Ela Foundation

Ela Journal of Forestry and Wildlife

ISSN 2319-4361
(Indexed in Google Scholar)

Volume 5 | Issue 2
April - June 2016

A quarterly scientific refereed e-Journal of Ela Foundation and Forest Department, Maharashtra for Nature Conservation through Education and Research

GIB Special Issue

Includes papers on:

- Habitat • Food • Flora • Telemetry • Acarology
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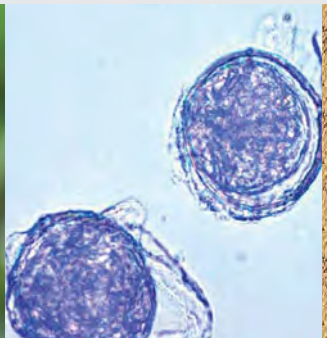
- Conservation viewpoint • Policy viewpoint



Struggle for survival

Dr. Satish Pande

It is estimated that less than 300 Great Indian Bustards *Ardeotis nigriceps* exist in the wild worldwide, as of today. This elegant and large bird is on the brink of extinction. The highly fragmented populations survive in India and Pakistan. In India it is distributed in Rajasthan, Gujarat, Maharashtra, Karnataka and Andhra Pradesh and is is not recently recorded from Madhya Pradesh. The Maharashtra Forest Department took a noteworthy initiative in 2013-2014, when the first ever GIB was fitted with a 70 gm solar powered satellite telemeter – PTT in Chandrapur Forest Division with the help of Wildlife Institute of India on the day of Christmas 2013.

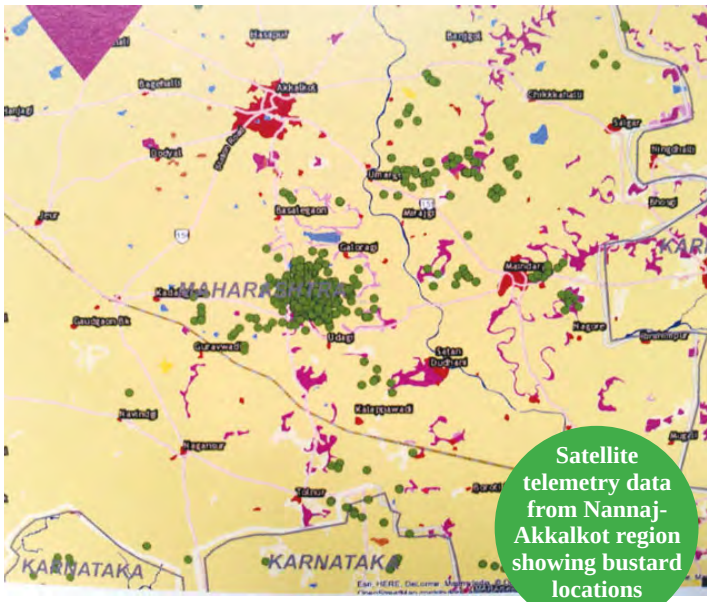
The data revealed that the GIB not only visited the protected compartments of the forest division (7 - A and B) but also frequented non-forest private lands near Warora and Bhatalia and the bird moved as much as 25 km. The PTT then failed due to technical snags. Based on the initial data, policy for the management of protected areas in Bhadrawati and Chandrapurwas districts was formulated under the guidance of Sanjay Thakre, IFS, CCF, Chandrapur. The government decided to extend the telemetry study to Nannaj, Maharashtra under the stewardship of Sunil Limaye, IFS, CCF-WL, Pune, where two more GIB's were fitted with telemeters by Bilal Habib of WII, Dehradun. Again the same movement pattern was seen from the data received from the PTT's. It was actually found that the GIB's spent more time on non-protected privately owned lands. Not that this was something new to the Forest Department, but the PTT gave actual locations of the bird both within and outside the protected areas (PA's). The GIB frequented Nannaj, Akkalkot, Vairag, Murum and Jevali. This micro-geo-location data about GIB movements outside the PA's has now posed new problems for the forest department managers because the use of land outside their jurisdiction is not under their control.

Fortunately, the farmers in these villages have unknowingly offered the much needed shelter for the GIB in their private lands, because they have resorted to traditional non-intense and organic cropping practices with land sparing and have kept large areas of cropland as fallow, mainly due to absence of irrigation and dry climatic conditions (eg. at Vairag in summer). In areas where intense farming was observed (Murum, Akkalkot and Jevali) the GIB was seen only on fallow and undisturbed land. Within the PA's of Nannaj the GIB was seen on open patchesin PA's for 4 months and outside the PA's for 7 months, spending more time on non-protected private landscapes.

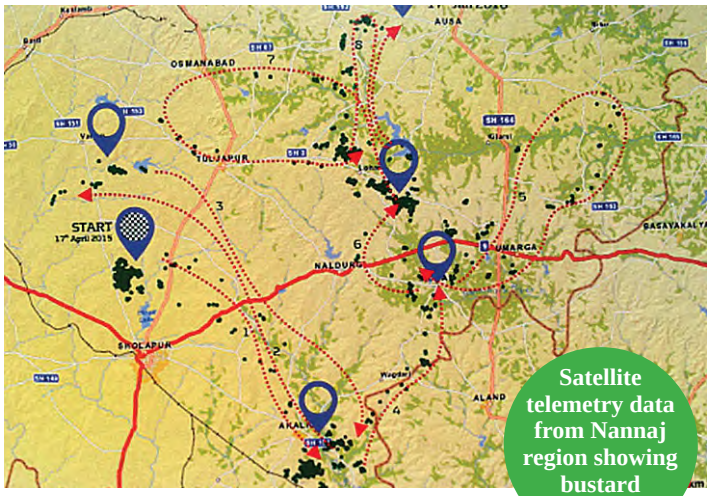
Telemetry data has showed that the GIB was also seen in the vicinity of intensely cultivated fields on adjacent fallow lands near irrigation canals where drinking water was available. For preserving such areas as open landscapes and not allowing cultivation on such land, compensatory mechanisms for the local farmers need to be urgently formulated, if the presence of GIB in such landscapes is to be assured in the future. The GIB presence is dictated by local community support, types of farming practices, landscape structure, prey species richness and abundance, sheltering and safety opportunities and breeding habitat availability. These factors have become the limiting factors for its presence. Hence, identification and conservation of multiple patches of micro-habitats used by the GIB is needed that the scattered populations of GIB can use for roosting, feeding and breeding; where they experience freedom from disturbance and persecution, both in the PA's and outside the PA's, the latter being the major challenge in front of the forest department. Open, fallow and semi-arid areas suitable for the GIB are already diverted for industrialization, with high tension power lines crisscrossing and surrounding the GIB habitats. It is now known that in the past 8 years 7 GIB's have died from electrocution, thereby drastically reducing their already meager population.

Though the bustard has been documented in India particularly in Maharashtra since mid-first millennium BCE through zoo-archaeological evidence, today, all the suitable GIB habitats are surrounded by human dominated areas. Hence, without community support the GIB cannot exist. Participatory management with the whole hearted support of sensitive local rural communities where GIB is recorded will need community

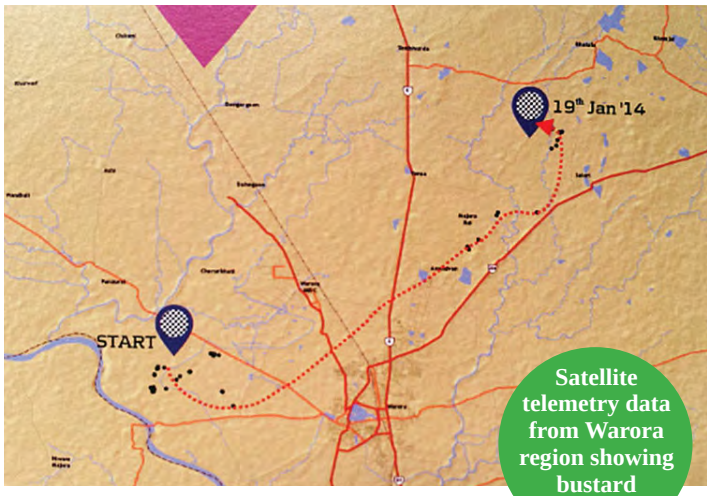
education programs, as is being done in Chandrapur and Nannaj, by forming Biodiversity Management Committees with joint government and community participation. The key to this is transparency in policy and winning the community confidence without jeopardizing their interests! We need a GIB and farmer friendly policy. Unless the farmers in the areas of GIB presence cooperate in minimizing pesticide and insecticide use, curtail high intensity farming, practice intentional land sparing; unless the menace of stray dogs is controlled and communities develop a tolerance for GIB, and report GIB sighting to the forest department officials; and in return the forest department reciprocates by suitable compensations, appreciation and understanding, the GIB cannot be saved. Continued surveillance with satellite trackers will assist the forest department in identifying areas for focusing the conservation efforts, but that will only be the beginning of the Herculean conservation exercise.



Satellite telemetry data from Nannaj-Akkalkot region showing bustard locations



Satellite telemetry data from Nannaj region showing bustard locations



Satellite telemetry data from Warora region showing bustard locations

[Above maps are provided by CCF (WL), Pune from: Habib, B. Talukdar, G. Kumar, R.S. Nigam, P. Limaye S., and Vaijayanti, V. (2016). Tracking the Great Indian Bustard in Maharashtra India. Technical Report 2016. Wildlife Institute of India and Maharashtra Forest Department. Pp 20.]

Conserving the Prince of the Grasslands

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Citation: Hussain M, (2016). Conserving the Prince of the Grasslands
Ela Journal of Forestry and Wildlife 5(2):173-174

Date of Publication:
30-6-2016

ISSN 2319-4361

Photograph: Niranjan Sant

The Great Indian Bustard *Ardeotis nigriceps* (henceforth GIB) is an obligate grassland bird and along with the Lesser Florican *Sypheotides indicus*, represent two species of birds that are in imminent danger of extinction in India. This issue of the *Ela Journal of Forestry and Wildlife* (EJFW) is primarily dedicated to field observations on the GIB and possible road map for its recovery.

The GIB has been listed in the critically endangered category by Birdlife International and IUCN in 2011. It has disappeared from about 90% of its range. There are only 200 birds left in India from about 750 to 780 in 1980. The total world population is estimated to be only 300 with no known breeding population outside India. In Maharashtra there are now about 20 to 25 GIBs from about 60 in 1980. Although post 1980, there are 8 sanctuaries for protection of the GIB (it is the state bird of Rajasthan), there has been a drastic fall in its population. This calls for a careful relook at conservation measures and identification of critical issues. This present issue of the EJFW attempts to highlight these conservation aspects.

The habitat needs of the GIB in the breeding and non breeding seasons are different and generally the female lays a single egg which it incubates for about 25 days by guarding the nest alone, on her own. The hatched chick fledges in about 75 days and is associated with the mother for food, protection and training for over a year. Disturbance to the nests, hatching and fledging are pivotal causes of breeding failure

Conservation measures start from looking at the status of grassland ecosystems. These have been severely affected by conversion of grasslands to tree plantations and differential use of common pastures. This implies the need for not only proper grassland management but also a total landscape management in the identified areas in a public- private partnership.

The Ministry of Environment and Forests has come up with guidelines for recovery program of the GIBs which is primarily based on outstanding research done

by the Wildlife Institute of India and Bombay Natural History Society, amongst others. The salient features are given below:

1.) Species Level Recovery

A. Study of autecology of the GIB to ascertain change of population over time and space.

B. Conservation Breeding, both *ex situ* and *in situ* due to K-selection nature as well as poaching. Inbreeding is another area to flag.

2.) Habitat Recovery

A. Core areas protection plan is required, especially of breeding areas.

B. Landscape level plan of conservation is needed where the GIB conservation is integrated with livelihood needs of people.

C. Species and habitat recovery, through careful monitoring and research studies.

The immediate and long term studies required are summarized below:

1. A centrally coordinated population estimation protocol needs to be brought in place to ascertain habitat relationships and seasonal movement patterns.
2. The traditional knowledge of people living in GIB habitat can be documented to get insight into some grey areas.
3. Quantitative data on the effect of predators and anthropogenic disturbances on GIB breeding is required.
4. Studies to check the movement of the birds during different seasons is necessary to know where and how it seems to disappear from the landscape.
5. The effect of grazing intensities and patterns on GIB needs to be studied.
6. The two critical life history phases of GIBs are breeding failure and death of adult birds. Factors influencing these need to be restudied and solutions found to allow recovery.
7. The impact of pesticides and other chemicals on the health of the GIBs needs to be studied to understand the effects in different stages of the life history.
8. The change in land use pattern over time and the resultant effect on GIB populations need to be assessed to know the causes linked to decline of the birds.

Some of the above studies have been already done by noted researchers from time to time, but the GIBs tend to be elusive. Alarmingly, with critical depletion of the birds, new parameters need to be assessed and indicators of GIB health listed. The most important aspect of GIB conservation is to bring in willingness in participation of local farmers and other local stakeholders. It would be necessary to develop incentives in the form of compensatory packages where required. The need of the times would be close cooperation of the government, local village leaders / gram-panchayats, researchers and NGOs. In some areas corporates are also stakeholders and it will be necessary to garner their support. Without concerted and multi pronged support, the Prince of the grasslands will be lost forever!

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Conserving the Great Indian Bustard *Ardeotis nigriceps* in Solapur District

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Citation: Limaye, S. (2016). Conservator's View Point: Conserving the Great Indian Bustard *Ardeotis nigriceps* in Solapur District
Ela Journal of Forestry and Wildlife 5(2):175-176

Date of Publication:
30-6-2016

ISSN 2319-4361

Photographs provided by the author

The Great Indian Bustard (GIB) *Ardeotis nigricolis* is a critically endangered avian species endemic to the Indian subcontinent. It exists in fragmented population in the state of Rajasthan (with a population in adjacent Pakistan), Maharashtra, Andhra Pradesh, Gujarat and Karnataka in India with a global population of around 300 wild birds. The largest populations exist in Jaisalmer, Barmer, and Bikaner districts of Rajasthan (100-125 bustards). The remaining population clusters are of less than 35 birds each. In the non- breeding season this grassland species inhabits low intensity agricultural lands or scrublands in semi- arid regions. During the breeding season, it congregates at undisturbed or less disturbed, traditional breeding grounds. It adopts the 'lek' system characterized by polygynous males defending small clusters of landscape units that are visited by females prior to mating. The GIB exhibits exploded leks, a variant of the classical lek system. The male GIB displays in an assemblage but the males remains considerably separated from one another and such aggregations are not detectable until they are mapped over a larger area. As a consequence, males hold larger territories and females can forage and even nest within them, unlike in classical leks where males would be the only resource users. This unique system followed by the GIB is however under a grave threat as more and more leking sites undergo drastic alterations due to land use change and other human disturbances, thereby posing a great challenge to conserve this magnificent bird.

The foraging area of the GIB, which comprises of open grassland and rain fed agricultural cropland, is getting reduced day by day and it is affecting the GIB population because the female does not lay egg in unfavorable conditions. Traditionally the GIB was and is being protected till today through general public awareness and by protecting the leking area of the birds; but now as it is clear that it is the foraging

area of the bird that has also to be conserved. A new strategy is being adopted to conserve this bird. Now the conservation strategy that we are now adopting is of creating public awareness, eliciting public support and giving special incentive to the people and farmers in bustard foraging areas. Putting a satellite transmitter (platform terminal transmitter - PTT) as was done in one of the birds in Nannaj, is the best available method to gather the movement data about this somewhat elusive bird. We are planning to put one more PTT on a female GIB in the near future.

The commonly asked questions are, 'What is so special about the GIB? Aren't there thousands of bird species in our country, many of which are more beautiful than the GIB?' The answer is, 'It is the habitat which makes the GIB special'. It needs only an open dry grass land with scanty vegetation cover. It is for this reason that the biggest numbers of them are surviving in Rajasthan in the semi-arid and arid lands of Jaisalmer near the Pakistan border. Along with dry grass land it also needs privacy, which the humans don't give to the bustard.

Local extinction of the GIB is a sign of human encroachment on natural habitats around us! It sadly indicates how fast we are driving away every living species around us. In addition to the GIB, which lives in dry grasslands, the habitats which used to be plentiful around every town or city, many other mammalian species like the hare, mongoose, wolf, hyena, blackbuck and pangolin also survive. Along with the GIB, all these species are slowly arriving on the threshold of extinction due to modifications of their habitats solely by human interference!

A terrestrial bird like the GIB that lays the egg on open ground has many enemies from lizards to snakes to jackals. Though the egg shell is quite hard and the egg gets camouflaged in the rocky brown background, it is prone for predation. But more than these natural enemies, which it has survived over the years, it doesn't stand a chance to survive in front of humans. We have not only directly killed the GIB by hunting for eating, but our other infrastructure development and intensive agricultural activities have driven the bird to near extinction. We encroached its habitat for myriad reasons, not forgetting the laying of power lines which have also killed the magnificent and hefty bustard in significant numbers through electrocution, a fate shared by several other larger birds globally.

Eliciting the support and participation of local people and communities, NGO's and the media for GIB conservation is the biggest challenge in GIB conservation. But I am sure that we foresters will be able to succeed. Government has already reduced the Nannaj GIB sanctuary area by restricting it to government lands; so also, as a policy more incentives will be offered to local people and farmers in the proposed eco-sensitive zone around the sanctuary, to support the movement of GIB conservation. In addition, the Maharashtra government is ready for captive breeding of this bird. The combination of *in-situ* and *ex-situ* conservation efforts is expected to augment the GIB populations. I am sure that our efforts will not go in vain and we will be able to bring more of these magnificent birds back into our landscape.

Great Indian Bustard *Ardeotis nigriceps* in Chandrapur District

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Citation: Thakare, S (2016). Conservator's View Point: Great Indian Bustard *Ardeotis nigriceps* in Chandrapur District
Ela Journal of Forestry and Wildlife 5(2):177-178

Date of Publication:
30-6-2016

ISSN 2319-4361

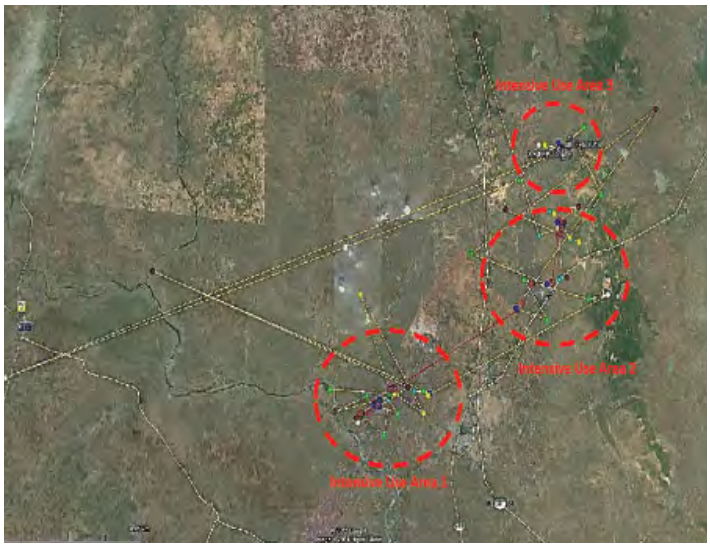
Photographs provided by the author

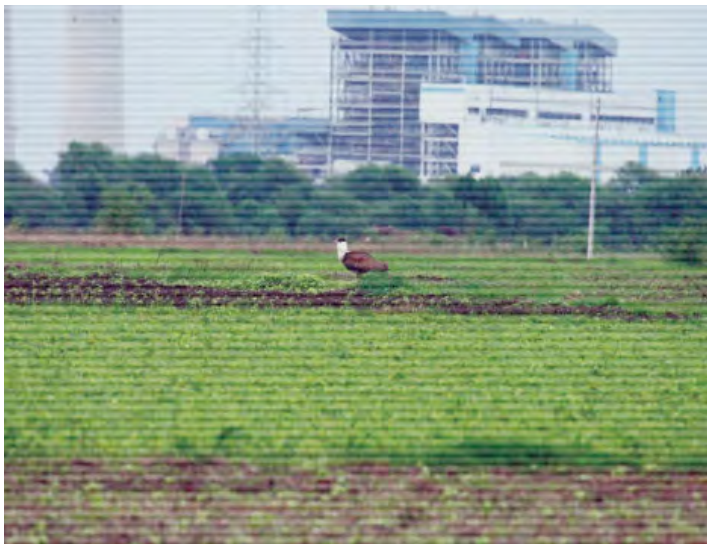
In Chandrapur District the Great Indian Bustard *Ardeotos nigriceps* (GIB) has been observed since long time. The unique feature about the bird is that it has been observed mostly in non-forest areas or agricultural fields in Warora and Bhadrawati Tahasil. When we talked with the old farmers in the rural area they frankly admitted that they had been observing this bird since their childhood. However, the forest department and the outside world came to know about the GIB only in 2005, when a sincere forest guard Mr. B.T. Lalsare of Warora range observed the birds for the first time near Wanoja- Tulana area of Warora range and identified and subsequently reported the matter to the higher authorities. Since then the GIB has been regularly monitored in Warora and Bhadrawati ranges of Chandrapur forest division.

Presence of around seven to eleven birds with 3 males and 7 to 8 females has been reported from Chandrapur district. The overall territory of the GIB seems to be spread over more than 20 villages. The forest department has been meticulously monitoring these birds on a regular monthly basis and has studied the feeding habits, local migration, mating, eggs, chicks and the various threat perceptions prevailing in the habitat. Apart from Mr. B.T.Lalsare, a number of observers have studied these birds. The notable among them are Mr. Gopal Thosar, Dr. Anil Pimpalapure, Dr. Sujit Narwade (BNHS), Dr. Bilal Habib and Miss. Vaijayanti (the latter two from WII). The forest department found that forest compartments number 1, 7, 8 and adjoining areas have been sometimes frequented by the GIB.

Important Observations about the GIB in this Landscape:

The birds have inhabited these areas in the Chandrapur district in moderate numbers in the past due to following probable reasons:





1) Presence of fallow lands in between the agricultural fields.
2) Amicable agricultural practices like leaving grass patches uncultivated in the fields.
3) Less use of insecticides and fertilizers by farmers.
4) Adoption of non-intensive farming practices.
5) Low level of disturbance and high level of tolerance towards GIB.
6) Absence or scanty number of polluting industries in this area.

Recent Studies

The WII entered into an agreement with Maharashtra Forest Department for undertaking telemetry studies of GIB in Maharashtra. Under this project WII team led by Dr. Bilal Habib captured one male GIB in Warora area and fixed it with PTT in December, 2013 and started studying the migration of this bird. Unfortunately the transmitter stopped working from February, 2014. But the data obtained clearly showed the migration pattern of GIB in this area.

This data has helped us to undertake grassland development in compartment numbers 7 and 8 in

the Temurda Round of Warora Range. About 40 ha of grassland have been developed since the last two years in these landscapes. This will definitely help in creating alternate habitat for the GIB.

Threat Perception

Although most of the farmers and villagers are GIB friendly the planned developmental activities are posing a grave threat to the existence of GIB in the entire landscape. In the areas mostly visited by these birds recent development of power and steel plants, cotton ginning mills, high tension power lines, conversion of agricultural areas for non-agricultural purpose are going to create serious threat to the survival of this bird in the near future.

Hence, the forest department has undertaken a massive campaign for promoting eco friendly farming practices like the use of vermin-compost, reducing the use of chemicals and fertilizers by the farmers in this landscape. The department is constantly monitoring the bird through forest staff and local volunteers from villages and is also developing alternate suitable habitats for the GIB. We hope that the birds will certainly regain their previous status and also give us the pleasure of observing its glorious flight in the Chandrapur district over the years to come.

Capacity Building for GIB Conservation

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Citation: Kakodkar, N (2016). Conservator's View Point: Capacity Building for GIB Conservation *Ela Journal of Forestry and Wildlife* 5(2):179

Date of Publication:
30-6-2016

ISSN 2319-4361

Maharashtra is indeed fortunate that it is amongst the very few States in the country to have a population, though very small, of the Great Indian Bustard *Ardeotis nigriceps*. It therefore casts an onerous duty on the field staff to be ever vigilant and also to be aware of the requirements of the species so that this small population is protected at all costs.

Wildlife management unlike forest management does not have a long history in the country and therefore the orientation of the staff towards concepts like habitat management and that too for avian species is not as strong as it should be. Behavioral studies of the Bustards in areas like Nannaj, Solapur district, Maharashtra, by scientists have helped the field staff in getting an insight on the requirements of the species.

The problem is that the field staff is transferable and thus the experience gained by these field employees is lost in a short time. The issue could be resolved by:

i) Conducting short term refresher courses for the field staff on a regular basis at the site itself, as the expertise on the habitat requirements as well as issues related to breeding are available locally and the forestry training institutes would not necessarily have the same. The frequency of such trainings can be decided by the protected area manager depending on the turnover of the field staff.

ii) Another measure would be to expose the field staff to practices adopted by other PA's having a Bustard population through field visits. This would be a great learning experience for them and the successful practices could be adopted back home.

iii) Recently excellent booklets have been published by the forest department on the aspects of behavior and requirements of the Great Indian Bustard. These should also be reviewed and revised periodically so that the concerns of the field staff are addressed.

iv) Similarly, literature could be prepared and widely circulated for the benefit of the people staying in and around the Bustard habitats so that they are made aware of the ecological role that the Bustard plays and the highly endangered status that this bird is presently facing. This awareness drive would also educate people on the activities that should be avoided so that the bird is not harmed unknowingly.

v) Experience of medical treatment given to the injured Bustards and their response to such treatment can also be discussed and documented so that the shortfalls if any could be met in the future.

vi) This special issue on the Great Indian Bustard could be a starting point and translating the summaries and findings in the papers published herein into Marathi language would be the step in the right direction.

Saving the Great Indian Bustard

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Citation: Sawarkar, V. (2016). Policy View Point: Saving the Great Indian Bustard
Ela Journal of Forestry and Wildlife 5(2):180-182

Date of Publication:
30-6-2016

ISSN 2319-4361

Heteropogon triticeus © J. Jayanthi

The Great Indian Bustard, rechristened the Indian Bustard and locally called "Maldhok" is endemic to the Indian sub-continent and is currently in deep trouble. It prefers a mix of sparse scrub and grassland country dotted with isolated trees, interspersed with dry land cultivation that is reasonably protected from fires and livestock grazing. The natural habitats of the bird in recent times in Ahmednagar and Solapur districts of Maharashtra have continually been destroyed in the past through release of land for cultivation and due to heavy pressure of livestock grazing. The habitat of this species—the uncultivable grasslands that also cannot grow trees—is often referred to as 'wasteland' or 'barren land' in Revenue department records even today. Besides supporting many wild species of animals and plants that occur only in such habitats, it is little known that such boulder strewn open areas are capable of scrubbing CO_2 from the atmosphere, a critical contribution for staving off global warming and the consequent climate change. When CO_2 dissolves in rain water in the atmosphere and reaches the ground it reacts with the silicates and other compounds in the shallow soils and rocks to form a weak solution of carbonic acid to be removed along with the water on the ground. Nature's dictionary does not have the words wasteland or barren lands.

The GIB in past has been well known as a game bird. During the last century, large numbers of birds were hunted. By the written accounts of the bustard going back to some 200 years, it appears that in Maharashtra the GIB was fairly common then. The account of Robert Mansfield in the 'Oriental Sporting Magazine' that has stopped publishing long time ago, relates of his having hunted not less than 961 bustards between 1809 to 1829 in the neighbourhood of Ahmednagar! By mid 1970s it was estimated that the bird was occupying only 1.7% of its former habitat in Maharashtra.

In order to determine the status and distribution of the species, extensive surveys were undertaken in India during the years 1980 to 1988 by the Bombay Natural

History Society. Among the six states that sheltered the GIB, its population in Maharashtra stood at third rank with an estimated population of 70-100 birds located in Solapur, Ahmednagar, Beed, Usmanabad, Aurangabad, Pune and Kolhapur districts. Rajasthan had the maximum of 500 to 1500 birds. The total population in India was placed between 770 to 1920 birds. There certainly was a problem in conducting the population estimates as the range of movement of the bird was not known—they moved long distances—and thus there were possibilities of double counting. However it was and is essential to track its status and problems at the all India level to be able to tease out the reasons for the adversity it faces today. The learning from the great crash in the populations of the two species of vultures worldwide must not be forgotten

Currently, within the short span of some 25 years after the last efforts during 1980 to 1988, the subsequent surveys have indicated that the population of the species in the country has crashed and stands at an astonishing low of less than 250 birds. The Wildlife Institute of India, Dehradun a few years back had mounted research to investigate the status and ecology of the GIB to understand the reasons for its continued decline. The institute has continued the efforts till today by using radio collars recently to understand the movement patterns. Several individual scientists along with WII and BNHS are desperately trying for a breakthrough. A species recovery plan has been prepared. We do not need an ecologist or a soothsayer to pronounce that the extinction of the GIB is imminent unless some serious efforts are made to stave off the tragedy. In the meantime, the government of India and the State Governments concerned need to support to the hilt the ongoing efforts to save the species. For that to take place, some fundamental rules need to be observed.

Extinction of a species is a catastrophic event—the disappearance of a fellow traveler on the planet which has been around much before the advent of the modern human being. Here we are also speaking of a bird which is a citizen of this country. There is a need to shut out the politics over land and ownerships to allow the principles enshrined in the Constitution of India, modern science, managerial wisdom and ground realities to chart the course for the recovery of the GIB.

Under the current social and political standoff against wildlife conservation it is not practicable or prudent just yet to newly create either a national park or a sanctuary for the conservation of the GIB in most states where it occurs. Further, this bird of the open country in all its innocence and evolutionary wisdom tries to find the prospects for its survival and procreation in scattered patches of Earth without consideration for the status and ownership of lands. However, being so, it is also necessary to state that under the garb of rationalization of boundaries of a protected area its existing or remodeled size on the basis of scientific knowledge and ecological needs—that are melded with realities—must never be downsized for the reasons that the population of the species concerned has declined or there is some perceived spat over the status of the lands. Instead the door needs to be kept open for future recovery of species and to explore seriously how the protected area land use can be accommodated along with lands under other ownerships within the framework of administration of forest and other departments using appropriate technology and schemes harnessed with justifiable incentives. Further, depending upon the status of the relevant lands there are options for creating Conservation Reserves and Community Reserves wherein the local people have a large say in managing these lands without misunderstanding the responsibilities.

For a species like the GIB that has temporally large geographical movements and is under the gun of the poachers and under many other threats that are still to be adequately understood within those seasonally used vast areas, the reduced presence of the species from its traditional haunts does not necessarily signify degradation of habitat quality or irrelevance of its size. There are many other threatened species that share the habitat with the bustard such as the Lesser Florican, the Indian wolf, blackbuck, chinkara—all in the threatened category along with many others of those that are not threatened. Consistent with realities it needs to be understood that several species currently placed variously under the IUCN Red Data Book categories like Lower Risk, Data Deficient and Not Evaluated also can move up the ladder of threat categories as a consequence of rapidly changing land uses and also because of lands under conservation objectives—protected areas—also getting either reduced in size by misplaced measures of rationalization or other areas of recorded forests being ceded for other purposes. All native wildlife species need the legal spaces expressly created for their stewardship and more that can be managed by resolve

and options available. Their presence—the other species—ought not to be forgotten while the fate of a specific target species is being pursued. Biodiversity should be viewed as a whole.

The GIB is said to have the attribute of site fidelity as well as seasonality, therefore some might think that because the bird is not seen in that particular area the site has become irrelevant—not so at all. We must not forget that climate is changing and every species gradually adapts to environmental change in terms of shifting traditional sites within the limits of its inherited evolutionary habitat structure and composition. What we need to do is to retain the available options by not foreclosing the future opportunities. That is what species recovery is all about. The term 'rocket science' is used metaphorically to express an extremely difficult science and tasks but one day it will be, and has to be replaced by the science of "wildlife ecology"—the most complicated science. When one feels that everything is understood about a species, that 'everything' later proves that it was only a fraction of the generated knowledge! The papers in this book by those who have studied the bird closely have put on the table the things we must do and must not do but a little more space here for some further thoughts might not cause any harm.

Since the GIB is wont to occupy patches of crops, the agriculture sector of the Central and State Government must provide incentives to the farmer that are more lucrative than the monetary loss of produce he might incur from that patch which he might have to forego while the GIB occupies it with added caveat about not disturbing the birds in any way and providing complete protection during that season. The Agriculture sector has the money and schemes those can be tapped into. There are other departments like the social welfare, tribal welfare, rural development and the like that have adequate funds, skills and wherewithal that could effectively chip in as well for the rescue of a species in severe distress.

The stewardship of the open lands that are non-agriculture type outside the purview of the forest department needs to be vested in the Biodiversity Management Committees (BMCs) created under the Biological Diversity Act 2002 and helped by the State Biodiversity Board with simple but appropriately responsible conservation plans. The PAs need to be managed under scientifically vetted management plans. There should be a well-designed interpretation center with high quality awareness programmes of desirable reach and nature guides assembled and properly trained from the local communities—there are species other than the GIB to be seen and the wonders of nature to be understood. Visitor management needs to be firm about what will be allowed and what will not with adequate safeguards that can be enforced. Local communities need to be largely involved in this. The last thing needed is visitors causing disturbance to the GIB

Research needs to be accorded top priority. Modern scientific knowledge is essential for turning around the future of the GIB to a stage that can be termed as good prospects

In his captivating perennial book *A Sand County Almanac* (1949), Aldo Leopold, a forest officer with the US Forest Service wrote thus—*If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.* No one before or since has defined the ethos of conservation so lucidly and effectively.

Wild Grasses And Legumes Of The Great Indian Bustard Wildlife Sanctuary, Maharashtra

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Citation: Jayanthi J, Jalal J and Lakshminarasimhan P (2016). Wild Grasses And Legumes Of The Great Indian Bustard Wildlife Sanctuary, Maharashtra. *Ela Journal of Forestry and Wildlife* 5(2):183-191

Date of Publication:
30-6-2016

ISSN 2319-4361

Photographs provided by the author

Introduction

Ecologically grasslands may be defined as "land covered with herbaceous plants with less than 10 % tree and shrub cover"; and wooded grassland (savanna) may be defined as "land covered with grassland and has 10-40 % of tree or shrub cover". Other definitions state the woody layer to be anywhere from 15-50% cover, as long as the ground layer has a more or less continuous grass or graminoid layer (UNESCO 1973; White 1983; White et al 2000; Faber-Langendoen & Josse 2010). Grasslands are an important part of the earth's many ecological communities, originally covering as much as 25% of the earth's surface. Grasslands have many biodiversity values, including wildlife habitat, occurrence of rare species, intrinsic ecosystem properties of structure, function, composition and ecosystem services. Globally scientists have declared that grasslands are vital to our future. Throughout the history grasslands play an essential role in the survival and livelihoods of millions of people around the world as well as support significant number of wildlife including many species at risk. Grasslands are important gene banks since most of our cereals have originated from wild grasses (Faber-Langendoen & Josse 2010; GCC 2008, 2016; Govt. of India 2006).

In India the estimated coverage of grasslands and shrub lands varies from 3.7 to 12 percent of the total land area (UNDP 2012). Based on the eco-climatic factors the grassland in India can be classified into Himalayan pastures, Terai grassland, Semi-arid grasslands and Shola grasslands. The semi-arid grasslands are found in Central India, Deccan and Western India are covered by grassland tracts with patches of thorn forests. Animals such as blackbuck, chinkara, wolf and birds such as bustards and floricans are adapted to this semi-arid habitat. There are 8 national parks and 85 wildlife sanctuaries in the semi-arid zone (Govt. of India 2006).

GIB habitat during different seasons

Methodology

Study Area and Study Period:

The Great Indian Bustard Wildlife Sanctuary (GIBWS) is a semi-arid grassland ecosystem in Maharashtra which was established in 1979 to protect the Critically Endangered endemic bird species, the Great Indian Bustard (*Ardeotis nigriceps*). It is located in the Solapur and Ahmednagar District of Maharashtra and lies between the latitudinal range 17022'17" to 18054'42" N and longitudinal range 74023'34" to 76015'01" E. On the whole the terrain of the sanctuary area is flat and undulating. The landscape is interspersed with pockets of crop fields in wide valleys and grasslands on plateaus. The area as a whole is monotonously covered by Deccan Trap basaltic lava flows, which, in turn, are covered by a thin mantle of black cotton soil almost everywhere which is the ultimate product of weathering of Deccan Trap. This region belongs to the dry belt of Maharashtra where rainfall is poorest, humidity low, temperature and evaporation rate high. The average annual rainfall in the district is between 550 mm to 650 mm and is frequently prone to annual droughts. The sanctuary is an abode of many birds and animals forming a significant habitat for its flagship species the Great Indian Bustard and also for good population of blackbuck. Botanical Survey of India undertook the survey and documentation on the floristic elements of GIBWS during the period 2010-2012 covering all three seasons.

Biogeography and vegetation profile of GIBWS

This area falls under the forest types of semi-arid biotope, open scrublands and southern tropical thorn forest of the Champion & Seth (1968) classification. As the region is drier with low rainfall the area is covered with vast grasslands interspersed with thorny shrubs and trees. The area looks yellow, dry during the winter and the summer period from December to June. After the first shower during the monsoon the barren area turns from yellow to lush green with full of grasses interspersed with a variety of herbaceocus plants. The common tree species are *Acacia nilotica, Acacia leucophloea, Capparis decidua* and shrubs such as *Mimosa hamata, Balanites aegyptiaca, Ziziphus mauritiana, Senna auriculata* and common herbs include *Alysicarpus* spp., *Crotalaria* spp., *Glossocardia bosvallIa, Indigofera cordifolia, Indigofera linifolia,* etc.

Results

As there was no floristic documentation existing on this wildlife sanctuary, the Botanical Survey of India undertook the floristic of GIBWS which resulted in the documentation of 436 angiosperm species. The life form pattern of GIBWLS demonstrates that Therophytes (32%) is the dominant class followed by Phanerophytes (21%), Chamaephytes (17%), Hemicryptophytes (16%) and Cryptophytes (14%).

Endemic taxa: As many as 25 peninsular endemic taxa were also recorded during the study viz: *Cleome simplicifolia, Crotalaria filipes, Crotalaria vestita, Vigna indica, Hardwickia binata, Dichrostachys cinerea var. indica, Neonotis montholoni, Glossocardia bosvallia, Goniocaulon indicum, Pulicaria wightiana, Tricholepis radicans, Exacum pumilum, Hemigraphis urens, Rungia elegans, Dolichandrone falcata, Euphorbia notoptera, Aristida stocksii, Isachne borii,*

GIB habitat during different seasons

Iseilema anthephoroides, Lophopogon tridentatus, Oropetium roxburghianum, Oropetium villosulum, Sehima sulcatum, Spodiopogon rhizophorus and Tripogon jacquemontii (Jayanthi & Jalal 2015, 2015a).

Diversity of grasses and legumes in GIBWS

Grasses and legumes form the dominant flora of this wildlife sanctuary. About 37 percent of the flora is contributed by grasses and legumes. The sanctuary harbours a total of 98 grass species (including 30 sedges) and 66 legume species (Table-1). The predominant grass species are *Apluda mutica, Aristida hystrix, Aristida stocksii, Cymbopogon martini, Chrysopogon fulvus, Heteropogon contortus, Lophopogon tridentatus, Melanocenchris jacquemontii, Sehima ischaemoides, Themeda laxa, Themeda triandra, Tragus mongolorum* etc. Among all the grasses the genus *Aristida* is dominant in terms of species diversity by having six species followed by *Eragrostis* having five species. About 37 species are annuals completing their lifecycle in one season lasting for few months. During this period they produce plenty of seeds and the seeds germinate in the next season.

Annual grasses: Some of the common annual grasses are *Andropogon pumilus, Aristida adscensionis, Aristida hystrix, Aristida redacta, Aristida stocksii, Hackelochloa granularis, Lophopogon tridentatus, Melanocenchris jacquemontii, Sehima ischaemoides* and *Tragus mongolorum* forming large carpet in areas such as Nannaj, Gangevadi, Mardi, Karamba, Akolekati and Korti.

Perennial grasses: The perennial grasses are represented by 31 species which forms large clumps at base or develop rhizome. The clumping root system is having a thick root system from a thick central clump that has multiple growing points and the rhizomatic root system has laterally spreading root system where the new grass sprout along the lateral spread. Grasses such as *Apluda mutica, Bothriochloa pertusa, Cenchrus setigerus, Chrysopogon fulvus, Cymbopogon martini, Cynodon dactylon, Dicanthium foveolatum, Heteropogon contortus, Heteropogon triticeus, Oropetium thomaeum, Themeda laxa, Themeda triandra, Sporobolus indicus* are the predominant perennial grasses.

Fodder value grasses: Out of the 68 grass species recorded 24 species have potential fodder value such as *Apluda mutica, Bothriochloa pertusa, Cenchrus setigerus, Chloris gayana, Cynodon dactylon, Dactyloctenium aegyptiacum, Dichanthium foveolatum, Digitaria ternata, Echinochloa colonum, Eleusine indica, Eragrostis pilosa, Eragrostis tenella, Eragrostis viscosa, Heteropogon contortus, Melanocenchris jacquemontii, Oryza sativa, Panicum hippothrix, Panicum curviflorum, Paspalidium flavidum, Pennisetum pedicellatum, Pennisetum purpureum, Sehima ischaemoides, Sporobolus indicus* and *Tetrapogon tenellus.* 30 species of sedges were also documented in GIBWS that are represented by genera such as *Cyperus, Eleocharis, Fimbristylis, Fuirena, Kyllinga, Lipocarpha, Mariscus, Pycreus, Scleria* and *Schoenoplectiella*. The genus *Cyperus* and *Fimbristylis* are the common sedges encountered.

Legumes: The legumes are mostly herbaceous species found growing interspersed with the grasses. Out of the 66 species found, *Alysicarpus, Crotalaria, Indigofera, Senna, Acacia* are the dominant genera with more number of species.

Table 1: List of wild grasses, sedges and legumes in GIBWLS

S.No.	Plant name	Habit	Flowering
Poaceae (Grasses)			
1	***Alloteropsis cimicina*** (L.) Stapf.	A	July - September
2	***Andropogon pumilus*** Roxb.	A	July – December
3	***Apluda mutica*** L.	P	September – December
4	***Aristida adscensionis*** L.	A	September – December
5	***Aristida funiculata*** Trin. & Rupr.	A	September – December
6	***Aristida hystrix*** L. f.	P	September – December
7	***Aristida redacta*** Stapf.	A	September – December
8	***Aristida setacea*** Retz.	P	September – December
9	***Aristida stocksii*** (Hook. f.) Domin	A	July – December
10	***Arundinella tuberculata*** Munro ex Lisboa	A	September – November
11	***Arundo donax*** L.	P	September – November
12	***Bothriochloa pertusa*** (L.) A. Camus	P	September – December
13	***Brachiaria distachya*** (L.) Stapf.	A	September – November
14	***Brachiaria eruciformis*** (Sm.) Griseb.	A	July – September
15	***Brachiaria ramosa*** (L.) Stapf.	A	July – September
16	***Cenchrus setigerus*** Vahl	P	July – September
17	***Chionachne gigantea*** (J. Koenig) Veldkamp	P	July – September
18	***Chloris gayana*** Kunth ex Stapf	P	July – September
19	***Chrysopogon fulvus*** (Spreng.) Chiov.	P	August – September
20	***Coix lacryma-jobi*** L.	P	July – September
21	***Cymbopogon martini*** (Roxb.) S. Watson	P	July – October
22	***Cynodon dactylon*** (L.) Pers.	P	August – October
23	***Dactyloctenium aegyptiacum*** (L.) Willd.	A	August – October
24	***Dactyloctenium aristatum*** Link	A	August – October
25	***Dichanthium foveolatum*** (Delile) Roberty	P	August – October
26	***Digitaria ciliaris*** (Retz.) Koeler	A	August – October
27	***Digitaria stricta*** Roth ex Roem. & Schult.	A	August – October
28	***Digitaria ternata*** (A. Rich.) Stapf.	A	September – December
29	***Dinebra retroflexa*** (Vahl) Panz.	A	August – October
30	***Echinochloa colonum*** (L.) Link	A	August – September
31	***Eleusine indica*** (L.) Gaertn.	A	July – September
32	***Eragrostiella bifaria*** (Vahl) Bor	P	July – September
33	***Eragrostiella brachyphylla*** (Stapf) Bor	P	July – September
34	***Eragrostis gangetica*** (Roxb.) Steud	P	September – October
35	***Eragrostis pilosa*** (L.) P. Beauv.	A	September – October
36	***Eragrostis tenella*** (L.) P. Beauv. ex Roem. & Schult.	A	August – October
37	***Eragrostis unioloides*** (Retz.) Nees ex Steud.	P	August – October
38	***Eragrostis viscosa*** (Retz.) Trin.	A	September – October
39	***Hackelochloa granularis*** (L.) Kuntze	A	September – October
40	***Heteropogon contortus*** (L.) P. Beauv. ex Roem. & Schult.	P	September – October
41	***Heteropogon triticeus*** (R. Br.) Stapf ex Craib	P	September – October
42	***Isachne borii*** Hemadri	A	September – October
43	***Ischaemum afrum*** (J.F. Gmel.) Dandy	P	July – September
44	***Iseilema anthephoroides*** Hack.	P	September – October
45	***Lophopogon tridentatus*** (Roxb.) Hack.	A	August – October

46	***Melanocenchris jacquemontii*** Jaub. & Spach	A	August – October
47	***Oropetium roxburghianum*** (Steud.) S.M. Phillips	P	August – September
48	***Oropetium thomaeum*** (L. f.) Trin.	P	August – September
49	***Oropetium villosulum*** Stapf ex Bor	A	August – September
50	***Oryza sativa*** L.	A	July– September
51	***Panicum curviflorum*** Hornem	A	July – October
52	***Panicum hippothrix*** K.Schum. ex Engl.	A	September – October
53	***Paspalidium flavidum*** (Retz.) A. Camus	P	August – October
54	***Pennisetum pedicellatum*** Trin.	A	July – September
55	***Pennisetum purpureum*** Schumach.	P	July – September
56	***Sehima ischaemoides*** Forssk.	A	July – October
57	***Sehima sulcatum*** (Hack.) A. Camus	P	July – October
58	***Setaria intermedia*** Roem. & Schult.	A	July – September
59	***Setaria pumila*** (Poir.) Roem. & Schult.	A	July – October
60	***Spodiopogon rhizophorus*** (Steud.) Pilg.	A	July – October
61	***Sporobolus coromandelianus*** (Retz.) Kunth	A	July – October
62	***Sporobolus indicus*** (L.) R. Br.	P	July – October
63	***Tetrapogon tenellus*** (J. Koenig ex Roxb.) Chiov.	A	July – October
64	***Themeda laxa*** (Andersson) A. Camus	P	July – December
65	***Themeda traindra*** Forssk.	P	July – December
66	***Tragus mongolorum*** Ohwi	A	July – October
67	***Tripogon bromoides*** Roth	P	July – October
68	***Tripogon jacquemontii*** Stapf	P	July – October
CYPERACEAE (SEDGES)			
69	***Bulbostylis barbata*** (Rottb.) C.B. Clarke	A	September – October
70	***Cyperus alulatus*** J. Kern	A	July – December
71	***Cyperus compressus*** L.	A	July – December
72	***Cyperus difformis*** L.	A	July – December
73	***Cyperus digitatus*** Roxb.	P	July – December
74	***Cyperus distans*** L. f.	P	August – October
75	***Cyperus exaltatus*** Retz.	P	August – December
76	***Cyperus iria*** L.	A	July – December
77	***Cyperus nutans*** var. ***eleusinoides*** (Kunth) R.W. Haines	P	July – December
78	***Cyperus pilosus*** Vahl	P	July – September
79	***Cyperus rotundus*** L.	P	July – December
80	***Cyperus tenuispica*** Steud.	A	August – October
81	***Eleocharis atropurpurea*** (Retz.) J. Presl. & C. Presl.	A	November – December
82	***Eleocharis geniculata*** (L.) Roem. & Schult.	A	August – December
83	***Fimbristylis complanata*** (Retz.) Link	P	July – October
84	***Fimbristylis dichotoma*** (L.) Vahl	A	July – December
85	***Fimbristylis ferruginea*** (L.) Vahl	P	August – October
86	***Fimbristylis ovata*** (Burm. f.) J. Kern	P	August – October
87	***Fimbristylis quinquangularis*** (Vahl) Kunth	A	September – October
88	***Fimbristylis tenera*** Schult.	A	September – October
89	***Fuirena cuspidata*** (Roth) Kunth	A	August – October
90	***Kyllinga brevifolia*** Rottb.	P	August – September
91	***Lipocarpha squarrosa*** (L.) Goetgheb.	A	August – September
92	***Mariscus squarrosus*** (L.) C.B. Clarke	A	August – September

93	***Pycreus flavidus*** (Retz.) T. Koyama	A	August – September
94	***Pycreus polystachyos*** (Rottb.) P. Beauv.	P	August – September
95	***Schoenoplectiella lateriflora*** (J.F. Gmel) Lye	A	July – September
96	***Schoenoplectiella roylei*** (Nees) Lye	A	September – October
97	***Schoenoplectiella supina*** (L.) Lye	A	July – September
98	***Scleria parvula*** Steud.	A	July – September
LEGUMINOSAE			
99	***Abrus precatorius*** L.	C	Almost throughout the year
100	***Aeschynomene indica*** L.	S	September – October
101	***Alysicarpus glumaceus*** (Vahl) DC.	H	September – October
102	***Alysicarpus heyneanus*** Wight & Arn.	H	July – September
103	***Alysicarpus monilifer*** (L.) DC.	H	July – September
104	***Alysicarpus scariosus*** (Rottl. ex Spreng.) Graham ex Thwaites	H	September – October
105	***Alysicarpus tetragonolobus*** Edgew.	H	September – October
106	***Alysicarpus vaginalis*** (L.) DC. var. ***nummularifolius*** Miq.	H	September – October
107	***Butea monosperma*** (Lam.) Taub.	T	February – March
108	***Canavalia africana*** Dunn	C	July – December
109	***Canavalia ensiformis*** (L.) DC.	C	July – December
110	***Crotalaria calycina*** Schrank	H	September – October
111	***Crotalaria filipes*** Benth	H	September – October
112	***Crotalaria hebecarpa*** (DC.) Rudd	H	September – December
113	***Crotalaria juncea*** L.	H	November – December
114	***Crotalaria orixensis*** Willd.	H	September – October
115	***Crotalaria pallida*** Aiton.	H	July – October
116	***Crotalaria vestita*** Baker	H	September – October
117	***Desmodium dichotomum*** (Willd.) DC.	H	September – October
118	***Desmodium gangeticum*** (L.) DC.	S	September – October
119	***Desmodium heterocarpon*** (L.) DC.	S	September – October
120	***Desmodium triflorum*** (L.) DC.	H	July – September
121	***Erythrina variegata*** L.	T	March – April
122	***Indigofera coerulea*** Roxb.	S	July – August
123	***Indigofera cordifolia*** B. Heyne ex Roth	H	September – December
124	***Indigofera linifolia*** (L.f.) Retz.	H	September – December
125	***Indigofera prostrata*** Willd.	H	August – October
126	***Indigofera tinctoria*** L.	S	July – October
127	***Indigofera trifoliata*** L.	H	September – December
128	***Lablab purpureus*** (L.) Sweet	C	July – September
129	***Rhynchosia capitata*** (B. Heyne ex Roth) DC.	C	September – December
130	***Rhynchosia minima*** (L.) DC.	C	September – December
131	***Stylosanthes fruticosa*** (Retz.) Alston	S	September – October
132	***Stylosanthes viscosa*** (L.) Sw.	S	September – October
133	***Tephrosia purpurea*** (L.) Pers.	S	September – October
134	***Tephrosia senticosa*** (L.) Pers.	S	September – December
135	***Tephrosia villosa*** (L.) Pers.	S	July – October
136	***Vigna aconitifolia*** (Jacq.) Morechal	C	August – September
137	***Vigna indica*** T.M. Dixit, K.V. Bhat & S.R. Yadav	C	August – September
138	***Vigna trilobata*** (L.) Verdc.	C	August – September
139	***Zornia gibbosa*** Span.	H	August – September

140	***Bauhinia racemosa*** Lam.	T	June – August
141	***Caesalpinia bonduc*** (L.) Roxb.	S	July – December
142	***Chamaecrista mimosoides*** (L.) Greene	H	September – October
143	***Hardwickia binata*** Roxb.,	T	August – December
144	***Senna alata*** (L.) Roxb.	S	July – December
145	***Senna auriculata*** (L.) Roxb.	S	Almost throughout the year
146	***Senna italica*** Mill.	S	July – August
147	***Senna obtusifolia*** (L.) H.S. Irwin & Barneby	S	September – October
148	***Senna occidentalis*** (L.) Link	S	August – December
149	***Senna sophera*** (L.) Roxb.	S	July – August
150	***Senna tora*** (L.) Roxb.	S	July – August
151	***Senna uniflora*** (Mill.) H.S. Irwin & Barneby	S	September – December
152	***Acacia campbelii*** Arn.	T	August – December
153	***Acacia catechu*** (L.f.) Willd.	T	August – October
154	***Acacia eburnea*** (L.f.) Willd.	T	September – December
155	***Acacia leucophloea*** (Roxb.) Willd.	T	September – December
156	***Acacia nilotica*** subsp. ***cupressiformis*** (J.L. Stewart) Ali & Faruqui	T	August – December
157	***Acacia nilotica*** subsp. ***indica*** (Benth.) Brenan	T	September – October
158	***Acacia tomentosa*** Willd.	T	September – December
159	***Dichrostachys cinerea*** **var.** ***indica*** Brenan & Brummit	S	August – December
160	***Leucaena leucocephala*** (Lam.) de Wit	T	August – December
161	***Mimosa hamata*** Willd.	S	August – December
162	***Mimosa pudica*** L.	H	August – December
163	***Pithecellobium dulce*** (Roxb.) Benth.	T	February – June
164	***Prosopis juliflora*** (Sw.) DC.	T	February – June

A– Annuals, C– Climbers, H– Herbs, S– Shrubs, T– Trees, P– Perennials.

Echinochloa colonum

Indigofera cordifolia

Tragus mongolorum

Zornia gibbosa, Tephrosia senticosa, Alysicarpus glumaceus, Acacia nilotica and Alysicarpus tetragonolobus

Trees: The common tree species are *Acacia nilotica* subsp. *indica, A. nilotica* subsp. *cupressiformis, A. leucophloea, A. tomentosa, A. campbellii, A. eburnea.* The common shrub species are represented by *Mimosa hamata, Senna auriculata, Senna obtusifolia, Senna uniflora* and *Stylosanthes fruticosa*. Herbs such as *Alysicarpus glumaceus, A. heyneanus, A. monilifer, A. scariosus, A. tetragonolobus, A. vaginalis, Crotalaria calycina, C. filipes, C. hebecarpa, C. orixensis, C. vestita, Indigofera cordifolia, I. linifolia, I. prostrata, I. trifoliata, Rhynchosia capitata, R. minima, Vigna aconitifolia, V. indica, V. trilobata* and *Zornia gibbosa* are the prevalent species amidst the grasses.

Discussion

Importance of grassland habitat for bustards

The Great Indian Bustard (GIB) flocks use wide, sparse grass-scrub landscapes with low intensity cultivation in the non-breeding season. They have a broad omnivorous diet chiefly consisting of fruits like *Zizyphus*, insects like grasshopper and beetle, reptiles, and seasonally available food crops like ground nut and millets. During mid-summer and monsoon they congregate at traditional areas to breed and avoid human disturbance (Rahmani, 1989; Dutta et al 2010). The Nannaj area of GIBWS in Maharashtra is one of the vital breeding sites of GIB. It was observed during this field study that many grass species such as *Andropogon pumilus, Apluda mutica, Aristida redacta, A. stocksii, Echinochloa colona, Iseilema anthephoroides, Lophopogon tridentatus, Melanocenchris jacquemontii, Oropetium spp.* etc and legume species such as *Alysicarpus glumaceus, A. heyneanus, A. monilifer, A. scariosus, A. tetragonolobus, A. vaginalis, Crotalaria calycina, C. filipes, C. hebecarpa, C. orixensis, C. vestita, Indigofera cordifolia, I. linifolia, I. prostrata, I. trifoliata, Rhynchosia capitata, R. minima, Vigna aconitifolia, V. indica, V. trilobata and Zornia gibbosa* supports variety of insects, beetles, grasshoppers etc. and form the base of the food web for birds, rodents, insects, and other grassland animals. Hence, the grasslands are very important for the plants and the animals that depend on them.

Threats & Conservation Measures

During this study several invasive plant species were encountered which could become a potential threat affecting the bionetwork and floristic quality of this semi-arid grassland. Since grasslands are more easily vulnerable, the invasive plants establish quickly, sometimes causing irreparable damage. Being non-native and not having natural predators here to hold them in check, invasive plants can out-compete native grassland plants and deplete food sources and shelter crucial to the survival of local wildlife (Leekie 2009/2010). Already the Great Indian Bustard is not only locally extinct in its former range, it has also disappeared from the three sanctuaries declared 25 years ago for its protection (Rahmani, 2006). Hence, it is crucial for GIBWS for maintaining the original habitat from the impact of invasive species.

About 109 invasive plant species were recorded from this sanctuary dominated by members of Asteraceae family (Jayanthi & Jalal 2015b). Besides, as much as 17 legume species and 10 grass species were also found to be invasive. The boundaries of grasslands are severely infested by invasive species such as *Senna uniflora, Alternanthera tenella, Lantana camara, Leonotis nepetifolia, Leucaena leucocephala, Prosopis juliflora, Senna occidentalis, Cleome gynandra* and *Cleome viscosa*. *Senna uniflora* forms large extensive dense patches along the roadsides. They form large colonies during rainy season and started encroaching into the grasslands from the roadsides as they produce plenty of seeds. The other species which forms large patches are *Senna occidentalis, Leonotis nepetifolia* and *Cleome gynandra*. Species such as *Blainvillea acmella, Hyptis suaveolens, Ageratum conyzoides, Blumea*

lacera, Dicoma tomentosa, Stylosanthes fruticosa are found interspersed along with the grasses and at several localities forms large patches in the gap areas amidst grasslands in the core area near Nannaj and Mardi. In close proximity to Gangevadi area population of *Chrozophora rottleri, Sida acuta, Martynia annua* are found amidst grasslands. *Ipomoea carnea* forms large colonies inside and edges of lake in Gangevadi (Jayanthi & Jalal, 2015b).

However, many grassland habitats that are protected are viable. Some of the worth mentioning grassland areas are found in villages such as, Nannaj, Mardi, Gangevadi, Akolekati, Karamba, Korti and Chapadgaon and are protected with great care by the Forest Department.

Acknowledgements

The authors are extremely thankful to Dr. Paramjit Singh, Director, Botanical Survey of India for facilities and encouragement. The first author is also sincerely grateful to the Forest Department, Maharashtra for granting permission to conduct the field studies.

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Checklist of Birds of Great Indian Bustard Sanctuary, Nannaj, Maharashtra

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Citation: Pande Satish, Sant N, Lonkar R, Pawar R, Deshpande P, Deshpande P and Thatte S (2016). Checklist of Birds of Great Indian Bustard Sanctuary, Nannaj, Maharashtra.
Ela Journal of Forestry and Wildlife 5(2):192-198

Date of Publication:
30-6-2016

ISSN 2319-4361

Referee: Vaibhav Deshmukh

The GIB Sanctuary at Nannaj (17°49'"25"N and 75°52'"18"E; 50 m ASL) is about 22 km from Solapur, 5 km from Mardi village and 2 km from Nannaj village. The sanctuary was first declared vide government notification of 1979 and 1985 and included 8493.44 sq km in Ahmadnagar district (parts of Karjat, Shrigonda and Newase talukas) and Solapur district (parts of Karmala, Madha, Mohol and North Solapur). However, vide government notification of 2016 the sanctuary area is now downsized to 366.76 sq km (36673.16 Ha). The overall landscape comprises of undulating open grassland with a mosaic of woodland, stony grazing land, agricultural cropland (Manakadan and Rahmani 1986) and scattered semi-arid regions adjacent to human habitation with an annual precipitation of 450 to 600 mm and minimum temperature of 16.6^{o}C and maximum of 44^{o}C. The climate is southern hot tropical thorn forest (6A/01) and the biogegraphic zone is the Deccan Plateau of India (Champion and Seth 1968)..

The present checklist of 192 birds including 132 Genera from 64 Families is an oucome of several visits to the sanctuary spanning the past 20 years. There are 14 Threatened and 4 Endemic species. The list is likely to grow over time with some additions and some deletions because bird life is dynamic depending on habitat modifications and climatic changes. The records are a compilation of bird records over this time spanning all the three seasons, summer, monsoon and winter. The areas included are from the talukas of Karjat, Shrigonda, Karmala, Madha, Mohol and North Solapur. Around Nannaj we studied Nannaj 10 Ha, Mardi 50 and 100 Ha, Karamba, Kale Talav, and Gangewadi. The various habitats encountered are open grassland with sparse vegetation and woodland, semiarid regions with thorny scrub, low hilly stony terrain, agricultural cropland, perennial waterbodies and canal.

Sr. No	Family	Common Name	*Scientific Name*	Status	WPA
1.	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	R	IV
2.	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	R	IV
3.	Phalacrocoracidae	Little Cormorant	*Phalacrocorax niger*	R	IV
4.	Ardeidae	Little Egret	*Egretta garzetta*	R	IV
5.	Ardeidae	Intermediate Egret	*Mesophoyx intermedia*	R	IV
6.	Ardeidae	Eastern Cattle Egret	*Bubulcus coromandus*	R	IV
7.	Ardeidae	Grey Heron	*Ardea cinerea*	R	IV
8.	Ardeidae	Indian Pond-Heron	*Ardeola grayii*	R	IV
9.	Ciconiidae	Asian Openbill	*Anastomus oscitans*	R	IV
10.	Ciconiidae	Woolly-necked Stork	*Ciconia episcopus*	R	IV
11.	Ciconiidae	Painted Stork	*Mycteria leucocephala*	RM	IV
12.	Threskiornithidae	Glossy Ibis	*Plegadis falcinellus*	R	IV
13.	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus*	R	IV
14.	Threskiornithidae	Eurasian Spoonbill	*Platalea leucorodia*	RM	I
15.	Threskiornithidae	Red-naped Ibis	*Pseudibis papillosa*	R	IV
16.	Anatidae	Common Teal	*Anas crecca*	M	IV
17.	Anatidae	Cotton Pygmy Goose	*Nettapus coromandelianus*	LM	IV
18.	Anatidae	Northern Shoveler	*Anas clypeata*	M	IV
19.	Anatidae	Indian Spot-billed Duck	*Anas poecilorhyncha*	R	IV
20.	Accipitridae	Black-winged Kite	*Elanus caeruleus*	R	IV
21.	Accipitridae	Black Kite	*Milvus migrans*	R	I
22.	Accipitridae	Black-eared Kite	*Milvus lineatus*	M	IV
23.	Accipitridae	Shikra	*Accipiter badius*	R	I
24.	Accipitridae	Eurasian Sparrowhawk	*Accipiter nisus*	M	I
25.	Accipitridae	Common Buzzard	*Buteo buteo*	RM	I
26.	Accipitridae	Oriental Honey-buzzard	*Pernis ptilorhynchus*	R	I
27.	Accipitridae	White-eyed Buzzard	*Butastur teesa*	R	I
28.	Accipitridae	Short-toed Snake-Eagle	*Circaetus gallicus*	R	I
29.	Accipitridae	Booted Eagle	*Hieraaetus pennatus*	M	I
30.	Accipitridae	Bonelli's Eagle	*Aquila fasciata*	R	I
31.	Accipitridae	Greater Spotted Eagle	*Clanga clanga*	M	I
32.	Accipitridae	Steppe Eagle	*Aquila nipalensis*	M	I
33.	Accipitridae	Tawny Eagle	*Aquila rapax*	R	I
34.	Accipitridae	Eastern Imperial Eagle	*Aquila heliaca*	M	I

35.	Accipitridae	Montagu's Harrier	*Circus pygargus*	M	I
36.	Accipitridae	Pallid Harrier	*Circus macrourus*	M	I
37.	Accipitridae	Western Marsh-Harrier	*Circus aeruginosus*	M	I
38.	Falconidae	Common Kestrel	*Falco tinnunculus*	M	IV
39.	Falconidae	Red-necked Falcon	*Falco chicquera*	R	I
40.	Falconidae	Peregrine Falcon	*Falco peregrines calidus*	M	I
41.	Falconidae	Shaheen Falcon	*Falco peregrines peregrinator*	R	I
42.	Falconidae	Laggar Falcon	*Falco jugger*	R	IV
43.	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	R	IV
44.	Phasianidae	Painted Francolin	*Francolinus pictus*	R	IV
45.	Phasianidae	Common Quail	*Coturnix coturnix*	R	IV
46.	Phasianidae	Rain Quail	*Coturnix coromandelica*	R	IV
47.	Phasianidae	Rock Bush-Quail	*Perdicula argoondah*	R	IV
48.	Phasianidae	Indian Peafowl	*Pavo cristatus*	R	I
49.	Turnicidae	Barred Buttonquail	*Turnix suscitator*	R	IV
50.	Otididae	Great Indian Bustard	*Ardeotis nigriceps*	R	I
51.	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	R	IV
52.	Rallidae	Purple Swamphen	*Porphyrio porphyrio*	R	IV
53.	Rallidae	Common Moorhen	*Gallinula chloropus*	R	IV
54.	Rallidae	Eurasian Coot	*Fulica atra*	R	IV
55.	Rostratulidae	Greater Painted-snipe	*Rostratula benghalensis*	M	IV
56.	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	R, M	IV
57.	Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	R	IV
58.	Glareolidae	Small Pratincole	*Glareola lactea*	R	IV
59.	Glareolidae	Indian Courser	*Cursorius coromandelicus*	R	IV
60.	Burhinidae	Indian Stone Curlew	*Burhinus indicus*	R	IV
61.	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	R	IV
62.	Charadriidae	Yellow-wattled Lapwing	*Vanellus malabaricus*	R	IV
63.	Charadriidae	Little Ringed Plover	*Charadrius dubius*	M	IV
64.	Scolopacidae	Common Greenshank	*Tringa nebularia*	M	IV
65.	Scolopacidae	Wood Sandpiper	*Tringa glareola*	M	IV
66.	Scolopacidae	Green Sandpiper	*Tringa ochropus*	M	IV
67.	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	M	IV
68.	Scolopacidae	Common Redshank	*Tringa totanus*	M	IV
69.	Sternidae	River Tern	*Sterna aurantia*	R	IV

70.	Pteroclidae	Chestnut-bellied Sandgrouse	*Pterocles exustus*	R	IV
71.	Pteroclidae	Painted Sandgrouse	*Pterocles indicus*	R	IV
72.	Columbidae	Blue Rock Pigeon	*Columba livia*	R	IV
73.	Columbidae	Laughing Dove	*Streptopelia senegalensis*	R	IV
74.	Columbidae	Red Collared-Dove	*Streptopelia tranquebarica*	R	IV
75.	Columbidae	Spotted Dove	*Streptopelia chinensis*	R	IV
76.	Columbidae	Eurasian Collared-Dove	*Streptopelia decaocto*	R	IV
77.	Columbidae	Yellow-footed Green-Pigeon	*Treron phoenicopterus*	R	IV
78.	Psittacidae	Plum-headed Parakeet	*Psittacula cyanocephala*	R	IV
79.	Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*	R	IV
80.	Cuculidae	Grey-bellied Cuckoo	*Cacomantis passerinus*	R	IV
81.	Cuculidae	Jacobin Cuckoo	*Clamator jacobinus*	M	IV
82.	Cuculidae	Asian Koel	*Eudynamys scolopaceus*	R	IV
83.	Cuculidae	Common Hawk-Cuckoo	*Hierococcyx varius*	R	IV
84.	Cuculidae	Blue-faced Malkoha	*Phaenicophaeus viridirostris*	R	IV
85.	Cuculidae	Sirkeer Malkoha	*Phaenicophaeus leschenaultii*	R	IV
86.	Cuculidae	Greater Coucal	*Centropus sinensis*	R	IV
87.	Tytonidae	Barn Owl	*Tyto alba*	R	IV
88.	Strigidae	Indian Eagle-Owl	*Bubo bengalensis*	R	IV
89.	Strigidae	Short-eared Owl	*Asio flammeus*	M	IV
90.	Strigidae	Mottled Wood-Owl	*Strix ocellata*	R	IV
91.	Strigidae	Spotted Owlet	*Athene brama*	R	IV
92.	Caprimulgidae	Sykes's Nightjar	*Caprimulgus mahrattensis*	R	IV
93.	Caprimulgidae	Indian Nightjar	*Caprimulgus asiaticus*	R	IV
94.	Caprimulgidae	Savanna Nightjar	*Caprimulgus affinis*	M	IV
95.	Coraciidae	European Roller	*Coracias garrulus*	M	IV
96.	Coraciidae	Indian Roller	*Coracias benghalensis*	R	IV
97.	Upupidae	Eurasian Hoopoe	*Upupa epops*	R	IV
98.	Dacelonidae	White-throated Kingfisher	*Halcyon smyrnensis*	R	IV
99.	Cerylidae	Pied Kingfisher	*Ceryle rudis*	R	IV
100.	Alcedinidae	Common Kingfisher	*Alcedo atthis*	R	IV
101.	Meropidae	Blue-cheeked Bee-eater	*Merops persicus*	R	IV
102.	Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	R	IV
103.	Meropidae	Green Bee-eater	*Merops orientalis*	R	IV
104.	Bucerotidae	Indian Grey Hornbill	*Ocyceros birostris*	R	IV

105.	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	R	IV
106.	Picidae	Eurasian Wryneck	*Jynx torquilla*	M	IV
107.	Picidae	Yellow-crowned Woodpecker	*Dendrocopos mahrattensis*	R	IV
108.	Alaudidae	Indian Bushlark	*Mirafra erythroptera*	R	IV
109.	Alaudidae	Oriental Skylark	*Alauda gulgula*	R	IV
110.	Alaudidae	Sykes's Lark	*Galerida deva*	R	IV
111.	Alaudidae	Ashy-crowned Sparrow-Lark	*Eremopterix griseus*	R	IV
112.	Alaudidae	Bimaculated Lark	*Melanocorypha bimaculata*	M	IV
113.	Alaudidae	Rufous-tailed Lark	*Ammomanes phoenicura*	R	IV
114.	Alaudidae	Greater Short-toed Lark	*Calandrella brachydactyla*	M	IV
115.	Hirundinidae	Dusky Crag-Martin	*Ptyonoprogne concolor*	R	IV
116.	Hirundinidae	Barn Swallow	*Hirundo rustica*	M	IV
117.	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	R	IV
118.	Hirundinidae	Wire-tailed Swallow	*Hirundo smithii*	R	IV
119.	Motacillidae	Western Yellow Wagtail	*Motacilla flava*	M	IV
120.	Motacillidae	Grey Wagtail	*Motacilla cinerea*	M	IV
121.	Motacillidae	Citrine Wagtail	*Motacilla citreola*	M	IV
122.	Motacillidae	White Wagtail	*Motacilla alba*	M	IV
123.	Motacillidae	White-browed Wagtail	*Motacilla madaraspatensis*	R	IV
124.	Motacillidae	Tree Pipit	*Anthus trivialis*	M	IV
125.	Motacillidae	Richard's Pipit	*Anthus richardi*	M	IV
126.	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	R	IV
127.	Motacillidae	Tawny Pipit	*Anthus campestris*	M	IV
128.	Motacillidae	Long-billed Pipit	*Anthus similis*	R/M	IV
129.	Tephrodornithidae	Common Woodshrike	*Tephrodornis pondicerianus*	R	IV
130.	Campephagidae	Black-headed Cuckooshrike	*Coracina melanoptera*	R	IV
131.	Campephagidae	White-bellied Minivet	*Pericrocotus erythropygius*	R	IV
132.	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	R	IV
133.	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	R	IV
134.	Aegithinidae	Common Iora	*Aegithina tiphia*		
135.	Laniidae	Long-tailed Shrike	*Lanius schach*	R	IV
136.	Laniidae	Southern Grey Shrike	*Lanius meridionalis*	R	IV
137.	Laniidae	Brown Shrike	*Lanius cristatus*	M	IV
138.	Laniidae	Isabelline Shrike	*Lanius isabellinus*	M	IV
139.	Laniidae	Bay-backed Shrike	*Lanius vittatus*	R	IV

140.	Rhipiduridae	White-spotted Fantail	*Rhipidura albogularis*	R	
141.	Muscicapidae	Blue Rock-Thrush	*Monticola solitarius*	R	IV
142.	Muscicapidae	Oriental Magpie-Robin	*Copsychus saularis*	R	IV
143.	Muscicapidae	Indian Robin	*Saxicoloides fulicatus*	R	IV
144.	Muscicapidae	Brown Rock Chat	*Cercomela fusca*	R	IV
145.	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	M	IV
146.	Muscicapidae	Isabelline Wheatear	*Oenanthe isabellina*	M	IV
147.	Muscicapidae	Desert Wheatear	*Oenanthe deserti*	M	IV
148.	Muscicapidae	Variable Wheatear	*Oenanthe picata*	M	IV
149.	Muscicapidae	Pied Bushchat	*Saxicola caprata*	RM	IV
150.	Muscicapidae	Common Stonechat	*Saxicola maurus*	R	IV
151.	Sylviidae	Yellow-eyed Babbler	*Chrysomma sinense*	R	IV
152.	Leiothrichidae	Common Babbler	*Turdoides caudata*	R	IV
153.	Leiothrichidae	Large Grey Babbler	*Turdoides malcolmi*	R	IV
154.	Cisticolidae	Zitting Cisticola	*Cisticola juncidis*	R	IV
155.	Cisticolidae	Ashy Prinia	*Prinia socialis*	R	IV
156.	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	R	IV
157.	Cisticolidae	Jungle Prinia	*Prinia sylvatica*	R	IV
158.	Cisticolidae	Plain Prinia	*Prinia inornata*	R	IV
159.	Acrocephalidae	Clamorous Reed-Warbler	*Acrocephalus stentoreus*	M	IV
160.	Sylviidae	Booted Warbler	*Hippolais caligata*	M	IV
161.	Sylviidae	Common Tailorbird	*Orthotomus sutorius*	R	IV
162.	Sylviidae	Common Chiffchaff	*Phylloscopus collybita*	M	IV
163.	Sylviidae	Eastern Orphean Warbler	*Sylvia crassirostris*	M	IV
164.	Sylviidae	Common Whitethroat	*Sylvia communis*	M	IV
165.	Sylviidae	Lesser Whitethroat	*Sylvia curruca*	M	IV
166.	Paridae	Great Tit	*Parus cinereus*	R	IV
167.	Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	R	IV
168.	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*	R	IV
169.	Nectariniidae	Purple-rumped Sunbird	*Nectarinia zeylonica*	R	IV
170.	Nectariniidae	Purple Sunbird	*Necterinia asiatica*	R	IV
171.	Emberizidae	Crested Bunting	*Melophus lathami*	R	IV
172.	Emberizidae	House Bunting	*Emberiza striolata*	M	IV
173.	Emberizidae	Black-headed Bunting	*Emberiza melanocephala*	M	IV
174.	Emberizidae	Red-headed Bunting	*Emberiza bruniceps*	M	IV

175.	Emberizidae	Grey-necked Bunting	*Emberiza buchanani*	M	IV
176.	Fringillidae	Common Rosefinch	*Carpodacus erythrinus*	R	IV
177.	Estrildidae	Red Avadavat	*Amandava amandava*	R	IV
178.	Estrildidae	Tricolored Munia	*Lonchura malacca*	R	IV
179.	Estrildidae	Indian Silverbill	*Euodice malabarica*	R	IV
180.	Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	R	IV
181.	Passeridae	House Sparrow	*Passer domesticus*	R	IV
182.	Passeridae	Chestnut-shouldered Petronia	*Petronia xanthocollis*	R	IV
183.	Ploceidae	Baya Weaver	*Ploceus philippinus*	R	IV
184.	Oriolidae	Indian Golden Oriole	*Oriolus kundoo*	R	IV
185.	Dicruridae	Black Drongo	*Dicrurus macrocercus*	R	IV
186.	Sturnidae	Common Starling	*Sturnus vulgaris*	M	IV
187.	Sturnidae	Brahminy Starling	*Temenuchus pagodarum*	R	IV
188.	Sturnidae	Rosy Starling	*Sturnus roseus*	R	IV
189.	Sturnidae	Common Myna	*Acridotheres tristis*	R	IV
190.	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	R	IV
191.	Corvidae	House Crow	*Corvus splendens*	R	IV
192.	Corvidae	Jungle Crow	*Corvus levaillantii*	R	IV

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Ecological Importance of Footprint and Dust Bath Imprints of Great Indian Bustard *(Ardeotis nigriceps)*

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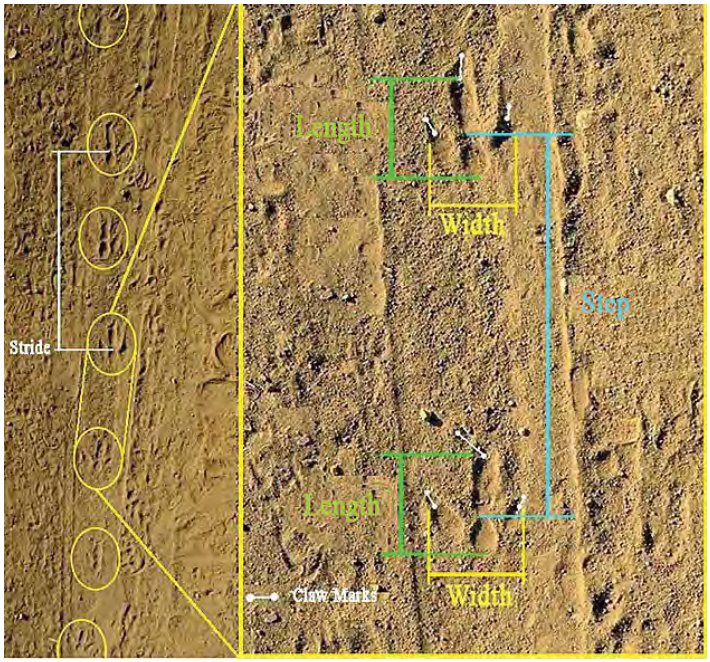
Citation: Hippargi R, Bolde P and Bolde A (2016). Ecological Importance of Footprint and Dust Bath Imprints of Great Indian Bustard *(Ardeotis nigriceps)*.
Ela Journal of Forestry and Wildlife 5(2):199-205

Date of Publication:
30-6-2016

ISSN 2319-4361

Referee: Nitin Kakodkar and Dr. Satish Pande



Photographs provided by the author

Figure 1: Method employed for Footprint measurements

Abstract:

In a study aimed to determine the summer habitat preference of Great Indian Bustard (*Ardeotis nigriceps*) in semi-arid grassland ecosystem of Solapur, habitat patches used by bustards were examined based on observations of footprints and dust bath imprints. Morphometry of footprints of adult male and female bustard showed that morphologically they are similar and the length to width ratio was found to be nearly the same. Our study demonstrated that sites with food abundance, optimal vegetation, roosting sites, substratum for dust bathing and traditional agro-ecosystem are most favoured by bustards even though they are moderately exposed to anthropogenic threats. Conservation efforts should primarily focus on the maintenance and management of such landscapes that showed long term site fidelity by bustards.

Keywords: Great Indian Bustard, ecology, footprint, dust bath, conservation.

Introduction:

The semi-arid thorn forest and grassland ecosystem of Solapur, Maharashtra once supported a viable population of critically endangered Great Indian Bustard (*Ardeotis nigriceps*). A detailed behavioural ethogram of *Ardeotis nigriceps* was discussed by Patil *et.al* (2013) while, Rahmani (1989) had elegantly recorded behaviours associated with territory, flocking, mating etc. Although a great deal of research has been focussed on their ecology (Rahmani, 1989), hardly any information is available on the description of their footprint tracks and dust bath imprints.

We describe herewith the morphometry of footprint tracks of an adult male and female Great Indian Bustard. Additionally, a general description of behaviour associated with dust bath and other behavioural notes recorded near imprints are discussed. The frequency of

sighting of fresh footprint tracks may help in determining their preferred environmental variables, abundance, distribution, behaviour and possible disturbances. Sites with regular tracks should be managed for long term conservation and protection.

Study Methods:

Observations were made during summer season from February to May, 2015 at the periphery of but outside the Great Indian Bustard Sanctuary, Nannaj, Solapur, Maharashtra, India. Preliminary surveys yielded two sites (Site I: 17^{o}48'41.75"N, 75^{o} 52'54.87"E; Site II: 17^{o}49'30.67"N, 75^{o} 53'04.64"E) that were regularly used by male and female bustards. These sites were selected for measurement of footprints, obtaining casts and observations on behaviour of both bustards. Only tracks with clear imprints were taken for measurement. The natural vegetation of the area is dominated with sparse thorny shrubs, herbs and tree species adapted to semi-arid conditions with an undulating landscape of grassland surrounded with traditional farmlands consisting mainly of Jowar (*Sorghum vulgare*), Maize (*Zea mays*), Bengal gram (*Cicer arietinum*), Groundnut (*Arachis hypogea*) and Pigeon pea (*Cajanus cajan*).

Step and stride distance are defined as per Alexander (2003). Step distance is the distance travelled while a particular foot is on the ground and the stride is the complete cycle of the movement, for example, from setting down of a foot to the next setting down of the same foot. Stride length is the distance travelled in one stride (Alexander, 2003). The step distance was measured from the tip of first foot's posterior pad to the tip of next foot's posterior pad, while, the stride distance was measured from tip of posterior pad of the foot to the tip of posterior pad of next imprint of the same foot using a standard scale (Fig.1). The 'Foot Length' was measured from the base of the posterior pad to the tip of third anterior pad or digit excluding the claw. While, the 'Foot Width' was measured as the maximum distance across the outer toe pad tips of a three toed footprint of bustard, excluding the claw (Maloney, 2001) (Fig.1). Multiple footprint tracks (n=07) were measured to avoid bias in footprint size due to variation in substratum. Notes on the pattern of dust bath imprints on soil of a female bustard were recorded twice during field surveys. Footprint tracks of peacock (*Pavo cristatus*) were also studied as they may be mistaken with the Great Indian Bustard because they often share the same habitat.

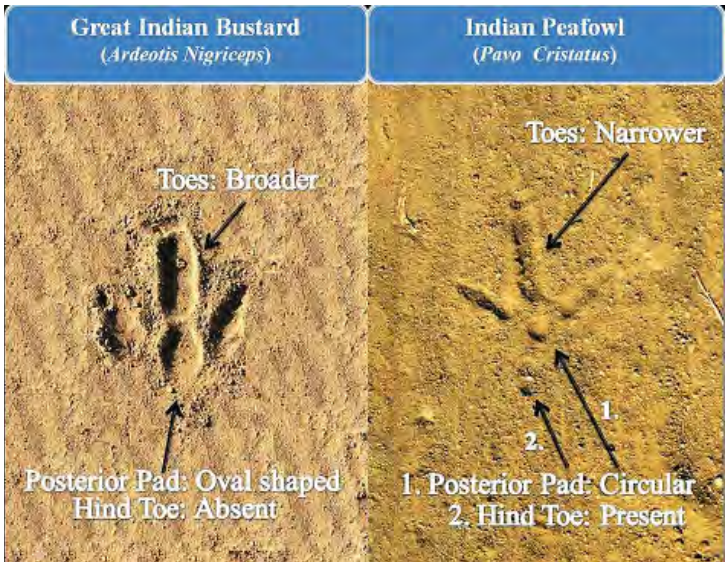


Figure 2: Difference between Great Indian Bustard and Indian Peafowl Footprints

Results:

I) Measurements of Footprint Tracks:

The mean values for length, width and step for both adult male and female Great Indian Bustard are given in Table.1 and for Indian Peafowl in Table. 2. Mean length of adult male is 15% larger (P=0.002, F=15.13) and mean width is 4-5% larger (P=0.17, F=2.091) than adult female. However, the ratio of length to width was found to be 1:1 for male and 1:0.89 for female (P=0.1112, F=2.957). The step distance of adult male is 9-10% larger (P=0.05, F=4) than adult female Great Indian Bustard. The stride distance of adult male was found to be 8% larger than female (P=0.0018; F=15.74). Footprints of Indian Peafowl are clearly differentiated by the presence of hind toe which are absent in bustards and presence of circular posterior pad in peafowl while the same is oval shaped in bustards. Toe pads of Indian Peafowl are longer and narrower compared to bustards which are much broader than Peafowl (Fig. 2).

II) Dust bath and Neck Dusting:

Dust bath imprints were observed in fine soft silt formed on a farm road due to regular movement of livestock and vehicles. Based on the observations of clear imprints of dust bath in the soil, it was quite easy to predict the behaviour and body position of female bustard during dust bathing. Before starting dust bathing the bird rests on its shank. In *Body dusting*, probably the bird had tried to kick off fine dust over its body which was easily recognizable with displaced soil, wing and foot markings

Table 1: Length and width of footprints (cm), length to width (L/W) ratio, step distance (SD) and stride of footprints of adult male and female Great Indian Bustard (n=7).

Adult Male (n=7)					
	Length	**Width**	**L/W Ratio**	**SD**	**Stride**
Min.	8	8	1.00	30	63
Max.	10	9.5	1.05	35	70
Mean	8.98571	8.95714	1.00	33.1429	66.8571
Stand. Dev.	0.708116	0.525538	1.34	1.77281	2.4103

Adult Female (n=7)					
	Length	**Width**	**L/W Ratio**	**SD**	**Stride**
Min.	6.7	7.5	0.89	25	57
Max.	8.2	9	0.91	33	65
Mean	7.64286	8.55714	0.89	30.1429	61.5714
Stand. Dev.	0.576938	0.509435	1.13	3.28778	2.57275

Table 2: Length and width of footprints (cm), length to width (L/W) ratio, step distance (SD) and stride of footprints of adult Indian Peafowl (n=7).

Indian Peafowl (n=7)					
0	**Length**	**Width**	**L/W Ratio**	**SD**	**Stride**
Min	13.8	11	1.12	35	70
Max	15.5	13.2	1.32	37	74
Mean	14.72857	12.37143	1.197143	36.14286	72.17143
Stand. dev	0.6074929	0.8014867	0.07016986	0.7612646	1.267168

on both the sides of the body indicating vigorous bodily movements during this act. In *Neck dusting*, the female Great Indian Bustard, after resting its neck on the soil, attempted to rub its neck in the dust. The markings of neck dusting can be discerned with fine imprints of frequently rubbed neck visible towards the front side of the shank imprints (Fig.3).

III) Behaviours of Great Indian Bustard Associated with Footprint Track:

A general list of various behaviours of adult male and female Great Indian Bustard recorded near their regular footprint tracks and dust bath sites are given in Table 3.

a) Behavioural Notes on Female Great Indian Bustard:

Based on our observations made during the summer season, it was noted that female had frequented this site almost on all days in search of food and water. Water turned out to be the most important variable during summer season due to its scarcity. The female bustard sometimes turned up twice per day to drink water. The female bustard mostly preferred to walk than fly while it approached to actual water body. The female bustard was observed regularly to feed on *Cicada* sps. (Hemiptera, Cicadidae), which were available in abundance during the summer. Additionally, it fed regularly on the leaves of the shrub *Capparis divaricata* (Family: Capparaceae) which are common near the study site.

b) Behavioural Notes on Male Great Indian Bustard:

Figure 3: Dust bath imprints of Great Indian Bustard

Male bustards preferentially used a farm road transecting agricultural farms on one side and a contiguous stretch of protected grassland surrounded with sparse vegetation. While on their way towards the farmland from the protected grassland for feeding, bustards used to leave behind clear tracks of footprints on the farm road. An elevated open shrub area separated farmland and dense vegetation which continued with the protected grassland. This open patch was frequently used as landing ground whenever the male bustards returned after feeding in the farmlands that were separated by a tar road (Fig.6).

The male birds preferred to night roost in the protected grassland area and during morning hours (between 6.30 to 9.30 AM) they flew towards farmlands for feeding. A tar road with trench-cum-mound separated these farmlands from the protected grassland. After feeding in farmland, male bustards used either to land on the open shrub area near footprint site or straightaway approached the water source in the protected area. Whenever, they landed near footprint site, depending upon the time of their arrival, they either day roosted in sparse vegetation or sometimes ventured for feeding in the farmland. Additionally, after their return and landing at the preferred open patch, bustards either resorted to preening behaviour or in the noon, with rise in temperature, they used to day roost in sparse vegetation. While day roosting, they either rested under the shadow of a shrub or resorted to feeding. Male bustards were also recorded to feed regularly on cicadsa during the peak summer (April-May).

c) Disturbances near the Footprint site:

Various anthropological disturbances were noted at both site-I and II during the study period (Table 4). Site-I is located just 120 m away from a tar road with regular vehicular movement. Male bird was frequently sighted feeding in traditional farms along this stretch of the tar road. Any farming activity at a distance of 50-100 m was tolerated by the birds and was not perceived as a threat. It was noted that the bird was disturbed with the movements of farmers that were directed towards the bird,

Figure 4: Male bustard chased by dog

Figure 5: Quarrying at habitat used by female bustard

albeit unintentional. Presence of dogs at both site-I and II was also a major threat to bustards and in one instance dogs were recorded chasing a male bustard (Fig.4). Soil extraction was a pressing threat to the habitat of Great Indian Bustards (Fig.5). The female bustard, after showing site fidelity for 45 days, finally abandoned the site with the concomitant drying of natural source of drinking water during peak summer month. As the water source was outside the sanctuary, female bustard experienced higher competitive risks during drier summer season, as the water source was also shared by a large number of livestock. In contrast, the male bustard continued to show site fidelity as it preferred to drink at water holes meant for them within the protected sanctuary area.

Discussion:

Morphometric data on length and width shows that the foot size of male Great Indian Bustards is larger than female. However, the length to width ratio was found to be insignificant between male and female bustard. Furthermore, sexing adult Great Indian Bustards in the wild based on their footprints seems to be difficult as they are morphologically similar and can vary with the age of the bird. Significantly larger male feet were noted in Houbara Bustards where differences in footprint size allow differentiating between sexes (Maloney, 2001).

Footprints and tracks of Great Indian Bustard served as important signs for monitoring their presence, habitat use, behaviour and threats during our study. It was also noted in our study that, male bustard footprints site was nearer to their display and roosting site than a female bustard, which preferred to remain isolated at an approximate

Table 3: Behaviours noted near Footprint Tracks

Types of Behaviour	Male	Female
Drinking	-	+
Feeding	+	+
Sitting	+	-
Standing	+	+
Dust bathing	-	+
Day Roosting	+	+
Flying	+	+

Table 4: Threats recorded near Footprint Tracks

	Site-I	Site-II
Distance from Tar Road (m)	120	1200
Number of temporary huts (within 100 m area)	04	02
Average number of human movements (3 hour study period)	05	06
Average number of vehicular movement (3 hour study period)	06	04
Number of dogs	07	10
Number of quarrying incidences (during study period)	00	08

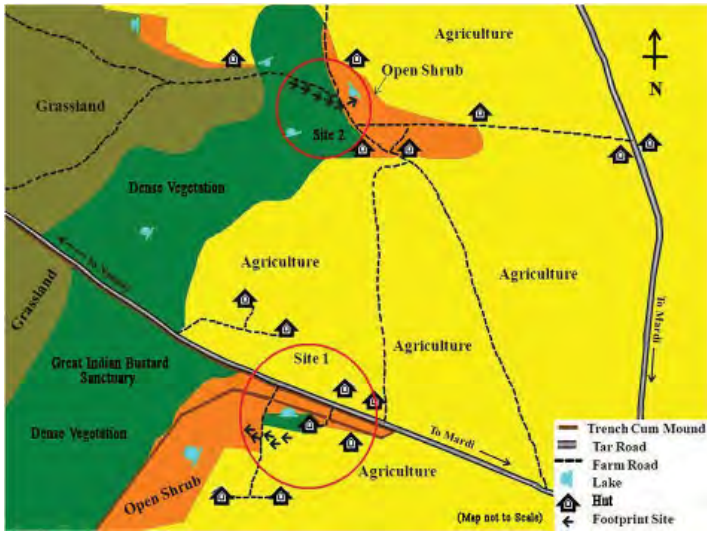


Figure 6: Study area map indicating study sites

Figure 7: Cast of Great Indian Bustard footprint

distance of 1.5 km from male footprint track site. Previous studies that followed footprints and tracks include habitat selection and abundance of threatened Little Bustard (*Tetrax tetrax*) in Iberian agricultural landscapes (Silva et al., 2007); behaviour of Houbara Bustard (*Chlamydotis undulate macqueenii*) in arid shrub land in United Arab Emirates (Launey, 1997); and estimating population number of Houbara Bustard in Pakistan (Nadeem *et al*., 2003).

Furthermore, our observations on dust bathing behaviour of female bustard at its regular footprint track site in addition to other behaviours such as feeding, drinking, day roosting etc. for more than 45 days proves their site fidelity. Both male and female bustard preferred to regularly use the same footprint track sites, even though they are exposed to many anthropogenic threats. It was interesting to note that female continued to use the same track site for drinking even after soil extraction activity near the water source that was ongoing for several days. Probably, sites with suitable environmental variables such as abundance of food, day and night roosting sites, water source, optimal floristic conditions and suitable substratum for behaviours such as dust bathing etc. proved most appropriate although the site was moderately disturbed. Similar behaviours associated with footprint tracks such as feeding on plants, pecking at the ground, standing, sitting and dust bathing were also recorded in Houbara Bustard (Launey, 1997).

Observations made in our study shown that footprint tracks of bustards are not just easy to locate and follow but they help us in interpreting the optimal environmental variables preferred by Great Indian Bustard. Understanding its habitat requirements and behaviour are crucial for *in-situ* and *ex-situ* conservation. Any future conservation breeding initiative for Great Indian Bustard must include variables that the bustard uses in wild. For example, areas for dust bathing should be part of an enclosure (AZA Gruiformes TAG 2009). Observations pertaining to disturbances noted in our study may help in designing strategies for protected area management.

Recommendations for Protected Area Management:

Many studies on bustards have used signs of presence of tracks and footprints to estimate population number (Nadeem *et al*., 2004); quantify sex related characteristics (Launey *et al*., 1996); gather knowledge about habitat requirement, preference and reverse the trend of habitat deterioration (Silva *et al*., 2004) and to trap and mark individuals for ecological study (Seddon *et al*., 1999). Tracks were also used to confirm the presence of Arabian Bustard (*Ardeotis arabs*) in Saudi Arabia (Shobrak & Rahmani, 1991). Based on our study we put forth following recommendations for monitoring and protection of Great Indian Bustards.

(1) *Use of pugmark as a method to record the presence of bustard*: Till now, direct sighting or head count method was used to ascertain the presence of Great Indian bustards in wild. Bustards being highly secretative and shy, many times their presence in wild remains unnoticed. In India, pugmarks are used to census population of large mammals like tiger and leopard. In line with these mammals, we recommend use of pugmarks as a sign of presence of bustards, as their tracks and footprints are easily seen and casted using plaster of Paris (Fig.7). We recommend surveying of tracks during morning and evening hours

when the sun rays are oblique and cast shadow across soil making footprints and tracks more visible.

As a long term policy, Forest Department may consider monitoring of tracks and footprints at waterholes maintained for wild animals and natural water sources at the periphery of sanctuary to ascertain the presence of bustards. Additionally, tracking strips surrounding waterhole can be created to record footprints of bustard and other associated endangered species like Indian Grey Wolf (*Canis lupus pallipes*).

(2) *Implementation as a Pilot Project in Maharashtra*: We recommend implementation of an exhaustive plan to chart out GPS based monitoring grids of potential waterholes maintained by Forest Department and those outside sanctuary areas. This method, if used in conjunction with PTT, will help in narrowing down selection of water holes, natural ponds, lakes and agricultural areas for detailed landscape level studies allowing forest personnel for effective management of bustard habitat.

Acknowledgement:

The author thanks UGC for financial assistance, Principal of the college and Forest Department for necessary permission to conduct surveys in and around the Great Indian Bustard Sanctuary, Nannaj, Solapur.

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First Record of *Choanotaenia* sps. (Cestoda; Dilepididae) in the Great Indian Bustard *Ardeotis nigriceps* (Gruiformes; Otididae)

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Citation: Hippargi R, Bolde P, Baviskar P, Kolte S and Baviskar B (2016). First Record of *Choanotaenia* sps. (Cestoda; Dilepididae) in the Great Indian Bustard *Ardeotis nigriceps* (Gruiformes; Otididae) *Ela Journal of Forestry and Wildlife* 5(2):206-210

Date of Publication:
30-6-2016

ISSN 2319-4361

Referee: Sunil Limaye and Dr. Satish Pande

Abstract:

We present the first record of the occurrence of a Cestode parasite from the genus *Choanotaenia* in the droppings of the Great Indian Bustard (*Ardeotis nigriceps*). Examination of droppings was carried out during the summer season in agro-ecosystems at the periphery of the Great Indian Bustard Sanctuary, Nannaj, Solapur, Maharashtra, India. Investigation of seven droppings yielded an average four parasites per sample. Such findings highlight our lack of knowledge about the background rates of parasitic load in the wild population, threats associated with the heavy infestation and the origin of these parasites in the wild population. Looking at the current status of Great Indian Bustard, any parasite poses great risk to wild population and demands detailed investigations to determine the impact of such parasites on their survival, behaviour and reproduction.

Key Words: Cestode, *Choanotaenia*, Great Indian Bustard, *Ardeotis nigriceps*.

Introduction:

The semi-arid thorn forest and grassland ecosystem of Solapur, Maharashtra once supported a viable population of Critically Endangered Great Indian Bustard (*Ardeotis nigriceps*) (IUCN 2015). Although a great deal of research has focused on its ecology (Rahmani, 1989), very little information is available on the occurrences of parasites in wild population. Previous records are scarce

and include description of new species *Mediorhynchus rajasthanensis* (Acanthocephala) and *Schistometra nigriceps* (Cestoda: Davaineidae:Idiogeninae) by Gupta (1975a, b) in Great Indian Bustard, Pokhran, Jaisalmer district of Rajasthan, India. Within the bustard group, cestodes belonging to various genera have been reported in Houbara Bustard (*Chlamydotis undulate macqueenii*) (Chaudhary *et al*, 1988; Jones *et al*., 1996; Nadeem *et al*., 2004; Rahmani *et al*., 2016). Jones *et al* (1996) reports 07 cestodes and 02 Acanthocephalans in captive Houbara, Kori (*Ardeotis Kori*) and Rufous-crested bustard (*Eupodotis ruficrista*). High parasitic burden caused by cestodes were reported in the post-mortem examination in wild Great Bustard: *Otis tarda* (Garcia-Montijano *et al*., 2002). Enteric cestodes are known to cause depression, anemia, blood stained faeces, hemorrhagic enteritis, debility, diarrhoea, weakness and anorexia in birds (Harrison *et al*. 1986); inflammation, mild atrophy, collapse, fibrosis of intestinal mucosa and obstruction of intestinal lumen in bustards (Jones et al., 1996); cestode infestation has been recorded as the main cause of death in captive Houbara Bustard (Chaudhary et al., 1988; Bailey et al., 1996; Jones et al., 1996) and in juveniles of Great Bustard (Garcia-Montijano *et al*. 2002). There is only one previous record of death of Great Indian Bustard in 1998-99 caused by infestation of unidentified worms in the stomach at the Great Indian Bustard Sanctuary, Nannaj, Solapur (Mangrulkar & Shendre, 2006).

Choanotaenia is a genus of parasitic tapeworms and is found in the upper half of the small intestine of the fowl (Soulsby, 1982), turkey and other wild gallinaceous birds like pheasants, quails. *Choanotaenia* has an indirect life cycle with domestic and wild birds as final hosts, and several fly species (e. g. *Musca domestica*), locusts, ants and termites as intermediate hosts (Premaalatha *et al*. 2014). Other intermediate hosts also include beetles of genus *Geotrupes*, *Aphodius*, *Calathus* and *Tribolium* (Soulsby, 1982).

In this paper, we present the first report on the occurrence of cestode parasite belonging to the genus *Choanotaenia* sps. (Family: Dilepididae) collected from the droppings of the Great Indian Bustard. General morphology of bustard droppings, morphometry of gravid proglottid and egg is also discussed. However, the Cestode from the genus *Choanotaenia* has never been reported in Great Indian Bustard (*Ardeotis nigriceps*) from India.

Photographs provided by the author

Fig. 1: Male Great Indian Bustards feeding in harvested *Sorghum* field.

Material and Methods:

(a) Study Site:

Study site lies in the Biogeographic Zone 6 (Deccan Peninsula–Central Plateau), Province 6 B (Chhota Nagpur) in India (Rodgers *et al*, 2002). As a part of our routine ecological study of Great Indian Bustard, we came across several droppings in agro-ecosystem outside the sanctuary limits and adjacent to the Great Indian Bustard Sanctuary, Nannaj, Solapur, Maharashtra, India (17^{O}48'41.75"N, 75^{O} 52'54.87"E) which were collected from traditional agricultural fields frequented by two male bustards (Figure-1).

(b) Collection of Cestode infested Bustard droppings:

Careful examination of fresh droppings revealed presence of live proglottids exhibiting wriggling movement. Gravid proglottids of *Choanotaenia* are known to quickly migrate outside the droppings and hence only fresh droppings were collected for further study. Droppings were photographed and movements of gravid proglottids were videographed using Sony: DSC-HX300 digital camera. Fresh and dried droppings were collected during April-May, 2015.

(c) Preservation and processing of samples:

Gravid proglottids were preserved in 70% alcohol and were brought to the research centre of Society for

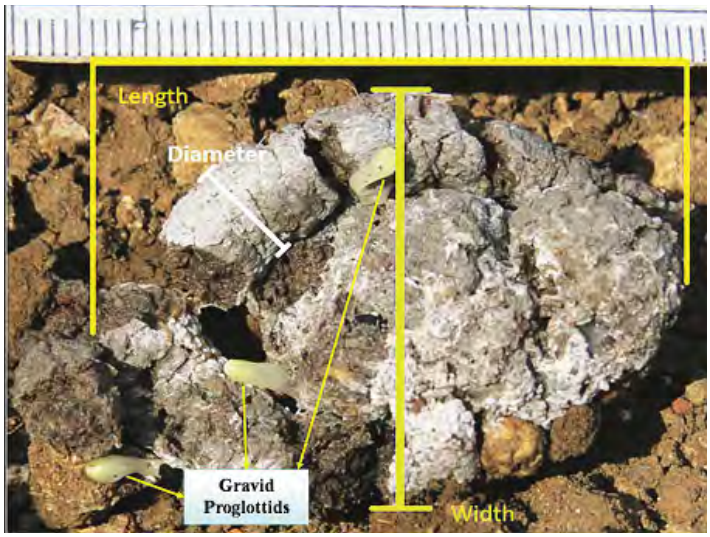

Fig. 2: Morphometry of fresh dropping (fecal sample) of Great Indian Bustard with gravid proglottids attempting to migrate outside the droppings.

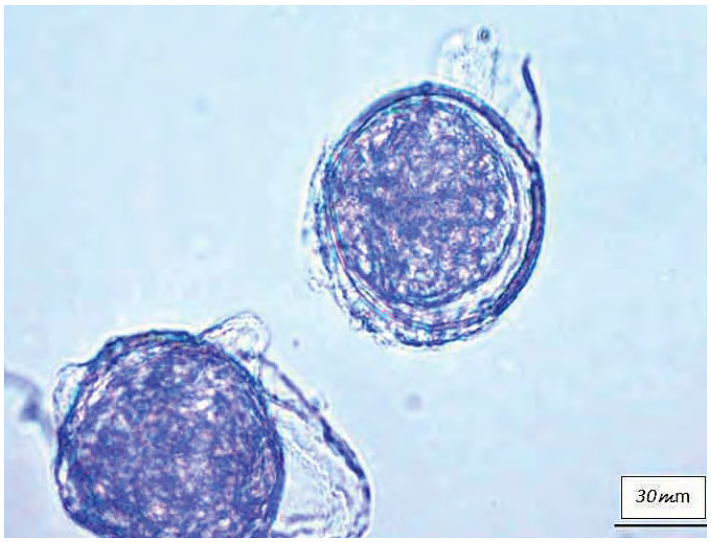

Fig. 3: Eggs of *Choanotaenia* (61.538mm in diameter).

Wildlife Conservation, Education and Research (Wild-CER). The proglottids were processed at the Department of Veterinary Parasiotology, Nagpur Veterinary College, Nagpur for microscopic examination and identification. Proglottids were pressed under cover glass, stained with Borax carmine, dehydrated in upgraded series of alcohol and cleared in clove oil and mounted on slide by using Canada balsam. Samples (gravid proglottids) are currently deposited with Department of Veterinary Parasiotology, Nagpur Veterinary College, Nagpur.

Results:

(a) Morphometry of Bustard Dropping:

Great Indian Bustard Droppings are flat, coiled and mostly dark brown in colour. Variation in size and colour may be correlated with diet. The average length of droppings (n=9) is 3.9 cm, width is 3.5 cm and the diameter of coil is 1 cm (Figure-2). Externally, the droppings are covered with whitish secretions from the inner lining of gut and with chalky white uric acid deposits towards the top.

(b) Morphology of the gravid proglottid:

Gravid proglottids were observed to be creamy white in colour and were longer than broad. Microscopic examination of pressed proglottids revealed presence of single set of genital organ. Gravid proglottids were markedly wider at posterior end and appeared funnel shaped. This feature is characteristic of the genus *Choanotaenia* (Figure-3) Uterus was observed as a sac like structure and was strongly lobed. It broke into egg capsule with one egg in each capsule.

(c) Egg morphology:

Each capsule contained a single oval to round egg covered with a delicate shell. Diameter of egg with capsule was 61.538 um (100X), which correlate with the standard egg size of the genus *Choanotaenia* (Figure-4). Photographs were taken using Axiocam ERc 5s (Zeiss) Lab A1binocular computerised research microscope.

(d) Percentage of infected hosts:

The Forest Department census data and our own field records in this area could find only three bustards during our studies in 2015. Out of the three bustards (2 males and 1 female), we could record presence of gravid proglottids in the droppings of two male bustards (66.66%). An average of four gravid proglottids per dropping were noted (n=07). Our study did not find any droppings of female bustard.

Discussion:

Our lack of knowledge about pathology and disease causing agents in the Great Indian Bustard may pose a serious challenge for future conservation initiatives like the captive breeding program. There are no recent published records on cestode parasites occurring in Great Indian Bustard anywhere in India. Parasites from both captive and free-living bustards have been studied extensively, but the effect of parasites on the population

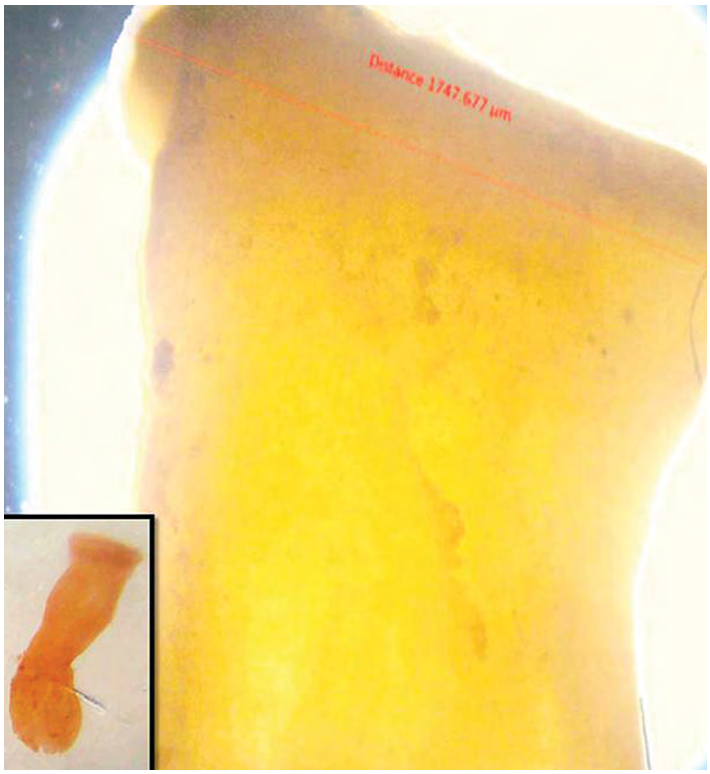

Fig. 4: Posterior end of gravid proglottid of *Choanotaenia* showing characteristic funnel shaped, wider posterior end.

dynamics of free-living bustard populations has not been well documented (Fowler and Miller, 2008). Pathological findings and post mortem examination of cestode infected bustards indicates that cestode infection can cause morbidity in the free living bustards and can pose a major threat to their population, even though they may not manifest clinical symptoms.

We have little information on the life cycle of the reported parasite. However, finding of parasites in both male bustards is a serious cause of concern. Of recently, Solapur region and specifically the area adjoining the Great Indian Bustard sanctuary, Nannaj, Solapur have seen activities that are putting continuous pressure on the sanctuary through habitat fragmentation, urbanization, quarrying, highways, industries and conflicts with local people. Currently, the real estate boom is posing greatest threats as traditional farms surrounding sanctuary are either purchased by landowners for housing projects or intensive farming methods. Such disturbances cause fragmentation of the once continuous grassland. As noted in our study, fragmentation has put bustards under several newer challenges arising through enhanced edge effect such as wider and highly criss-crossed roads; higher human activity; increased density of dogs,

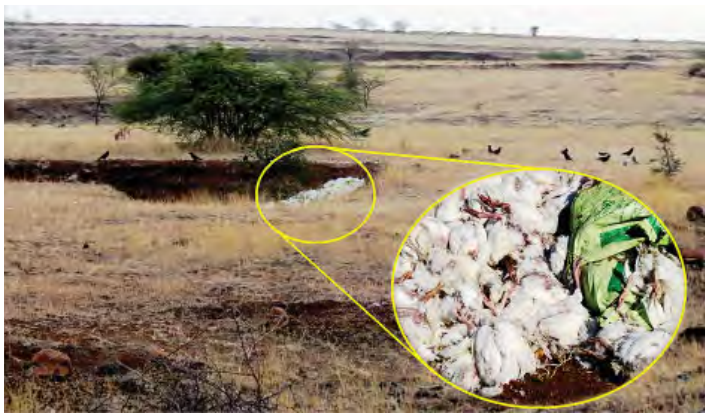

Fig. 5: Carcass of poultry birds around the sanctuary area.

wild boar, domestic birds and cattle, easy exposure and sighting by predators and poachers. It is likely that the cestode infestation noted in our study could be traced to exposure of wild bustards with domestic animals. High rate of contact between host and the parasite is one factor that encourages the spread of disease. Higher the fragmentation, higher will be the risk of potential source of infection (Primack, 1993). Declining bustard population with increasing disturbance causing or 'weedy' species (wild boar, dogs, domesticated animals, etc.) is an indication of elevated harmful edges. Cohn (1991b) states that human modifications of the environment have inadvertently increased the densities of disease-causing organisms. As, the Great Indian Bustard Sanctuary, Nannaj, Solapur and surrounding grasslands harbour many hatcheries and sometimes the dead carcass of poultry birds are thrown around the sanctuary boundary (Figure-5), it puts bustards in great crisis as diseases can spread from domestic animals into wild bustard population.

The infested bustards may act as reservoirs and pass on the disease causing parasite to a remote population when they migrate. At a time when 'Project Bustard' is on anvil in India, a thorough survey of cestode and other parasites in animals from the sanctuary surrounding areas is needed to minimize risk of exchange of diseases with captive stocks of bustards that are necessary for the successful implementation of 'Captive Breeding Program'.

Acknowledgement:

The author thanks UGC for financial assistance, Principal of the college and Forest Department for necessary permission to conduct surveys in and around the Great Indian Bustard Sanctuary, Nannaj, Solapur. Dr. Anil Pimplapure for his support, guidance and

encouragement. We appreciate the logistical support extended by the director, Govt. Veterinary College, Nagpur.

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Seasonal Diversity, Spatial and Temporal Abundance of Insect Prey of Great Indian Bustard *Ardeotis nigriceps* at Nannaj, Maharashtra

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Citation: Pande Satish, Sharma, R. M., Ghate, H.V., Rao, M. K., Joshi, R., Pathak, G., Mujumdar, N. and Kulkarni, A. (2016). Seasonal Diversity, Spatial and Temporal Abundance of Insect Prey of Great Indian Bustard *Ardeotis nigriceps* at Nannaj, Maharashtra *Ela Journal of Forestry and Wildlife* 5(2):211-220

Date of Publication:
30-6-2016

ISSN 2319-4361

Referee: Sunil Limaye and Nitin Kakodkar

Photographs provided by the authors

Abstract

Seasonal diversity, spatial and temporal abundance of insect prey of Great Indian Bustard *Ardeotis nigriceps* was studied in and around the Great Indian Bustard Sanctuary, Nannaj, Maharashtra using quadrat sampling, line transects and light trap methods. Significant seasonal, temporal and spatial variation in abundance and diversity of insects was observed. Quadrat sampling yielded 13 insect Orders dominated by Orthoptera followed by Homoptera and Lepidoptera. Monsoon season showed marked increase abundance gradually decreasing in winter and summer. Orthopterans were seen in all seasons. Grassland with plantations exhibited maximum insect diversity but maximum abundance was seen in natural grassland patches (dominated by 28 species of Lepidopterns belonging to 4 families) with least diversity in semi-natural grassland / fallow land patches. The abundance of grasshoppers was highest in natural grassland patches (100Ha) followed by grassland with plantations (Gangewadi) and fallow land patches (Mohitewadi). In addition to environmental factors, extent of habitat fragmentation, degradation and other direct or indirect human disturbances may also be critical drivers of seasonal trends in insect population. Continued year round qualitative and quantitative monitoring of prey base of the Great Indian Bustard will aid the forest department in prioritizing areas for habitat protection and bustard conservation.

Introduction

Insects dominate the ecosystems on earth both in terms of diversity and ecological functions and constitute food resources of several organisms (Wilson 1992). Poulin et al (1992) and Borg & Toft (2000)

highlight the importance of diversity and abundance of insect prey during the breeding period of insectivorous, nectarivorous, graminivorous and frugivorous birds. Seasonal availability of diverse insect fauna as prey may be decisive factors in the selection of feeding and breeding habitats by birds (Borg & Toft 2000).

Insects form important part of the diet of Great Indian Bustard *Ardeotis nigriceps* (Gruiformes: Otididae), a critically endangered species from the Indian subcontinent (Ali and Rahmani 1984). It faces multiple threats of varying severity throughout its present range : for example threats to its habitat, including fragmentation, destruction, and degradation and the bustard now survives in small remnant pockets of habitats in its diminishing distributional range which spans Maharashtra, Karnataka, Andhra Pradesh, Rajasthan, Gujarat and Madhya Pradesh in India (Rahmani 2006). One small population of this bird is harbored in the Great Indian Bustard Sanctuary near Nannaj, Maharashtra. Even in this area, the bustard faces threats such as clandestine persecution, grassland fires, direct or indirect interventions from humans, livestock and other domestic animals.

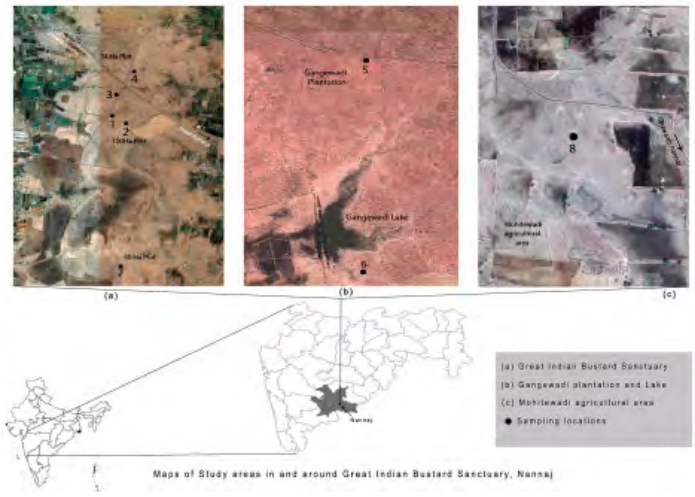
The bustards use flat open landscapes dominated by grasslands interspersed with short scrub and agricultural land and uses wide agro-grass-scrub landscapes in non-breeding season and congregates in undisturbed grassland patches during the breeding season (Rahmani 1989). It is an opportunistic omnivore, mainly feeding on insects and vegetative matter and rarely reptiles. The insect food involves Orthopteran and Coleopteran members followed by Lepidoptera while vegetative matter includes grass seeds, drupes of *Ziziphus* and agricultural crops such as groundnut, millets and legumes (Bhushan and Rahmani 1992).

Considering the dwindling population of the bustards, it is important to study the spatial and temporal dynamics of the available food in its preferred habitats in terms of abundance, diversity and distribution so as to characterize the quality of the available patches of habitats in the insect food resource from the Great Indian Bustard Sanctuary (henceforth abbreviated as GIBS). Such studies are few for Indian grasslands.

In our study, we assessed the seasonal changes in diversity, abundance and distribution of insect food resource and its temporal and spatial distribution at the GIBS Nannaj, Maharashtra. It shall augment the understanding of the dietary needs of the bustard and other insect feeding species of grassland at GIBS and assist the forest department in identifying priority areas for protection and conservation.

Materials and Methods

Study Area: The study was conducted on the request of the Maharashtra Forest Department in and around GIBS near Nannaj, Maharashtra on the Deccan Plateau in central India ($17^0$49'40"N and $75^0$51'35"E) in accordance with the provisions of the WPA, 1972. The study period was during December 2011 to September 2012. The climate is hot and arid with major monsoon precipitation concentrated in the months of July-October. The area experiences cold and dry weather between November-February and hot summer between March-June. The study area included protected and non-protected grassland patches nestled within a mosaic of multiple-use landscapes such as agricultural land, grazing land, fallow land and forestry plantations (see **Map**). Plantations include *Azadirachta indica*, *Glyricidia sepium.* Grass species include *Aristida* spp, *Heteropogon* spp, *Chrysopogon* spp, *Cymbopogon* spp, and *Dicanthium* spp. Along with grassland, there are patches of natural scrub vegetation including *Zizyphus mauritiana*, *Acacia leucophloea*, *Acacia nilotica*, a characteristic of tropical thorn forest (Champion and Seth 1968). Important native fauna included Jungle Cat *Felis chaus*, Golden Jackal *Canis aurious* and Indian Fox *Vulpes benghalensis* in relatively low densities (Vanak & Gompper 2010). Apart from the Indian Bustard *Ardeotis nigriceps*, GIBS is home to several endangered fauna like Black Buck *Antilope cervicapra*, Indian Wolf *Canis lupus* and Indian Pangolin *Manis crassicaudata* (Pande 2003; Unpublished record by author MKR).



Maps of Study areas in and around Great Indian Bustard Sanctuary, Nannaj

Sampling Area	Sampling units used	Habitat
Ha Core Area	Quadrats (**Q1, Q2**) and transect (**T1**)	Protected grassland
Tephrosia plot N1 N2	**Q3**)	Grassland and Scrub
Ha Mardhi Area	**Q4**) and Transect (**T2**)	Short Grass and Scrub
Gangewadi	**Q5, Q6**) and Transect (**T3**)	Lake, Forest Department Plantation and Scrub
Ha Mardhi	**Q7**) and transect (**T4**)	*Azadirichta indica* plantation
Mohitewadi	Quadrat (**Q8**) and transect (**T5**)	Agricultural land

Table 1. Habitat and sampling units used in study area

Insect Sampling:

1. Quadrat Sampling: 10m X 10m quadrats were used to access the seasonal changes in relative insect abundance. Sweep net (net diameter: 30cm; mesh size: 2mm) was used to capture the insects. Sweeping was done so as to cover an area near to the ground to approximately 1m. (Sutherland, 1996). Each quadrat was sampled by two persons working together, each covering half of the quadrat respectively (Table 1). The net was emptied after each sweep and insects collected were identified to order level designated as operational taxonomic units (OUT) by expert entomologists or sometimes from photographs taken in the field and released outside the quadrat after completing of the entire sweep to avoid re-sampling of same individuals. Total sampling effort consisted of 12 sweeps per quadrat, during each sampling study in winter, summer and monsoon respectively.

2. Line transects survey: One 500m line transect was executed in each study area to observe diversity of butterflies. Transects were laid such that all possible microhabitats were covered. Butterflies were observed in morning as well as evening hours, up to a distance of 10m on both sides of the transect. All individuals observed were identified to species level visually, except members of Family Lycaenidae which were captured by net, identified (Kihimkar 2008) and released.

3. Light trap method: Light trap was set up at Forest Department Rest House using mercury vapour lamp lit in front of white cloth screen to attract nocturnal insects. Pit fall traps were not used for sampling in order to avoid possible consumption of insect preservative chemicals by bustards or any other wild animal.

4. Opportunistic records: We also recorded Amphibians, Reptiles and birds during the study (given in Appendix 4, 5 and 6). The observations were purely opportunistic and no particular method was used while recording these taxa. Further, these records were not used in data analysis as study was mainly focused on insect groups.

5. Analysis: The results of line transect and light trap are not comparable to quadrat data owing to their qualitative nature, extent and effort of sampling. For analysis all the data of seasonal abundance of insects was pooled from quadrat sampling only. The three methods together, however, gave an overall assessment of diurnal and nocturnal insects in the GIBS.

Results

We observed significant seasonal variation (**Fig 1**) both in abundance and diversity of insects. Total 240 sweeps in entire quadrat sampling yielded 311 individuals belonging to 13 Orders. The sweep net samples were dominated by individuals of order Orthoptera followed by Homoptera and Lepidoptera. The monsoon season showed marked increase in the numbers of captured insects, however, sampling survey in monsoon suffered from serious under sampling due to water logged condition and inaccessibility of some study sites. Nevertheless, highest numbers of Orthoptera were observed in monsoon where number of captured individuals was more for grassland habitat. Lepidopteran number was moderate in winter and lowest in summer but started increasing soon after monsoon. Winter was marked with higher numbers of homopterans (Cow bugs) and heteropterans (Stink bugs) as compared to other seasons. Overall diversity of insect orders was also high for winter. Mantodea were low in numbers but were consistently present in all the seasons.

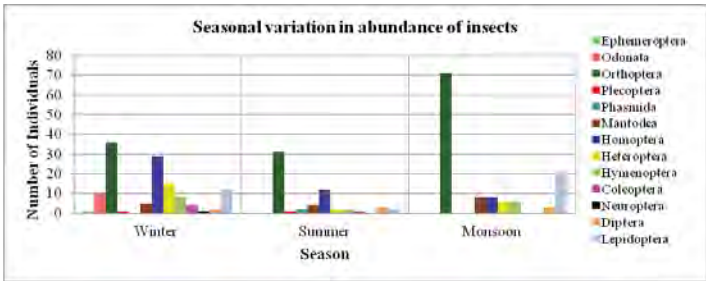


Fig.1 Bar chart showing seasonal variation in diversity and abundance of insects. (Data from all the quadrats is pooled for each season).

A more detailed picture evolved when insect abundance and diversity within each sampling location was compared across the seasons (**Fig 2: a, b and c**). Though the monsoon survey suffered from under-sampling, it nonetheless showed more number of insect captures per quadrat. In winter, sampling sites in Gangewadi area showed high diversity in terms of number of insect orders captured. This might be attributed to more complex nature of vegetation at this site compared to other sites. Summer season showed significant decrease in diversity as well as abundance of insects throughout all the sampling locations with few dominant taxa such as Orthoptera and Homoptera. Fresh growth of vegetation during monsoon boosted the abundance of insects, indicated by significantly higher numbers of insects captured, especially Orthoptera, Lepidoptera and Homoptera. Winter season shows a more or less uniform distribution of insect orders across the sampling sites.

Grouping of study sites according to the type of habitats gives a better understanding of variation in abundance and distribution of insect orders (**Fig 3: a, b and c**). Patches of grassland with plantation (**Fig 3b**) harbor more insect diversity followed by natural grassland patches (Fig 3a), however, number of captured insects stands significantly higher in natural grassland. Further, uncommon order like Ephemeroptera (Mayflies) and Plecoptera (Stoneflies) were found only in grasslands with plantations. Individuals of Coleoptera were present in grassland with plantation and semi-natural grassland / fallow land patches but were represented by low numbers. Lepidopterans were significantly high in natural grasslands compared to all other habitat types.

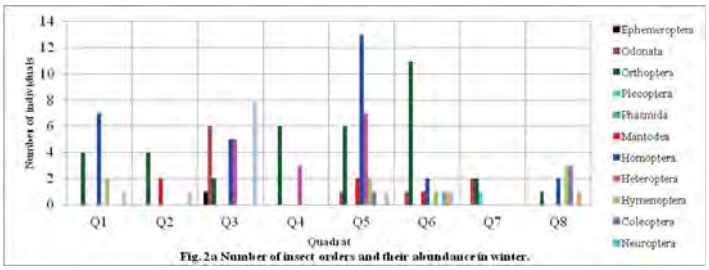


Fig. 2a Number of insect orders and their abundance in winter.

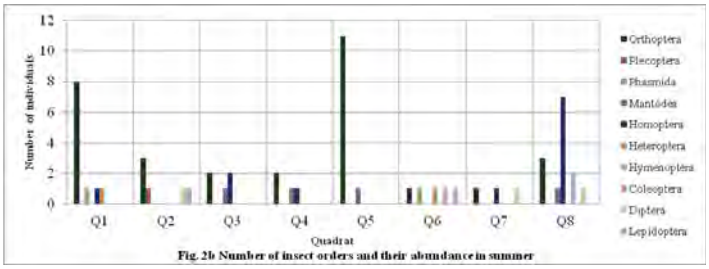


Fig. 2b Number of insect orders and their abundance in summer

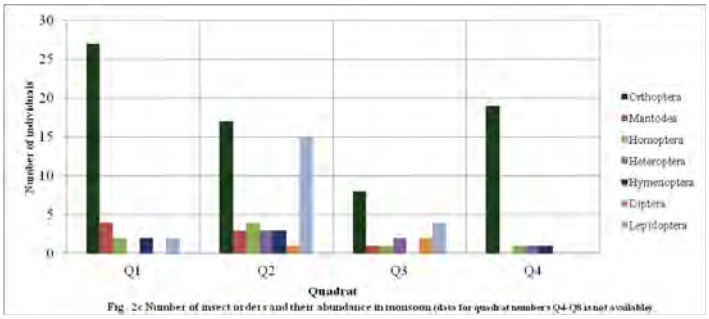


Fig. 2c Number of insect orders and their abundance in monsoon (data for quadrat numbers Q4-Q8 is not available)

Fig 2(a, b and c): Seasonal diversity and abundance of insect Orders between each sampling site.

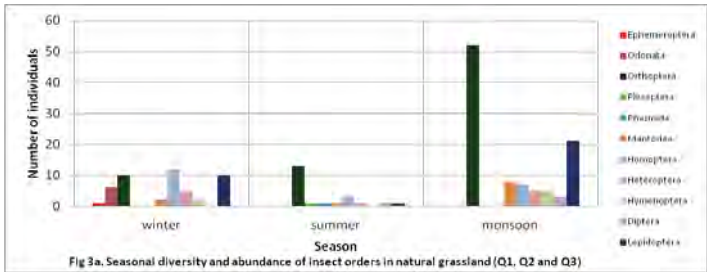


Fig 3a. Seasonal diversity and abundance of insect orders in natural grassland (Q1, Q2 and Q3)

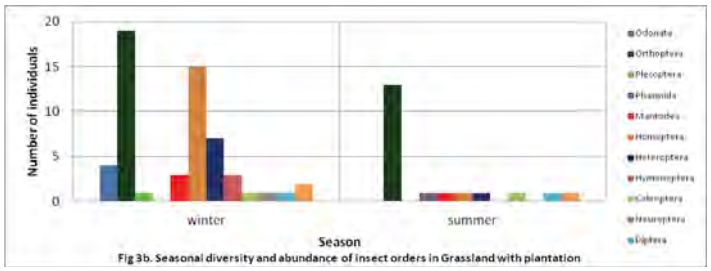


Fig 3b. Seasonal diversity and abundance of insect orders in Grassland with plantation

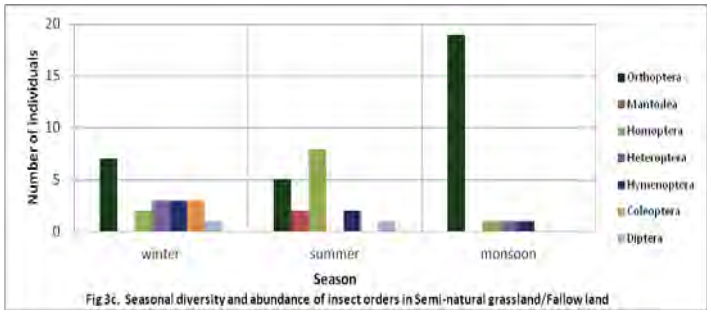


Fig 3c. Seasonal diversity and abundance of insect orders in Semi-natural grassland/Fallow land

Fig 3 (a, b and c): Seasonal variation in diversity and abundance of insects across three habitat types

Orthoptera dominated in all habitats in all the seasons with highest abundance in natural grassland followed by grassland with plantation and fallow land patches. Semi-natural grassland/ fallow land patches (**Fig 3c**) showed considerably lower diversity and abundance of insects compared to other two habitat types.

Line transect and light trap surveys:

28 species belonging to 4 families of butterflies were recorded during the line transect surveys. Highest concentration of butterflies was found in natural grassland patches especially during monsoon. Family Lycaenidae showed highest number of species followed by Nymphalidae, Pieridae and Papilionidae. Diversity of butterflies varied significantly with available food resources for larval stages and adults. Light trap surveys showed most of the orders of insects captured in sweep net sampling; however these were dominated by Lepidopterans (Moths). Individuals of Coleoptera which were rarely captured in sweep nets showed up in significant numbers on light traps. Other insects on light trap included individuals of Homoptera and Heteroptera in moderate numbers followed by stray counts of insects of other orders.

Limitations of the study:

All the methods of sampling (Sweep Net, Line Transect and Light Trap), even if considered together contribute partial assessment of the entire insect population in the study area. However, these sampling methods provide a thorough survey of insects within the small spatial region of habitats. Particular insect orders were certainly under-represented in sweep net sampling since Coleoptera may be crepuscular and Diptera or other day flying insects may have evaded the net. Never the less, the overall sampling effort, although not comprehensive in terms of assessment of absolute numbers and diversity of insects, served to indicate relative numbers and seasonality of insect groups which was the primary aim of the study. The other limitation of the study was scarce rainfall during the years prior to the study period that may have led to insect paucity. But this study fills the long gap that existed in the food availability for the Great Indian Bustard in the Nannaj WLS. Their earlier study was conducted in 1982-83 (Ali and Rahmani 1984).

Discussion

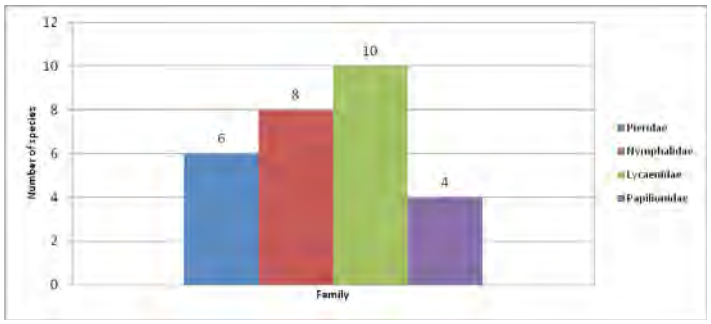


Fig4: Family wise species richness of butterflies.

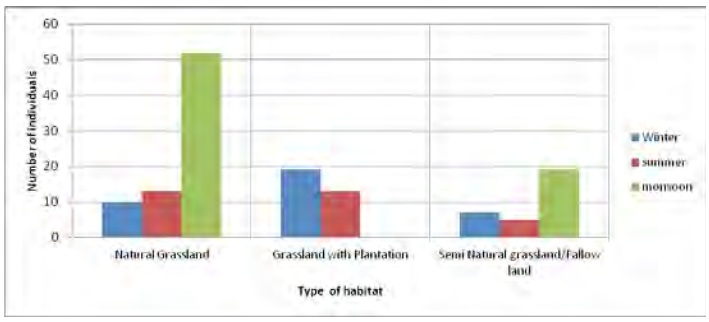


Fig. 5 Seasonal abundance of grasshoppers (nymphs+adults) in different habitats.

We observed a significant temporal variation in number and diversity of insects. Composition of insect groups in different sampling sites also varied with season and type of habitat. Grasshoppers (Order: Orthoptera) formed a major quantum of insect diet of Great Indian Bustard in our study and this is comparable to findings of others (Bhushan and Rahmani 1992). Parker (1930; Dempster (1963) and Bhushan & Rahmani (1992) have shown seasonal variations in grasshopper populations depending on rainfall and temperature. In our study also, we observed significant seasonal variation in the abundance of grasshoppers (Order: Orthoptera) (Fig. 5). The number of adult grasshoppers was low in winter which steadily increased and peaked in monsoon. The abundance of grasshoppers was significantly high in natural grassland patches (100Ha) followed by grassland with plantation (Gangewadi) and fallow land patches (Mohitewadi). The low numbers in semi-natural grassland/fallow land patches may be attributed to heavy grazing leading to less grass availability. We found grasshopper nymphs in every sampling site during winter and summer, although the number in summer was significantly low. In contrast, no nymphs were recorded in winter and summer in a previous study done by Rahmani and Ali (1984) in the same area. Existence of nymphs in this period may relate to short and scanty rainfall in previous year and less availability

of food resources to continue metamorphosis and reach adult stage.

The breeding season of Great Indian Bustard spans over July-November. The bustards start courtship displays in June followed by egg laying during July and August and hatching starts from mid August till late September (Rahmani and Ali 1984). It seems that breeding events of the bustard coincide with concurrent increase in the number of grasshoppers in monsoon season. when grasshoppers along with other insects are available in plenty for the bustards to meet their energy demands and to feed the chicks with the protein rich diet.

Natural grassland patches (100Ha) showed highest abundance of insects in all the seasons but the insect diversity was slightly greater in grasslands with plantation (Gangewadi). In winter, the abundance was low. Heterogeneity in structure of such habitats might accommodate greater number of insect feeding guilds resulting in comparatively high diversity. Both abundance and diversity of insects was low in semi-natural / fallow land patches consisting of few dominating orders, of which Orthoptera were highest in number. Nevertheless, we found Dung Beetles (Coleoptera) only in semi-natural / fallow land habitat at Mohitewadi where cattle grazing was ongoing. Coleoptera also form a part of bustard's diet (Rahmani and Ali 1984; Bhushan & Rahmani 1992). Dung Beetles, owing to their size and ease of capture can be considered as important constituents of the diet of the bustard. Sighting records of bustards in Mohitewadi area is a testimony to this fact.

Probability of sighting and capturing insect prey by the bustard could depend on the size of the insect. Greater the size of insect prey higher would be the possibility of its sighting and capture by the bustard. Availability of larger prey items could play an important role in habitat preference of bustards. Patches of natural grassland in 100Ha area harbor plenty of larger insects like grasshoppers, locusts, (Order: Orthoptera), praying mantis (Order:Mantodea), Neuropterans, Lepidopteran larvae, etc. Hence, these patches are important for bustards in their breeding period. Lepidoptera are also among known insect prey of bustards (Bhushan and Rahmani 1992), however, it is uncertain if the bustards feed on adults or larvae.

Patterns of seasonality in insect populations are probably consistent from year to year, but would vary in amplitude with environmental factors such as rainfall and temperature (Lowman 1982). In addition to environmental factors, extent of habitat fragmentation, degradation and other direct or indirect human disturbances may also be critical drivers of seasonal trends in insect population.

Conclusions

Great Indian Bustard shows variable habitat preferences in breeding and non breeding periods. Based on the finding in our study, certain areas in GIB sanctuary can be highlighted as priority areas for the bird. Though the study suffered from some limitation due to lack of rainfall in the study area for two previous consecutive years, it nonetheless provides an index of insect abundance, enabling us to weigh different habitat types in the GIB sanctuary in terms of seasonal shifts in insect prey availability. Natural grassland in 100Ha area of the sanctuary holds highest importance since it harbors highest insect abundance. Grasslands with plantation in Gangewadi area are also important as they show good insect diversity and abundance. As expected, dung-beetles were found only in areas where cattle grazing was permitted (Mohitewadi) and were absent from areas where it was banned. Though the semi-natural grassland / fallow land patches adjoining 34 Ha plantation plot showed comparatively low insect diversity and abundance, they are used by bustards in dry period, probably due to good distant visibility and connectivity with other habitats. Continuous monitoring of insect diversity and abundance is important owing to their seasonal shifts and vulnerability to different threats. Insects are part of diet of not only bustards but also of other grassland birds and mammals. Prey base in the habitat inter-connects various trophic levels. Hence, continued year round qualitative and quantitative monitoring of prey base will aid the forest department in prioritizing areas for habitat protection and bustard conservation.

Acknowledgement: Authors are grateful to the Maharashtra Forest Department for requesting them to conduct the survey in the GIBS, for granting the necessary permissions and facilitating the study. Authors express gratitude to the staff of the forest department (particularly Mr. Bhagwat Mhaske), Nannaj, Solapur for support during the survey. We thank Shriraj Jakhalekar for assistance.

Appendix 1

Original Data of all the 8 quadrates in all the three seasons

Sr. No	Orders	Seasons																			
		Winter								Summer								Monsoon*			
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q1	Q2	Q3	Q4
1	Ephemeroptera	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Odonata	0	0	6	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Orthoptera	4	4	2	6	6	11	2	1	8	3	2	2	11	1	1	3	27	17	8	19
4	Plecoptera	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
5	Phasmida	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
6	Mantodea	0	2	0	0	2	1	0	0	0	0	1	1	1	0	0	1	4	3	1	0
7	Homoptera	7	0	5	0	13	2	0	2	1	0	2	1	0	0	1	7	2	4	1	1
8	Heteroptera	0	0	5	3	7	0	0	0	1	0	0	0	0	1	0	0	0	3	2	1
9	Hymenoptera	2	0	0	0	2	1	0	3	0	0	0	0	0	0	0	2	2	3	0	1
10	Coleoptera	0	0	0	0	1	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0
11	Neuroptera	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Diptera	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	1	0	1	2	0
13	Lepidoptera	1	1	8	0	1	1	0	0	0	1	0	0	0	1	0	0	2	15	4	0

* Note that the data for quadrates 5 to 8 is absent as sampling was not done due to heavy rains

Appendix 2: Checklist of Plants in GIBS

S.N.	Family	Name of Species
1	**Acanthaceae**	*Lepidagathis cristata*
2		*Rungia repens*
3	**Amarantheceae**	*Alternanthera pheloxeroides*
4		*Celosia argentea*
5	**Asteraceae**	*Tridax procumbens*
6		*Wedelia sp.*
7	**Boraginaceae**	*Trichodesma indicum*
8	**Caesalpiniaceae**	*Cassia auriculata*
9		*Cassia tora*
10	**Capparaceae**	*Cleome simplicifolia*
11	**Convolvulaceae**	*Evolvulus alsinoides*
12	**Euphorbiaceae**	*Bridelia retusa*
13	**Fabaceae**	*Alysicarpus tetragonolobus*
14		*Desmodium sp.*
15		*Leuceana leucocephala*
16		*Tephrosia purpurea*
17	**Lamiaceae**	*Lavandula bipinnata*
18		*Leucas aspara*
19		*Ocimum gratissimum*

S.N.	Family	Name of Species
20	**Meliaceae**	*Azardirachta indica*
21	**Mimosaceae**	*Acacia auriculata*
22		*Acacia leucophloea*
23	**Nyctaginaceae**	*Boerhavia repens*
24	**Pedaliaceae**	*Sesamum orientale*
25	**Rhamnaceae**	*Zyzipus mauritiana*
26	**Scrophulariaceae**	*Striga asiatica*
27		*Striga densiflora*
29	**Verbenaceae**	*Lantana camara*

Appendix 3: Checklist of Butterflies in GIBS

S. N.	Family	Scientific Name	Common Name
1	Pieridae	*Catopsilia pomona*	Common Emigrant
2		*Eurema hecabe*	Common Grass Yellow
3		*Cepora nerissa*	Common Gull
4		*Delias eucharis*	Common Jezebel
5		*Catopsilia pyranthe*	Mottled Emigrant
6		*Ixias marianne*	White Orange Tip
7	Nymphalidae	*Junonia orithya*	Blue Pansy
8		*Tirumala limniace*	Blue Tiger
9		*Euploea core*	Common Crow
10		*Ypthima asterope*	Common Three-ring
11		*Tirumala septentrionis*	Dark Blue Tiger
12		*Cynthia cardui*	Painted Lady
13		*Danaus chrysippus*	Plain Tiger
14		*Acraea violae*	Tawny coster
15	Lycaenidae	*Azanus* sp.	Babul Blue
16		*Castalius rosimon*	Common Pierrot
17		*Zizeeria karsandra*	Dark Grass Blue
18		*Euchrysops cnejus*	Gram Blue
19		*Freyeria trochylus*	Grass Jewel
20		*Lampides boeticus*	Pea Blue
21		*Chilades pandava*	Plains Cupid
22		*Tarucus nara*	Rounded Pierrot
23		*Zizula hylax*	Tiny Grass Blue
24		*Leptotes plinius*	Zebra Blue
25	Papilionidae	*Papilio polytes*	Common Mormon
26		*Pachliopta hector*	Crimson Rose
27		*Papilio demoleus*	Lime Butterfly
28		*Graphium agamemnon*	Tailed Jay

Appendix 4: Checklist of Amphibians in GIBS

S. N.	Family	Scientific Name	Common Name
1	Bufonidae	*Dattaphrynus melonosctictus*	Common Indian Toad
2	Hylidae	*Fejervarya limnocharis*	Cricket Frog
3	Microhylidae	*Uperodon systoma*	Marbled Balloon Frog
4	Microhylidae	*Microhyla ornata*	Ornate Narrow-mouthed Frog
5	Ranidae	*Euphlyctis cyanophlyctis*	Indian Skipper frog

Appendix 5: Checklist of Reptiles in GIBS

S. N.	Family	Scientific Name	Common Name
1	Agamidae	*Sitana ponticeriana*	Fan-throated Lizard
2	Agamidae	*Calotes versicolor*	Garden Lizard
3	Gekkoinidae	*Hemiductylus brookii*	Brook's House Gecko
4	Gekkoinidae	*Hemiductylus triedrus*	Termite Hill Gecko
5	Viperidae	*Echis carinatus*	Saw-scaled Viper

Appendix 6: Checklist of opportunistic records of birds in GIBS

Family	Scientific Name	Common Name
Accipitridae	*Circus pygargus*	Montagu's Harrier
Accipitridae	*Elanus ceruleus*	Black -shouldered Kite
Accipitridae	*Milvus migrans*	Black Kite
Accipitridae	*Haliastur indus*	Brahminy Kite
Accipitridae	*Aquila fasciata*	Bonelli's Eagle
Otididae	*Ardeotis nigriceps*	Great Indian Bustard
Phasianidae	*Pavo cristatus*	Indian Peafowl
Glareolidae	*Cursorius coromandelicus*	Indian Courser
Alaudidae	*Mirafra cantillans*	Singing Bush-Lark
Alaudidae	*Mirafra erythroptera*	Red-winged Bush-Lark
Alaudidae	*Eremopterix griseus*	Ashy-crowned Sparrow Lark
Dicruridae	*Dicrurus macrocercus*	Black Drongo
Pycnonotidae	*Pycnonotus cafer*	Red -vented Bulbul
Campephagidae	*Pericrocotus cinnamomeus*	Small Minivet
Sturnidae	*Sturnus roseus*	Rosy Starling

Photoplate No.1: Order Orthoptera Grasshoppers (Fig. 1-4) and Cricket (Fig 5,6)
Order Plecoptera: Stonefly (Fig. 7)
Order Odonata Dragonflies (Fig. 8) and Damselflies (Fig. 9)

Photoplate No. 2: Order Coleoptera (1) Coleopteran beetle (2) Cerambysid beetle (3) Dung beetle
Order Mantodea: Mantis Adult (Fig. 4 and 5) and Nymph (Fig 6)
Order Neuroptera: (7) Mantispa (8) Neuropteran Fly (Antlion)

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Photoplate No. 3: Order Homoptera: (1), (2) and (3) Leafhoppers
Order Heteroptera: Pentatomid or stink bugs (4) *Agonoscelis nubilis* (5) *Stenozygum speciosum* (6) *Plautia crossota* (7) Coreid bug
Order Diptera: (8) House fly (9) Robberfly
Order Hymenoptera: (10) *Camponotus compressus* tending homopterans (11) *Tetraponera allaborans* (12) *Dorylus sp*. winged morph

Photoplate No. 4: Butterflies at Nannaj (1) Blue tiger (2) Painted Lady (3) Gram Blue (4) Pea Blue (5) Rounded Pierrot (6) Common Emigrant (7) Common Gull (8) Plain Tiger

Photoplate No. 5: Lepidoptera (Moths) on Light Trap observed at Nannaj

Photoplate No. 6: Class Amphibia (1) Common Indian Toad
Class Reptilia: (2) Fan Throated Lizard (Sitana) (3) Saw-scaled Viper
Class Aves (Birds): (4) Syke's Creasted Lark (5) Singing Bush Lark (6) Plain's Prinia (7) Baya Weaver Bird Male (8) Bonelli's Eagle

Great Indian Bustard *Ardeotis nigriceps* in Archaeofaunal Record

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Citation: Joglekar, P. P. (2016). Great Indian Bustard *Ardeotis nigriceps* in Archaeofaunal Record *Ela Journal of Forestry and Wildlife* 5(2):221-222

Date of Publication:
30-6-2016

ISSN 2319-4361

Fig. 1 Bustard bones identified from Inamgaon (Thomas 1988). Photograph from author's archive.

Due to various types of interactions of humans with the other animals in the past, archaeofaunal record is rich. Physical remains of diverse animals are found during archaeological excavations. These include bones, teeth, egg shells and other hard materials that survive in the archaeological deposits. Mammals as well as non-mammals that have had some role to play in the past human life appear in the archaeological deposits. The archaeological deposits from the lower Palaeolithic till as late as ninetieth century modern period have yielded remains of animals. These have been useful in reconstructing the past cult human subsistence and their environment (Joglekar and Goyal 2015). The study of past animals and their relations with humans is known as archaeozoology (Zooarchaeology), which is a branch of archaeology. The remains of animals found in archaeological contexts are primarily related to food procurement (hunting/trapping / keeping domestic animals) and food consumption related activities. In a rare situation the remains of animals dead due to natural reasons are found (Joglekar 2015).

Due to variety of reasons (porous bird bones, technology of hunting / trapping) it has been observed that the remains of birds are far less in proportion than mammals (Joglekar 2005). So far, only ostrich has been identified from the pre-Holocene deposit at a site of Patne in Maharashtra dated to 25000 ± 200 B.P. A few bird species that have been identified include domestic fowl (*Gallus domesticus*), jungle fowl (*Gallus gallus*), peafowl (*Pavo cristatus*), goose (*Anser indicus*), heron (*Ardea* sp.) crane (*Grus* sp.), black partridge (*Francolinus francolinus*) and cattle egret (*Bubulus ibis*).

The evidence of bustard (*Ardeotis nigriceps*) is limited to only two sites in Maharashtra. The sites where bustard bones have been securely identified are Inamgaon and Tuljapur Garhi. At Inamgaon a few bones of bustard were recovered from Late Jorwe Phase (Fig. 1)

At Inamgaon cultural material of Malwa Phase (1600-1400 BCE), Early Jorwe Phase (1400-1000

Fig. 2 Bustard bones identified from Tuljapur Garhi (Faunal material: Thomas 1992). Photograph from author's archive.

BCE) and Late Jorwe Phase (1000-700 BCE). Thomas (1988) has identified a few bones of bustard – *Ardeotis nigriceps* from the Chalcolithic sites of and Inamgaon in Maharashtra.

Tuljapur Garhi is situated in Amravati district of Maharashtra. It was excavated by the Archaeological Survey of India in 1984-85. This site has evidence of Malwa Phase and Jorwe Phase of the Chalcolithic culture. Bustard bones (Fig. 2) were recovered from the Jorwe Phase dated to the mid-first millennium BCE (Thomas 1992).

Besides these two sites a few bones of the bustard (based on size) have been identified at three sites – Tharsa in Nagpur district (Joglekar and Thomas 1997-1998), Apegaon in Aurangabad district (Joglekar 2000-2001) and Kaothe in Dhule district (Thomas and Joglekar 1990). Tharsa was a site of Meglithic culture with Chalcolithic affiliations. Kaothe was a single culture site of Salvada Phase of Deccan Chalcolithic (2000-1800 BCE). Apegaon belonged to Ramathirtha culture of Deccan Chalcolithic tradition dated to approximately 18th century BCE. The skeletal elements recovered at these sites were mainly the long bones (femur and tibia) and phalanges, but devoid of specific distinguishing markers. These skeletal elements were found in association with food refuse where remains of other animals have been discarded after eating their meat.

To conclude, it may be mentioned that though the evidence is not conclusive at sites such as Tharsa, Kaothe and Apegaon; there is possibility that the bustard had a wide range of distribution in the past. It was spread at least from Nagpur in the east, northern region of Maharastra and in south Maharashtra until about 700-600 BCE.

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Great Indian Bustard *Ardeotis nigriceps* in Sanskrit Literature: An Ethno-ornithological Conservation Perspective

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Citation: Pande, Suruchi and Pande, Satish (2016). Great Indian Bustard *Ardeotis nigriceps* in Sanskrit Literature:
An Ethno-ornithological Conservation Perspective
Ela Journal of Forestry and Wildlife 5(2):223-224

Date of Publication:
30-6-2016

ISSN 2319-4361

Arid and semi-arid landscapes in India are occupied by the large majestic Great Indian Bustard *Ardeotis nigriceps* which is presently facing the risk of extinction. A search was made to find references to this bird in the ancient Indian literature to investigate its cultural links. Interestingly I came across a few interesting references to the Great Indian Bustard from the Vedic texts including the texts on *Ayurveda* and also in the *Smritis* (which are dynamic books on social, political and economic laws that kept on changing according to the developments and changes in social structure). Though the references are not too frequent, it is interesting to document that our ancestors had taken note of this big bird residing in desert areas.

The various references to the Great Indian Bustard are as follows:

Sanskrit names for the Great Indian Bustard[1]:

- *Vaarata* – It means an open field. This refers to the bird that wanders in a field or in an open space. The name denotes the habitat occupied by the bustard.

- *Marubaka* – A stork like bird of the desert (Sanskrit word for desert is *Maru*). This is an apt name for the Great Indian Bustard. The name compares the bustard with another bird from a different and more familiar habitat and also alludes to the habitat of the bustard.

- *Guru Kantha* – One with a broad neck. This name probably refers to the peculiar gular or neck pouch of the male bird that is particularly prominent during the breeding season. It is conspicuously enlarged during the courtship behavior of the male for attracting the attention of the females. The Great Indian Bustard is known to breed in exploded leks. The name denotes an anatomical feature of the bustard.

- *Khadira Varna* – *Khadira* is a type of tree and *varna* is colour of the body (complexion). One who is rufous brown in colour. *Khadira* tree is the *Khair* or Heart Wood tree *Acacia catechu*. The colour of the extract of the bark of this tree is rufous brown and it is traditionally used as a digestive, astringent, for sore throat, pruritus and diarrhea. Is eaten after meals.

The plumage colour of the back of the Great Indian Bustard is similar to that of the *Khadira* extract. The *Khadira* tree is distributed in Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, and Karnataka, which is where the Great Indian Bustard is also seen. The name denotes plumage colour of the bustard and its comparison with the colour of the extract of a tree species with medicinal value.

- *Gonarda* – *Go* means a cow and *narda* is to bellow or to roar. Hence, the word alludes to one who gives out bellowing calls like a cow and hence is called the *gonarda*. The Great Indian Bustard also emits deep resonant loud calls that can be heard over long distances in the open habitats that it occupies, particularly during the night. Its calls are very different from those of the wolf, a distinctively vocal mammal that shares the habitat with the bustard. The name denotes the call of the bustard and its breeding habit.

- *Maru Tanka* – where *Maru* is a desert and *tanka* means a twanging sound. The name denotes the call of the bustard.

- *Hingu Raaja* – One who has a smell like asafetida? The meaning of this word is not clear.

Local names for the Great Indian Bustard

- *Godavan* – Great Indian Bustard is the state bird of Rajasthan and it is locally called as *godavan*. Probably this word is derived from the Sanskrit word *gonarda*.
- *Hookna* – The name is descriptive of the deep resounding call of the bustard.
- *Maaldhok* – The local Marathi word *Maaladhok* may have derived from the Sanskrit word *Marubaka*.

Summary of Ethno-ornithological Interpretation:

When we analyze the various Sanskrit names of the Great Indian Bustard we find that our ancestors have looked at this species in a comprehensive perspective like what we see for avian species from other widely separated geographical areas in our country (Pande and Abbi, 2010). For the Great Indian Bustard we find two names referring to the habitat used by the bustard (desert and arid areas), one name indicative of a prominent anatomical feature (gular pouch), one name describes the breeding behavior (puffing of the neck pouch by the breeding male), one name describing the plumage colour (of the back), two names take note of the distinctive call of the bustard, three names compare the attribute of the bustard with another species of bird (stork), mammal (cow) and flora (*Acacia* species), while one name presently remains unclear but compares it with the smell of a culinary ingredient.

Table 1: Different attributes and the corresponding names of the bustard for that attribute are summarized in this table:

Attribute of the name	Sanskrit name of bustard
Habitat	*Vaarata, Marubaka, Marutanka, Maaldhok*
Anatomical feature	*Guru Kantha*
Plumage colour	*Khadira Varna*
Behaviour - courtship	*Guru Kantha*
Sound	*Gonarda, Godavan, Hookna*
Meaning unclear	*Hingu Raaja*
Comparison with another species	*Khadira Varna, Marubaka, Gonarda*

The ethno-ornithological analysis indicates that our ancestors were very observant and looked at the flora and fauna around them as a whole and related themselves with the surrounding biodiversity as an inseparable whole (Pande and Abbi, 2012). This is a unique feature of the ancient Indian culture that has helped in the conservation and preservation of the biodiversity of our country. Unfortunately the elegant bustard was later considered as a game bird in the 20th century and was widely persecuted for the sport of hunting and has now sadly approached the Critically Endangered status. The present paper is written with an intention of not only documenting the ethno-ornithological links of the bustard as an academic exercise, but also for providing the much needed cultural links of this beautiful bird for the officers and staff from the forest department and other enforcement agencies, with a hope that they may find these links useful to attract the attention and participation of the common public for the conservation of the Great Indian Bustard.

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