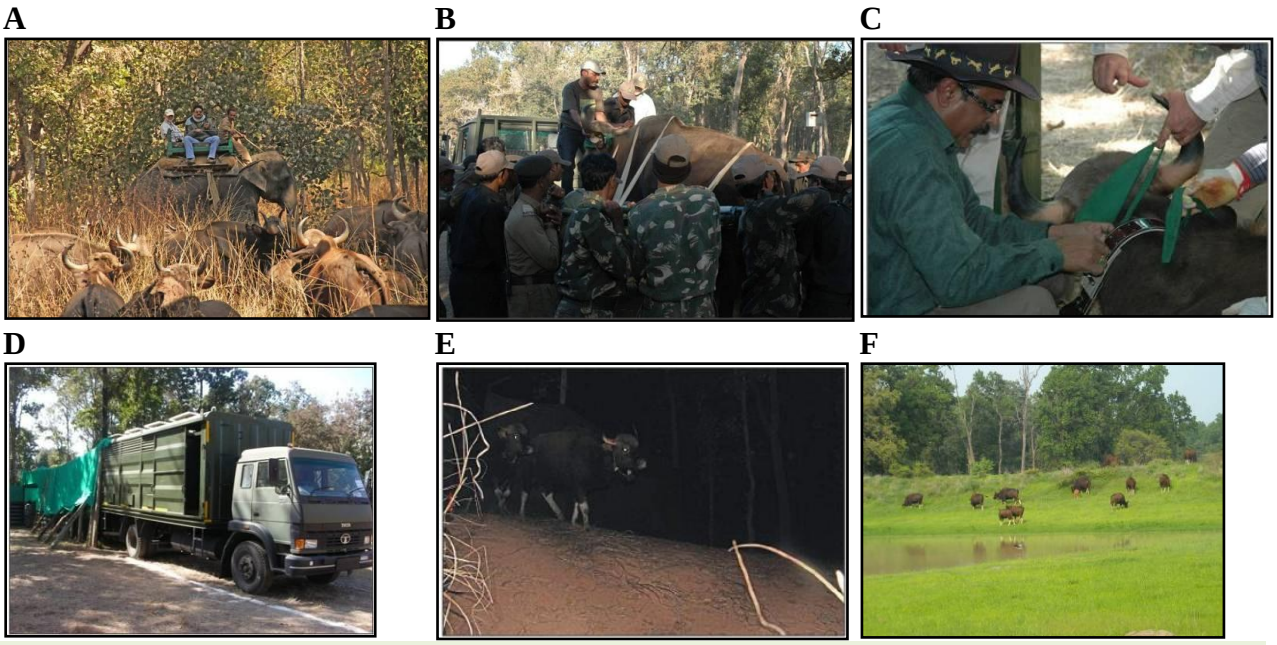

Fig. 4. A: Gaur Capture in Kanha Tiger Reserve; B: Gaur shifting into a small truck in Kanha Tiger Reserve; C: Fitting of radio-collar on gaur at Kanha Tiger Reserve.; D: Truck used to transport gaur from Kanha TR to Bandhavgarh TR.; E: Gaur released in an enclosure at Bandhavgarh Tiger Reserve; F: A herd of free ranging gaur in Bandhavgarh TR. PHOTO CREDITS – By Authors

Gaur have been reported to feed on the bark of trees such as *Adina cordifolia* and *Tectona grandis* in many areas throughout central India [47, 51]. In dry seasons, a high fibrous diet increases digestive efficiency by increasing the retention time of food in the gut [52] and also by increasing the turnover rate of the rumen content [53]. Incidences of de-barking of trees by gaur were rare in BTR, perhaps because even in summer considerable green foliage (trees/shrubs/bamboo) is available in the park.

Village relocation plays a major role in reducing the anthropogenic pressures on the forest area and is highly beneficial to wild animals [54]. In BTR there are 15 villages with large livestock populations located inside the National Park. Two villages in Kallwah range (Kallwah and Kumuruwah) from the National Park were successfully relocated in June 2011, which can set an example to expedite relocation of the remaining villages. Since August 2011, gaurs have been observed using these relocated village sites and hence creation of more such vacated habitats is vital for conservation of this species. Gaur are highly susceptible to transmission of infections from domestic livestock, and there are many records of populations of gaur succumbing to epidemics of foot and mouth disease (FMD), rinderpest and anthrax

in various parts of its distributional range [55]. There is a need to implement a wide vaccination program for the domestic livestock in and around BTR, to prevent the transmission of livestock diseases to gaur.

Implications for Conservation

The known extinction of gaur from three protected areas in India (Thattakad Wildlife Sanctuary, Kerala; Bhandhavgarh Tiger Reserve and Kanger Valley National Park, Madhya Pradesh) in the last two decades shows that this species is losing ground very fast and urgent measures are required to stem the process. Therefore, conservation requires active programs like reintroduction and reestablishment of important species in the areas where they have been recently lost, with or without habitat related interventions. Hence, the gaur reintroduction program in Bandhavgarh Tiger Reserve is an important attempt to re-establish a gaur population in an area that was once part of its historical range, from which it was locally extirpated in the recent past (Fig. 4). The present study takes a successful step towards the conservation of this large bovid, providing first-time information on ranging patterns of gaur and their degree of preferences for different vegetation and terrain types in different seasons. Such information will be very useful to the park administration for conservation of this endangered species and for habitat intervention, if needed. Per the proposed supplementation plan, 31 more gaur (nine males and 22 females) were reintroduced in BTR during March 2012 to establish a viable population of 50 animals.

A long-term study on ecological aspects such as ranging pattern, habitat use, food habits and predation of the reintroduced gaur in BTR will be crucial for the conservation and management of this endangered bovid. Also, the protocol prepared for gaur capture, chemical immobilization and transportation [14] will be highly useful for managers and conservationists in planning and execution of similar reintroduction program of mega-herbivores in their entire distributional range.

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Appendix 1. Home ranges of individual gaur in different seasons (summer, monsoon and winter) in Bandhavgarh Tiger Reserve.

Gaur ID	Summer	Monsoon	Winter			
	Home range (km^2)	Number of locations	Home range (km^2)	Number of locations	Home range (km^2)	Number of locations
GF1	44.5	196	108.7	207	83.4	81
GF3	44.5	194	108.7	207	95.9	81
GF5	33.1	119	xx	-	-	-
GF6	110.4	106	^^	-	45.8	86
GF7	106.5	106	xx	-	-	-
GF8	106.5	164	108.7	207	95.9	81
GF9	110.6	139	^^	-	^^	-
GF10	44.5	178	108.7	207	95.9	84
GF14	123.6	136	^^	-	^^	-
GM1	44.5	196	108.7	207	95.9	81
GM3	45.2	196	108.7	207	87.7	79
GM5	231.5	167	110.6	193	95.3	67

Note: GF= Gaur female; GM= Gaur male; 'xx'= animal dead; '^^'= animal was kept inside enclosure.

Appendix 2. Preference of different vegetation types by gaur in Bandhavgarh Tiger Reserve as shown by Bonferroni simultaneous confidence interval analysis.

Habitat types	Proportion use		Proportion available	Preference	Significance
	Lower limit	Upper limit			
Summer					
Agriculture land	0.0000	0.0112	0.0148	Used less than availability	
Bamboo forest	0.1412	0.1996	0.1862	Used in proportion to availability	
Grassland	0.3573	0.4332	0.0935	Used more than availability	P < 0.0001
Mixed forest	0.1406	0.1989	0.4535	Used less than availability	P < 0.0001
Open mixed forest	0.0087	0.0301	0.0659	Used less than availability	P < 0.0001
Riparian forest	0.0079	0.0287	0.0278	Used in proportion to availability	
Sal forest	0.1893	0.2537	0.1582	Used more than availability	P < 0.0001
Monsoon					
Agriculture land	0.0000	0.0000	0.0134	Used less than availability	
Bamboo forest	0.3525	0.4523	0.1758	Used more than availability	P < 0.0001
Grassland	0.0757	0.1386	0.0942	Used in proportion to availability	

Mixed forest	0.2556	0.3490	0.4745	Used less than availability	P < 0.0001
Open mixed forest	0.0000	0.0000	0.0557	Used less than availability	P < 0.0001
Riparian forest	0.0087	0.0401	0.0398	Used in proportion to availability	
Sal forest	0.1261	0.2014	0.1466	Used in proportion to availability	
Winter					
Agriculture land	0.0000	0.0000	0.0142	Used less than availability	
Bamboo forest	0.3201	0.4117	0.2035	Used more than availability	P < 0.0001
Grassland	0.0094	0.0386	0.0976	Used less than availability	P < 0.0001
Mixed forest	0.4248	0.5198	0.4314	Used in proportion to availability	
Open mixed forest	0.0000	0.0000	0.0494	Avoided	P < 0.0001
Riparian forest	0.0062	0.0323	0.0245	Used in proportion to availability	
Sal forest	0.0878	0.1493	0.1795	Avoided	P < 0.05

Appendix 3. Preference of different habitat types by reintroduced gaur in Bandhavgarh Tiger Reserve as shown by Ivlev's Selectivity Index analysis.

	Summer			Monsoon			Winter		
	Use	Availability	Ivlev's Index	Use	Availability	Ivlev's Index	Use	Availability	Ivlev's Index
Agriculture land	6.55	17.61	-0.45778	0	9.37	-1	0	11.39	-1
Bamboo forest	204.44	221.76	-0.04064	281.68	123.09	0.391803	292.71	162.77	0.285281
Grassland	474.29	111.39	0.619622	75.03	65.94	0.064482	19.2	78.09	-0.6053
Mixed forest	203.73	340.06	-0.45218	211.6	332.2	-0.22177	377.87	345.09	0.045341
Open mixed forest	23.26	78.53	-0.54298	0	38.96	-1	0	39.49	-1
Riparian forest	21.92	33.06	-0.20262	17.08	27.87	-0.24004	15.38	19.57	-0.11989
Sal forest	265.8	188.38	0.170461	114.61	102.61	0.055244	94.86	143.59	-0.20436

Appendix: 4. Food plants and parts eaten by gaur in Bandhavgarh Tiger Reserve (January 2011 to January 2012).

Family	Species	Parts eaten	Season
Trees			
Rutaceae	*Aegle marmelos*	Le	S
Leguminoseae	*Albizzia procera*	Le	S
Combretaceae	*Anogessus latifolia*	Le	S
Leguminoseae	*Bauhinia Racemosa*	Le	S
Burseraceae	*Boswellia serrata*	Le	M, W
Euphorbiaceae	*Bredelia retusa*	Le	S
Anacardiaceae	*Buchanania lanzan*	Le	M
Leguminoseae	*Butea monosperma*	Le	S, M, W
Meliaceae	*Chlorozylon swetiena*	Le	W
Fabaceae	*Cassia fistula*	Le	M
Poaceae	*Dendro calamus strictus*	Le	S, M, W
Ebenaceae	*Diospyros melanoxylon*	Le	S, M
Moraceae	*Ficus hispida*	Le	S
Bixaceae	*Flacourtia ramontchi*	Le	S, M
Tiliaceae	*Grewia tiliifolia*	Le	S
Apocynaceae	*Holarrhena antidysenterica*	Le	S
Sapotaceae	*Madhuca indica*	Le, Fu, Fl	S, M, W
Rubiaceae	*Mitragyna parviflora*	Le	S
Euphorbiaceae	*Phyllanthus emblica*	Le, Fu	S
Dipterocarpaceae	*Shorea robusta*	Le, Br	S, M, W
Myrtaceae	*Syzygium cumini*	Le, Fu	S, M
Combretaceae	*Terminalia chebula*	Le	W

Family	Species	Parts eaten	Season
Combretaceae	*Terminalia arjuna*	Le, Br	S
Combretaceae	*Terminalia tomentosa*	Le	S
Labiateae	*Vitex sps.*	Le	S
Apocynaceae	*Wrightia tinttoria*	Le	W
Rhamnaceae	*Zizyphus mauritiana*	Le, Fu, Br	S, M, W
Rhamnaceae	*Zizyphus xylopyra*	Le, Fu	S
Shrubs			
Colchicaceae	*Gloriosa sps.*	Le	M, W
Verbinaceae	*Lantana camara*	Le	S, M
Fabaceae	*Mimosa hamata*	Le	M
Arecaceae	*Phoenix acaulis*	Le	S
Rubiaceae	*Randia dumetorum*	Le	S
Lytharaceae	*Woodfordia floribunda*	Le	S, M, W
Herbs			
Asparagaceae	*Asparagas racemosus*	Sh	S
Cyperaceae	*Bulbostylis barbata*	Sh	M, W
Leguminoseae	*Cassia tora*	Sh	S, M
Cyperaceae	*Cyperus sps.*	Sh	M, W
Leguminosae	*Desmodium heterocarpus*	Sh	M, W
Fabaceae / Leguminosae	*Desmodium pulchellum*	Sh	M, W
Euphorbiaceae	*Euphorbia hirta*	Sh	S
Lamiaceae	*Leucas aspera*	Sh	M
Lamiaceae	*Leucas biflora*	Sh	M, W
Lamiaceae	*Ocimum tenuiflorum*	Sh	M
Grasses			
Amaranthaceae	*Achyranthes aspera*	Sh	M, W
Poaceae	*Andropogon sps.*	Sh	S

Family	Species	Parts eaten	Season
Poaceae	*Apluda mutica*	Sh	S
Poaceae	*Aristida sps.*	Sh	S
Poaceae	*Chloris dolichostachya*	Sh	S, M, W
Poaceae	*Cynodon dactylon*	Sh	S, M, W
Poaceae	*Dicanthium sps.*	Sh	S
Poaceae	*Digitaria setigera*	Sh	M, W
Poaceae	*Eragrostis tenella*	Sh	M
Poaceae	*Heteropogon contortus*	Sh	M, W
Cyperaceae	*Lipocarpha chinensis*	Sh	M
Poaceae	*Oplismenus sps.*	Sh	S
Poaceae	*Paspalidium flavidum*	Sh	M
Poaceae	*Saccharum spontaneum*	Sh	M, W
Poaceae	*Setaria glauca*	Sh	M
Poaceae	*Seteria pumila*	Sh	M
Poaceae	*Sorghum halepense*	Sh	S
Poaceae	*Sporobolous pulchelus*	Sh	W
Poaceae	*Themeda triandra*	Sh	S, M, W
Gramineae	*Thysanolaena maxima*	Sh	M
Poaceae	*Vetiveria zizanioides*	Sh	S, M, W
Climbers			
Rhamnaceae	*Zizyphus oenopila*	Le, Br	W
leguminoseae	*Butea supreba*	Le, Br	W
Fabaceae	*Bauhinia vahlii*	Le, Br	S, M, W

Le-Leaves; Br-Bark; Fr- fruits; Fl- Flowers; Sh- Shoot; S -Summer; M - Monsoon; W – Winter.