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Full Length Research Paper

Using citizen science in assessing the distribution of Sarus Crane (*Grus antigone antigone*) in Uttar Pradesh, India

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The Indian Sarus Crane (*Grus antigone antigone*), is the world's tallest flying bird and a globally 'Vulnerable' species as per IUCN Red List of Threatened Species. It is the only resident breeding crane in India. Citizen scientists currently play active roles in a varied range of ecological assignments, and their contributions have enabled scientists to collect large amounts of data at minimal cost. eBird is a large citizen science database that contains a large and growing volume of bird count data which has been successfully used to analyze diversity, distributions of bird species. The present work deals with the utilization and presentation of citizen science data to map the distribution of Sarus Cranes in Uttar Pradesh in the last 10 years (that is 2008 to 2017). Mapping is done using Arc GIS 10.2 software and resulted in various patterns of Sarus sightings in the state. The study concluded that a total of 1,902 Sarus documented by 342 social groups or e-birders from 43 districts of Uttar Pradesh. This study showed public participation as an important data collection tool for the species, which has a reportedly large distribution range.

Key words: Birds, public participation, IUCN, eBird, mapping.

INTRODUCTION

Analyses of any animal population status and change are fundamental actions of conservation and ecological research. Traditionally, the main source of information to estimate the changes in population and trends is counting the individuals. Citizen scientists currently play active roles in obtaining a large scale data ecological project and their contributions have permitted researchers at the nominal cost. In worldwide, evenly in India, birdwatching is very popular and curiously increasing day by day among the general public and have been supporting the many major bird monitoring program or projects at participating citizen scientists. The Campus Count, Backyard Count, Winter Count, etc., have successfully relied on citizen scientist to collect data (LePage and

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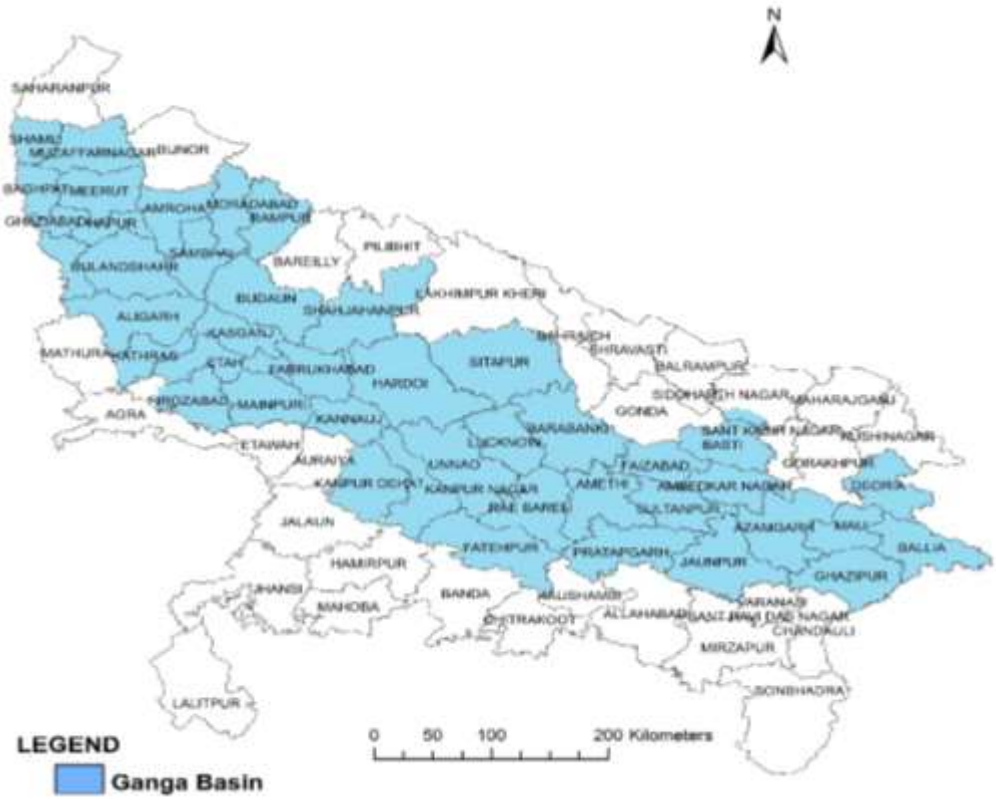

Figure 1. Map of the study area (Uttar Pradesh) with Ganga Basin.

Francis, 2002; Sauer et al., 2005; Dunn et al., 2005).

Citizen science was principally considered as an aspect of educational tools, but it also is a way to collect large sets of data (Brossard et al., 2005; Evans et al., 2005). Due to a lack of manpower and funding, a large-scale set of data could not be gathered, so one way of solving this problem is to involve a cadre of citizen scientists who play a significant role in obtaining the data for the larger ecological projects (Ebersole, 2003). eBird is a large citizen science database that holds a large and increasing capacity of bird count data (Sullivan et al., 2009; Callaghan and Gawlik, 2015; La Sorte et al., 2014; Supp et al., 2015; Clark, 2017; Walker and Taylor, 2017).

The Indian Sarus Crane (*Grus antigone antigone*), the world's tallest flying bird and a globally 'Vulnerable' species as per IUCN Red List of Threatened Species, is the only resident breeding crane in India. As per the count, Uttar Pradesh shelters approximate 12,246 Sarus Cranes, thus indicating its status of being the biggest Sarus-supporting state in the country (Sundar et al., 2000a; Singh and Tatu, 2000). The present work deals with the utilization and presentation of citizen science data to map the distribution of Sarus Cranes in Uttar Pradesh in the last 10 years (2008 to 2017). The main purpose of the study is to map the distribution of Sarus Crane in Uttar Pradesh so that organizations concerned with the Sarus conservation can use this information in locating and conserving the areas where there are depleting Sarus populations.

MATERIALS AND METHODS

Study area

The study was conducted in 2010 across the entire state of Uttar Pradesh (UP). This state lies between 23°52' - 30°24' N latitude and 77°5' - 84°38' E longitude covering over 294,410 km^2. Uttar Pradesh is confined on the Shivalik Range which forms the southern foothills of the Himalayas, slopes down into a boulder bed called Bhabhar, the transitional belt running along the entire length of the state is called the Terai and Bhabhar area. It has rich forests, cutting across it are innumerable streams which swell into raging torrents during the monsoon. Average rainfall varies between 600 and 2,500 mm, most of which comes during the monsoon period of the rainy season. The climate of the state is a tropical monsoon. The average temperature varies in the plains from 3 to 4°C in January to 43 to 45°C in May and June. There are three distinct seasons, winter from October to February, summer from March to mid-June, and the rainy season from June to September. The study includes the whole of Uttar Pradesh which will be divided into Gangetic Plains, Terai area, Semi-arid zone and Bundelkhand region different zones (Figure 1). The study area included protected areas, non-protected areas, rivers, lakes, ponds and the marginal areas including, agricultural field, paddy and human habitations.

Table 1. Total number of individual Sarus crane and social groups observed in the various districts of Uttar Pradesh.

S/N	Year	Total number of groups observed	Total number of individuals recorded
1	2008	5	4
2	2009	6	40
3	2010	8	22
4	2011	15	50
5	2012	12	20
6	2013	11	29
7	2014	29	119
8	2015	70	139
9	2016	95	926
10	2017	91	553
Total		342	1,902

Data collection

Permission was given to access the data and downloaded the complete eBird basic dataset and again reduced it to checklists from 2008 to 2017. Checklists of Sarus are based on the spot identifiers observations of the bird populations. The incomplete checklists or data and repetitions of spot identifier were eliminated and shortened the repetitive data sets. Once the population trends for the species were estimated, only checklists from eBird locations were used as defined by the “locality ID” and GPS locations, with at least one record for the species. The citizen scientists observed the different numbers of a species at particular sites and GPS; the maximum number of count of the species at those particular locations was determined and others were eliminated. Some of the reported sites were verified during 2008 to 2017 by visiting the individual locations by numerous citizen scientists by the web survey. The survey involved questions related to: the species' location, group size, (that is, the total number of birds present in each sighted group) and current conservation concerns. Population changes were also analyzed for distribution of species that occur on the study area and awareness and concern of local birders, students and public related to species conservation.

Statistical analysis

Mapping was done using Arc GIS 10.5 software and resulted in various patterns of Sarus sightings in the state. Maps were prepared showing sighting and distribution patterns of Sarus and the comparison of sights in different years. Other statistical data were managed by IBM SPSS software version 20.

RESULTS

Study concluded that a total of 1,902 Sarus were documented by 342 social groups or e-birders from 43 districts of Uttar Pradesh from 2008 to 2017 (Table 1). The adults, sub-adults and juveniles were counted during the observation (Figure 2). There were no observations recorded from 32 districts. Maximum numbers and distribution of Sarus Crane were observed in Ganga basin and a minimum in Bundelkhand region. The overall numbers of sightings increased every year with some declines in-between, that is, four in 2008, 40 in 2009, 22 in 2010, 50 in 2011, 20 in 2012, 29 in 2013, 119 in 2014, 139 in 2015, 926 in 2016, and 553 in 2017 (Figure 3). In comparison, the number of sightings for all consecutive years, shows that the Ganga Basin of Uttar Pradesh (21 districts) has the maximum number of sightings every year (Figures 4 to 14).

DISCUSSION

Indian Sarus Crane (*Grus antigone antigone*) is one of the tallest flying birds of the world with 1.5 to 1.8 m height and is the only resident breeding crane found in India and south-east Asia (Meine and Archibald, 1996; Singh and Tatu, 2000). Uttar Pradesh is considered to be the stronghold of the Sarus, with the largest population within India. But substantial data collection and records are not available for Uttar Pradesh. In this study, adult, sub-adult and juvenile individuals were enumerated during observations by citizen scientists who reported the data. Most of the individual Sarus were seen in wetlands, ponds, lakes and agricultural fields, because Sarus is a wetlands birds and depends on water for their breeding, feeding and foraging (Kumar and Kanaujia, 2017). Sarus cranes have a preference for shallow water zones and avoid deeper sites and other wetlands for their habitation (Borad et al., 2001), the preferred nesting sites of Sarus are in marshlands and rice paddies (Sundar, 2009), with varying water depth between 25 and 65 cm (Mukherjee et al., 2000). Population fluctuations across habitats by Sarus are extremely dependent on season (Mukherjee, 1999). Preferred foraging habitats of Sarus cranes include shallow marshes, lakeshores, small streams, and upland pastures (Scott, 1993). Sarus completes its whole breeding cycle in or near the wetlands. Some earlier reports of the demography and habitat use by Sarus Cranes can be found in the report by Vyas (2002).

A total of 1,902 Sarus were documented by 342 social groups or e-birders from 43 districts of Uttar Pradesh from 2008 to 2017. There were no observations recorded from 32 districts. Sarus Cranes are normally seen in pairs, or family groups, and form congregations up to 55.

A B

Figure 2. (A) Adult Sarus Crane. (B) Sub-adult with Adult Sarus.

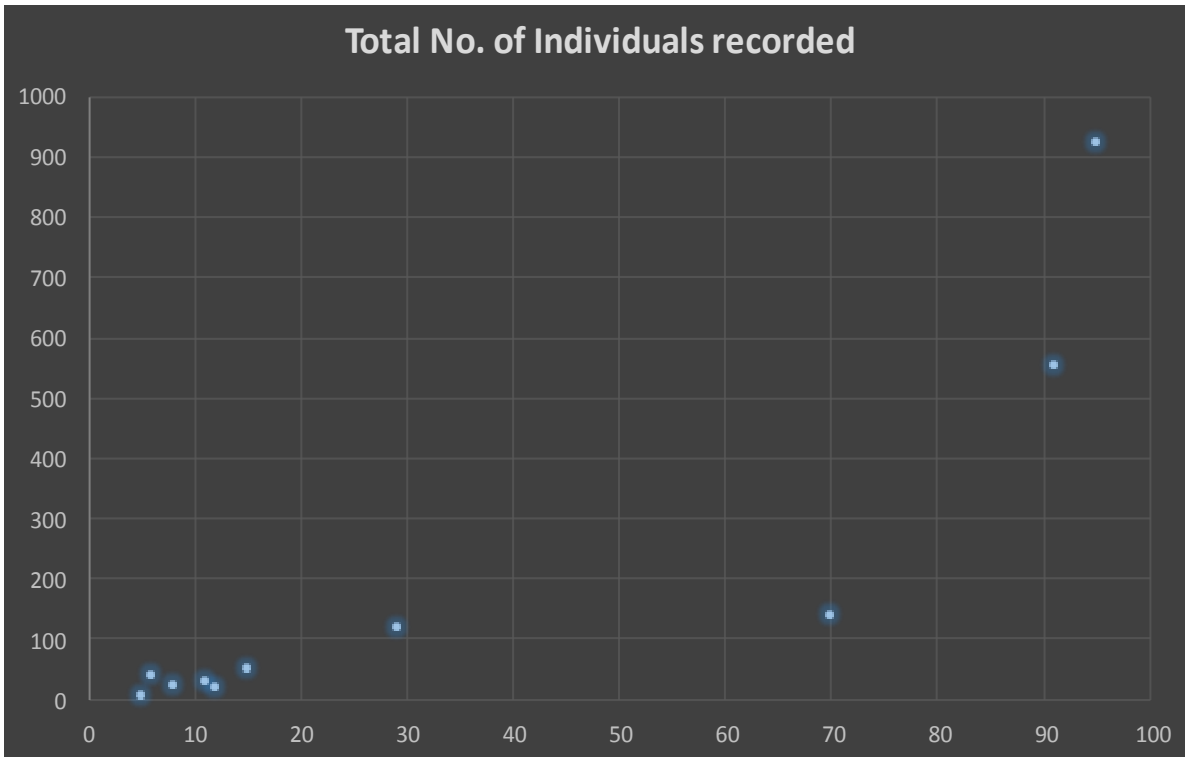

Figure 3. Scatter chart between the total number of individual Sarus crane recorded and social groups observed.

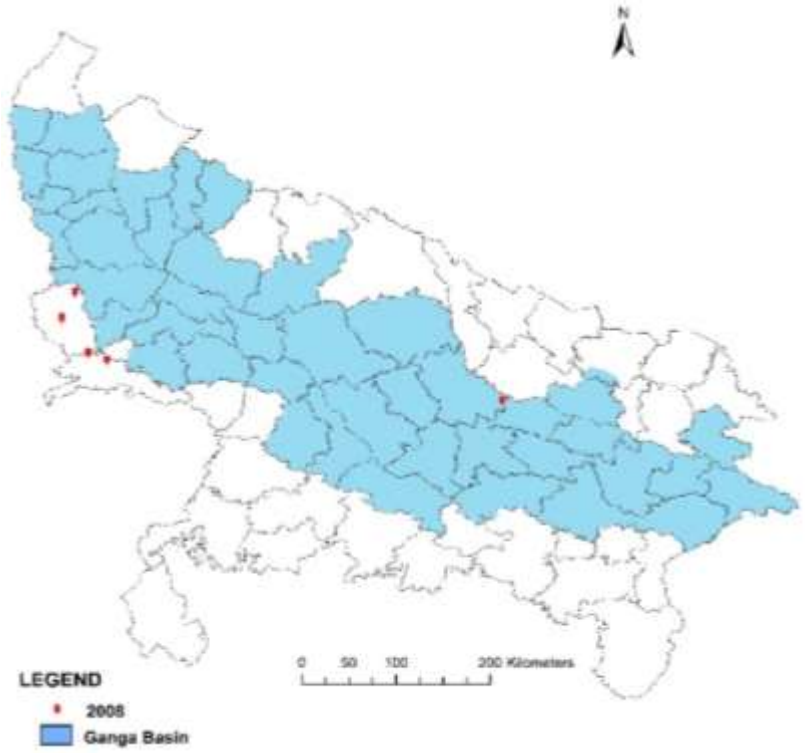

Figure 4. Population status and distribution of Sarus in 2008.

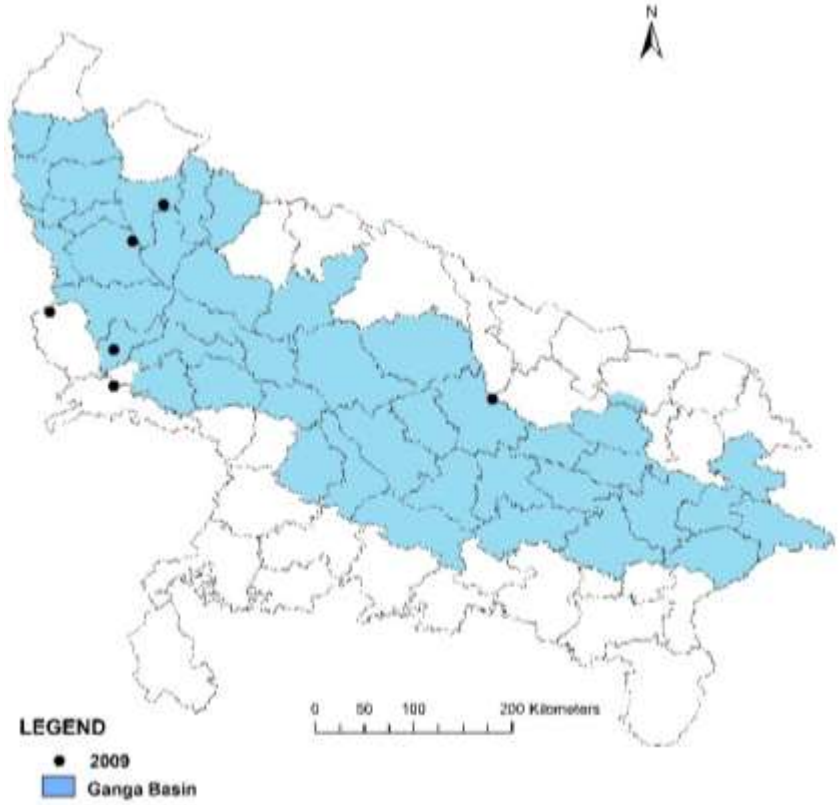

Figure 5. Population status and distribution of Sarus in 2009.

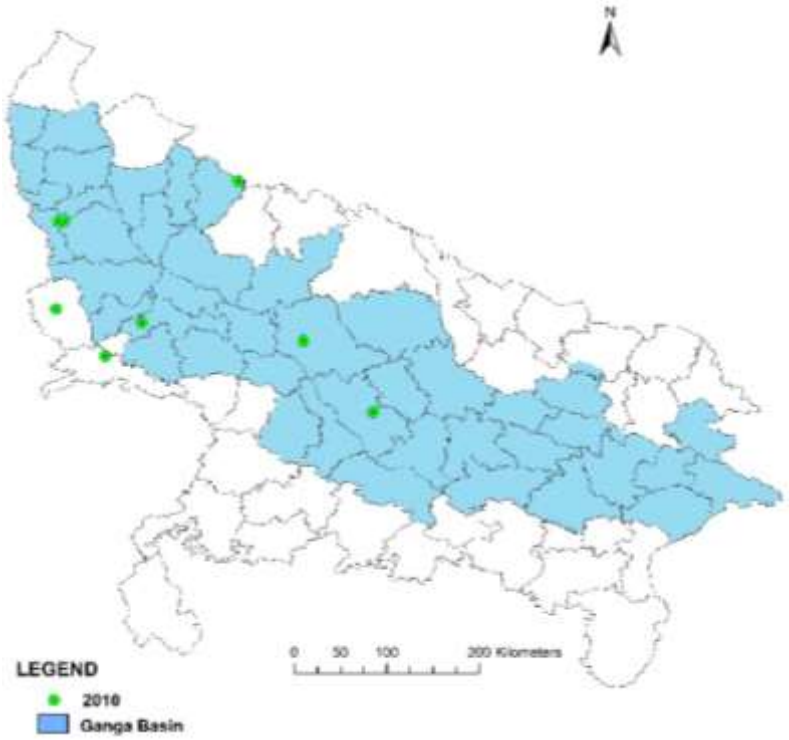

Figure 6. Population status and distribution of Sarus in 2010.

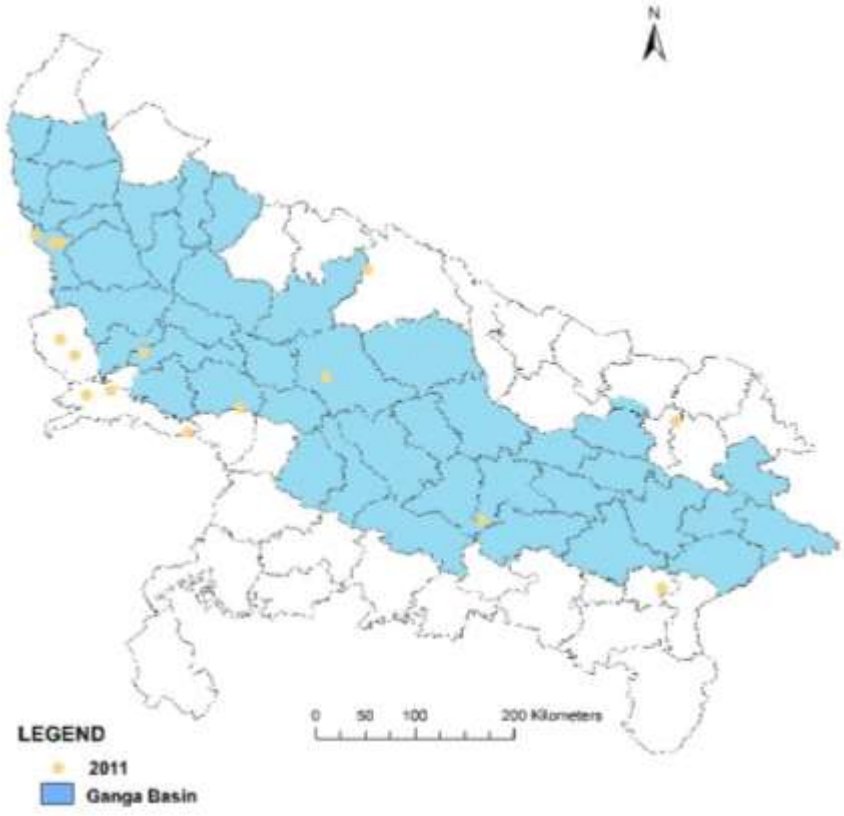

Figure 7. Population status and distribution of Sarus in 2011.

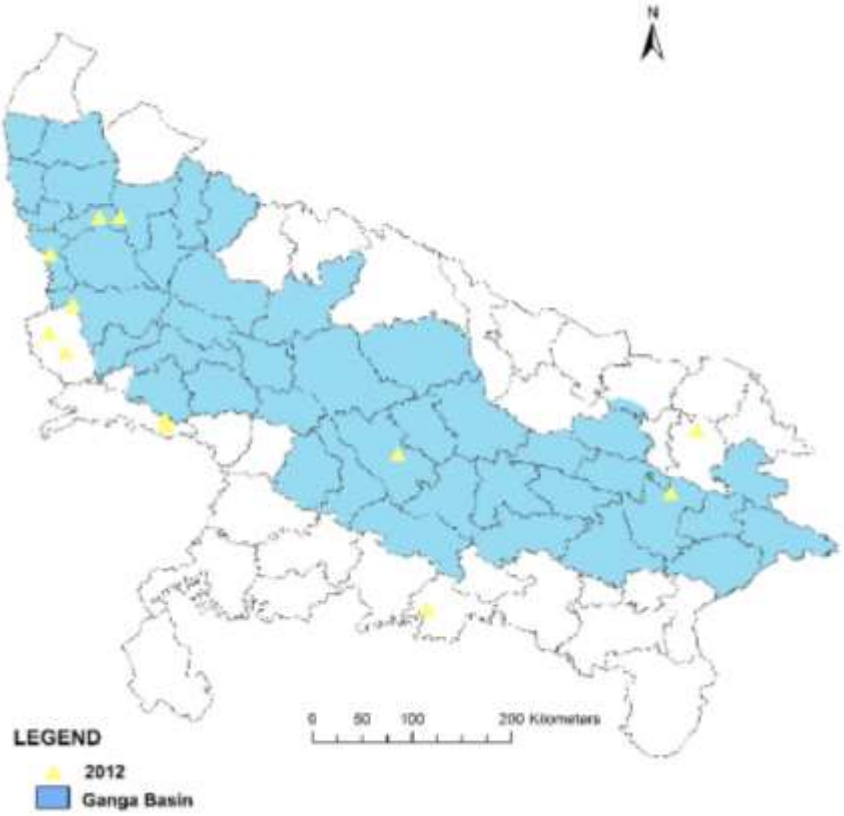

Figure 8. Population status and distribution of Sarus in 2012.

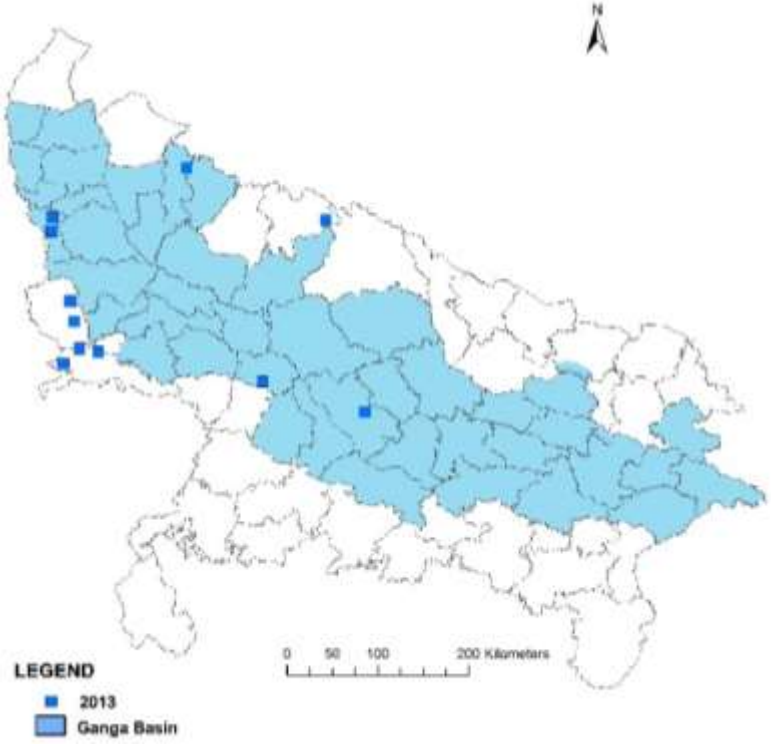

Figure 9. Population status and distribution of Sarus in 2013.

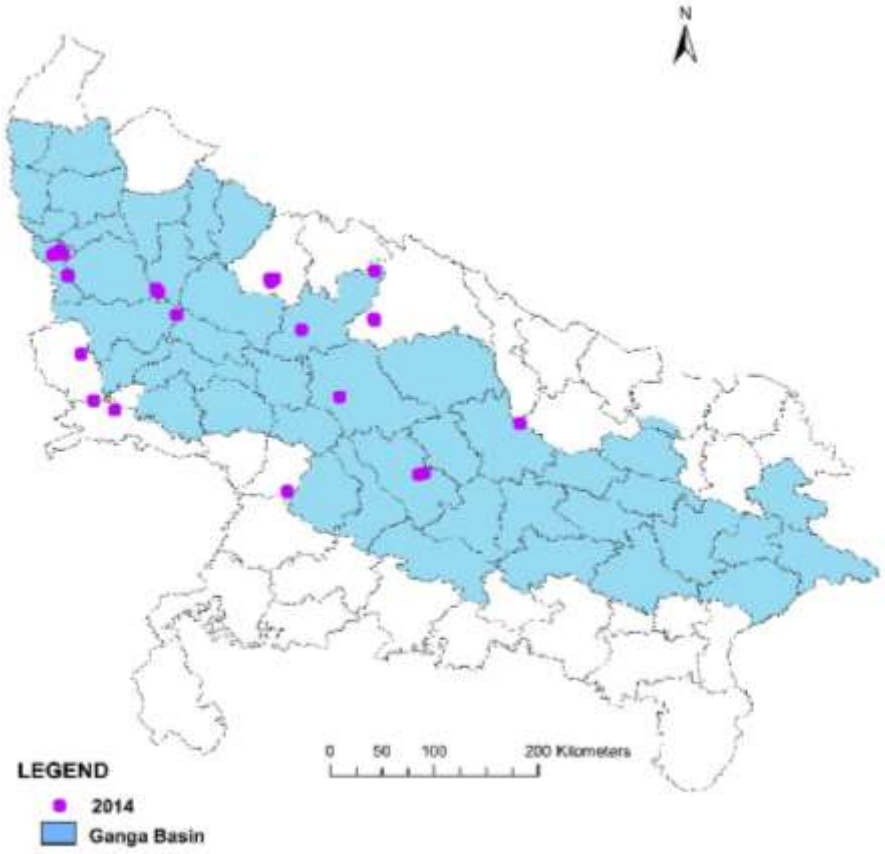

Figure 10. Population status and distribution of Sarus in 2014.

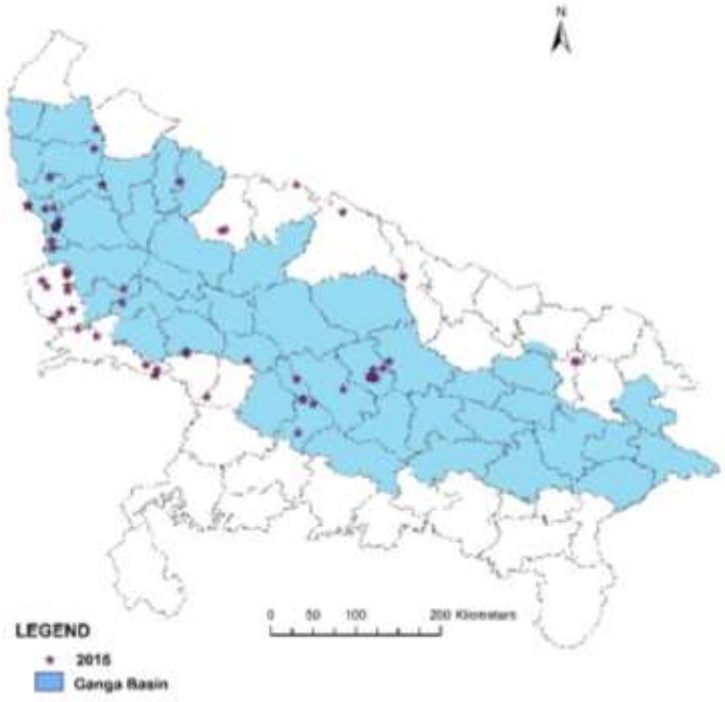

Figure 11. Population status and distribution of Sarus in 2015.

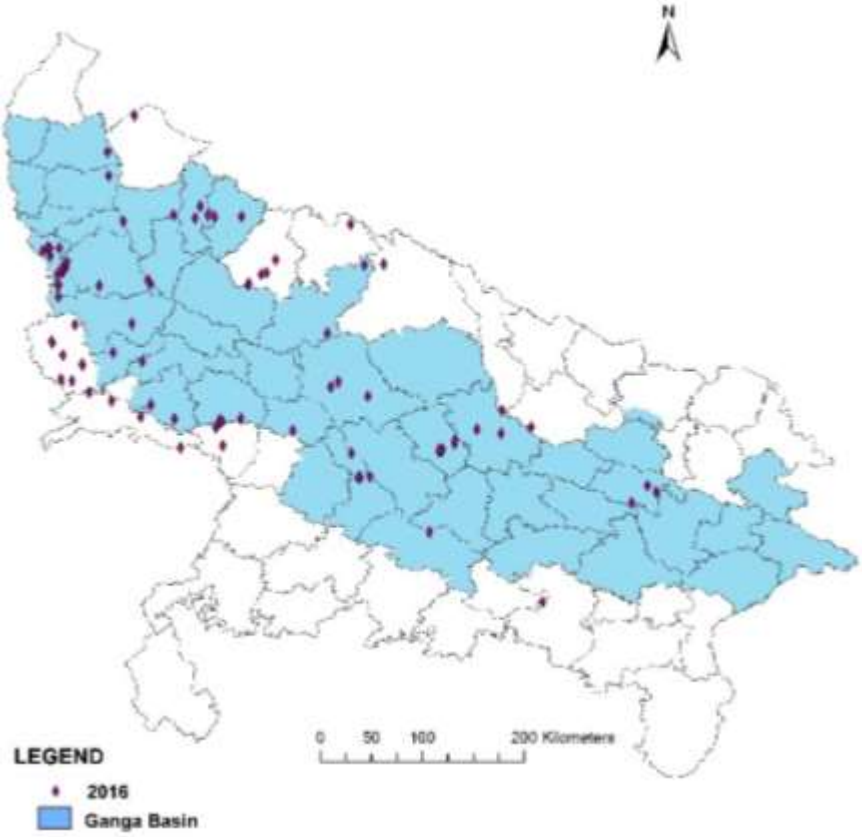

Figure 12. Population status and distribution of Sarus in 2016.

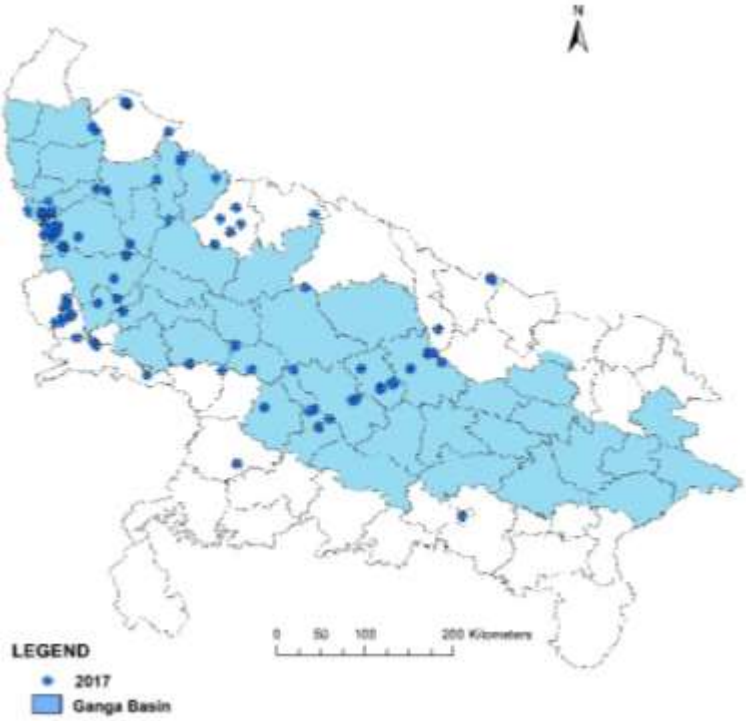

Figure 13. Population status and distribution of Sarus in 2017.

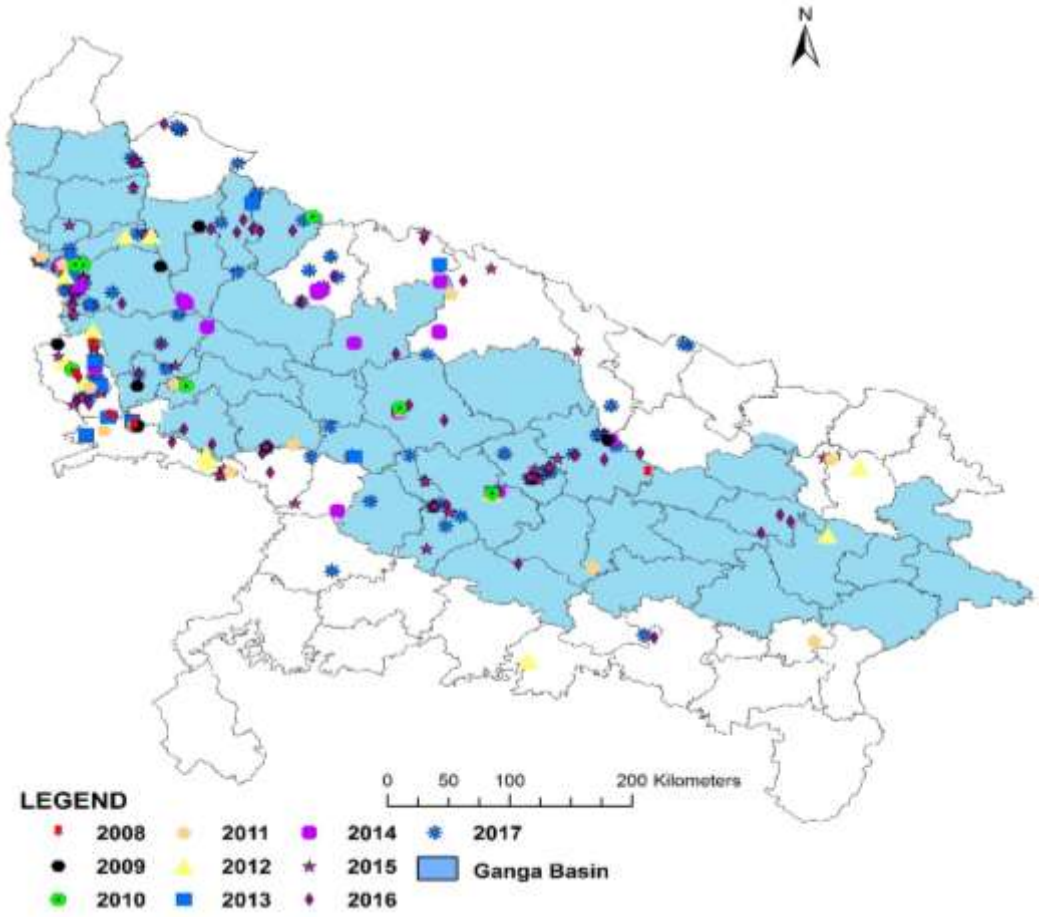

Figure 14. Overall scenario status and distribution of Sarus crane in Uttar Pradesh (2008-2017).

Based on studies done in Gujarat the population is estimated to be 1,730 (Singh and Tatu, 2000). The number estimated for Rajasthan is 332 and other states 183 (Sundar et al., 2000a), while 168 were reported in trans-Indian Nepal Tarai (Aryal et al., 2009).

Maximum numbers and distribution of Sarus Crane were observed in Ganga basin and a minimum in Bundelkhand region. The probability of occurrence in wetlands is maximum near the Ganga basin of Uttar Pradesh; because the ground water level is maintained due to the proximity of the Ganga River, which is an indicator of, and favorable habitat for, Sarus breeding and feeding. On the other hand, the Bundelkhand region is a water-scarce area or drought-prone area, so the number of observations of Sarus is declining in this area. The population status of the Sarus in Lalitpur and Jhansi face severe climatic misfortunes; and this is a backward region regarding the importance of wetlands and its biodiversity (Kushwaha et al., 2018)

The overall number of sightings increased every year with some declines in-between; that is, four in 2008, 40 in 2009, 22 in 2010, 50 in 2011, 20 in 2012, 29 in 2013, 119 in 2014, 139 in 2015, 926 in 2016, and 553 in 2017. In comparison, the number of sightings for all consecutive years shows that the Ganga Basin of Uttar Pradesh (21 districts) has the maximum number of sightings every year. Etawah and Mainpuri districts are the major sites with maximum sightings throughout the study period (Mukherjee et al., 2002a; Sundar 2009; Chaudhary et al., 1999; Archibald et al., 2003; Sundar, 2005). Though citizen science is a very useful tool for data collection, it also has its limitations. Great care has to be taken to verify as much as possible what is reported, and also to explain carefully how the data was generated and how it can be understood or used. There are very few reports on Sarus distribution or its presence based on available published records, and this is one of the more complete records currently available.

Conclusion

This innovative study involved public participation as a significant data collection tool for the Sarus crane species, which has an apparently broad distribution range. The results reported in this study suggest that

Sarus Cranes are fairly persistent in the Ganga basin near the wetlands, ponds and lakes, but mostly prefer to inhabit in pairs; which strongly indicates that their distribution pattern is largely in the Ganga basin. As a conclusion, we consider wetlands as the primary habitat of Sarus during the breeding season. In the meantime, during the non-breeding season, Sarus also prefers agricultural fields of wheat and rice paddies for feeding and to congregate for pairing. This study revealed that in spite of declines in population and breeding pairs at the global level, the number of Sarus Crane in Uttar Pradesh has a good number of Sarus, especially relative to India. This data can also be used to study the population trends, and even to perform occupancy modelling and habitat modelling, of Sarus Crane in Uttar Pradesh.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Drill monkeys (*Mandrillus leucophaeus*) are known to be the most endangered species of primates in Africa. Hunting and habitat loss are believed to be the major causes of the species decline in Cameroon. It is for this reason that the study explored the behaviour of captive drills in Limbe Wildlife Centre (LWC) in line with reintroduction plan. Data collection started in May 15th 2016 and ended in August 15th 2016. Scan and focal samples were collected in mixed strategy, continuous sampling started from 6:00 am and ended at 6:30 pm, where the following behavioural categories were recorded: Feeding, foraging, movement, resting, socialization, grooming, play, aggression and vocalization. Simultaneously, data were recorded on weather changes. Data analysis comprised of descriptive and inferential statistics. The time budget was recorded as follows; 52.54% resting, 23.70% foraging, 10.0% feeding, 9.30% moving, 2.02% grooming,2.0% play, 0.40% aggression and 0.20% vocalization. There exist a significant difference between behaviours and age/sex classes, ($P<0.05$). Adult males spent more time resting than any age-sex class ($X^2=277.4$, df=1, $P<0.05$). Female adults spent most of their time foraging than any category ($X^2=93.4$, df=1, $P<0.05$). Female adults also dominated in grooming than any age/sex class ($X^2=118.5$, df=1, $P<0.05$). Male adults executed more aggressive behaviour than any other category ($X^2=28.7$, df=1, $P<0.05$), There is a significant difference for resting between adult males and juveniles ($X^2=273.2$ df=1 $P<0.05$), there is a significant difference for resting between female adults and juveniles ($X^2=27.58$ df=1 $P<0.05$). Also, there is a significant difference for resting female and male adults ($X^2=261.469$ df=1 $P<0.05$). The survey revealed a smooth interaction between the adult males, adult females, sub-adult males and sub-adult females, and the juveniles.

Key words: Drill monkeys, hunting, habitat loss, reintroduction, wildlife, behavior.

INTRODUCTION

Primates are among the most threatened mammals (IUCN, 1996), and many species threatened in their natural habitat have been the focus of translocation and reintroduction projects to augment their chances of restoration (Horwich et al., 1993). Drill monkeys (*Mandrillus leuciphaeus)* is one of the rare monkeys in

Africa and the world at large, Drill and their congener Mandrills (*Mandrillus sphinx*) are the only two species belonging to the genus Mandrillus found only in three African countries, the South West of Cameroon, South East of Nigeria and the Bioko Island of Equatorial Guinea. They are among the African most endangered primate species, being highest in conservation priority as listed by International Union for the Conservation of Nature (Oates and Butynski, 2008). They are forest floor dwelling, short tail monkeys which are sexually dimorphic both in size and in colour.

Drill population in the wild is currently running into extinction and estimated population is about 2,500 to 3000 in Korup National Park (KNP). Declining drill population remains a key threat to their survival; these threats are obviously hunting, forest fragmentation and illegal logging (Gadsby, 1990). The presence of drills in captivity is the possible means of bringing back or restoring the population of drills in the wild. Population increase and reintroduction programs depend on the ability of zoological gardens to breed species under good conditions of reproductive and behavioural repertoires (Carlstead, 1996). In line with conservational efforts, zoological gardens are now bent on breeding programs for reintroduction.

Drill survival in Cameroon and Nigeria does not depend only on captive breeding but this can be achieved if the surrounding neighbours to drill ecosystems are also key advocates to this species protection and the commitment of the host country Government to enforce existing laws. While other primate species have been highly protected and their number in the wild is a little higher, the drill population decline is a problem, and the solutions to increase it had been on going through the Pandrillus Foundation in Nigeria and in Cameroon. Many threats had led to the decrease of this species in the wild, illegal hunting with dogs and habitat fragmentations are the main threat to the survival of primates (Oates and Butynski, 2008). Drill activity budget, the time these individuals allocate to various activities such as resting, foraging, feeding, socializing, moving are key parameters for the quality of the enclosure and the living status of the group. Reintroduction programs are often used as a potential tool for ecological restoration and the recovery of endangered species (Macdonald et al., 2002). IUCN had defined reintroduction as an attempt to re-establish a species in an area which was once part of its historical range but from which it has been extirpated or become extinct (IUCN, 1998). Drills in captivity had shown successful reintroduction in a chosen site in Nigeria (Ijeomah and Choko, 2014).

According to some estimates, forest cover in Cameroon decreased from the period 1965 to 1995 by 30% (Gbetnkom, 2005). Habitat loss outside protected area is due to forest being either cleared for agriculture and human settlements or degraded from logging and mining. Although rates of deforestation may vary from period to period, as of 1998 approximately 23.950 km^2 of forest within the historical range of the Drill monkeys in Cameroon were classified as a logging concession or a forest reserve. The fundamental threats to drill monkey survival are hunting and habitats fragmentation, as is the case with most of the central Africa primates (IUCN, 2008). These threats are especially to Drill monkeys because of their limited distribution but high human population density within their range. In total, it is estimated that 12% of the remaining drill habitat is incorporated in strictly protected areas. Although there are reports of mandrills crossing small logging roads in Lope, Gabon (Rogers et al., 1996), both mandrill species are thought to be averse to open areas. It is unlikely that drills would cross large roads where overlying canopy and edge vegetation has been removed. The drills diurnal nature also means that such crossing would have to take place during periods of peak human use. Drill population is most affected by shrinking habitat of Douala-Edea, Mt Kupe, Mt.Cameroon, and Bioko Island protected areas. The expanding network of public and logging roads further fragments the drills habitat, limiting reproductive contact between sub-populations and increasing human presence in once remote area (Oates and Butynski, 2008). Also, the drills are vulnerable to hunting with the use of dogs (Wild et al., 2005). The common hunting techniques of night hunting and trapping are especially destructive for certain wildlife species but probably have only little impact on the drill monkeys.

The priority of zoo management organizations is to house animal in perfect and considerable conditions, in order to reduce stress and stereotype behaviours. In modern zoological parks, social behaviours of wildlife remain influential factors to conservation. The ability of these animals to live in good conditions can greatly interfere in their time budget on different activities, the environment in which species are been housed have proven to be a stressor to provoke abnormal behaviours in many animals and non-human primates (Poole, 2008).

Wildlife conservation in Cameroon and other countries in Sub-Saharan Africa is facing enormous challenges, mainly to rainforest fragmentation and poaching for bushmeat. For this reason so many wildlife species are highly threatened and are at the edge of regional extirpation. The Drill monkeys are known to be endemic

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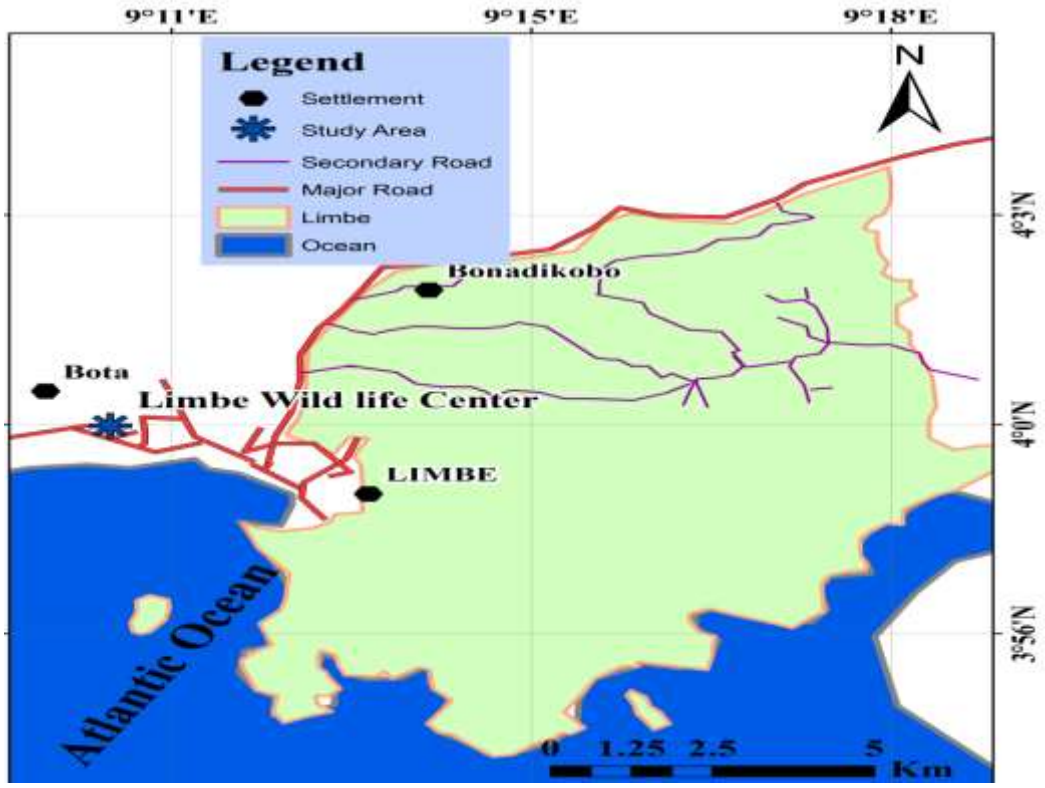

Figure 1. Map of Limbe City.

in Cameroon forest zone and neighbouring Nigeria, but its population is declining at alarming rate, creating a conservation research attraction. The main aim of this study is to assess the activity budget of the captive Drill monkeys preserved by the zoo management authorities for future reintroduction. Any behavioural study in a zoo setting will always improve or contribute to better management of the animals in question, considering the varying characteristics of individuals within a population. Conservation efforts and goals of reintroduction programs are only achieved when the release species prove to thrive in the release site with continuous monitoring before and after the reintroduction.

MATERIALS AND METHODS

Description of the study area

Limbe Wildlife Center (LWC) is found in the centre of the City of Limbe, located in the South West Region of Cameroon. It is located at latitude 4.1° 27.12' N and to longitude 9.12° 53.64' E (Figure 1). It was created in 1993 by the efforts of the Cameroon Government and the Pandrilus Foundation. The centre is bounded by roads within the town, just a stone throw from the Limbe City Council. All species of the centre had been donated or confiscated by the Government of Cameroon through the Ministry of Forestry and Wildlife (MINFOF) and the Pandriillus Foundation. The centre helps to rescue these species and later reintroduce them to natural environment in a protected area. The centre houses 15 Primates species in separate enclosures. The centre has a total of 21 cages; two cages house the western lowland gorillas (*Gorilla gorilla deihli*). The papionini section contains three small cages for the drills, two for the olive baboon (*Papio anubis*) and two for the mandrills. All the primate cages have an electric fence enclosure where they spend their time during the day. There are also separate cages for the guenons (*Cercopithecus* spp.*)*; mangabeys (*Cercocebus torquatus)* and other small enclosures contain the duikers (*Cephalophus* spp.*).* The quarantine section contain up to seven small cages housing different species of wildlife.

Data collection

The behavioural data collection started on the 15th May and ended on the 15th of August 2016. Six days of data collection was carried out each month and 4 months data was collected. The enclosure was divided into seven observational areas, called zones, each zone had its distinctive point for clear identification. The partitioning of the enclosure was based on the fact that these areas can be clearly visualized with or without a binocular at different relative positions around the enclosure. Behavioural observations began in the morning between 6:00 and 6:30 and ended at 12:30 every day, while in other days, observations started between 12:00 to 12:30 and ended at 6:30 in the evening. Data were collected using instantaneous scan sampling at predetermined intervals. Martin and Bateson (2007) define “instantaneous scan sampling” as when “a whole group of subjects is rapidly scanned, or “censused,” at regular intervals and the behaviour of each individual at that instant

Table 1. Behavioural categories and definitions used in the study.

Activity type	Behaviour	Description
Feeding	Drink or eat	Process of drinking water or eat food
Foraging	Search, dig, scratch, hunt, smell, turn	Process of looking for food ,insect by any means
Locomotion	Run, climb, walk, jump	Any locomotory process without a defined reason
Resting	Sitting, standing, selfgroom and play alone	The state of being inactive
Social (grooming, play, aggression)	Presentation, chases, groom, flee, smell mouth or vulva, play, volcalise.	Any positive and sexual interactions
Vocalisation	Alarm, grunt, song	The act of producing sound either for predators or aggression

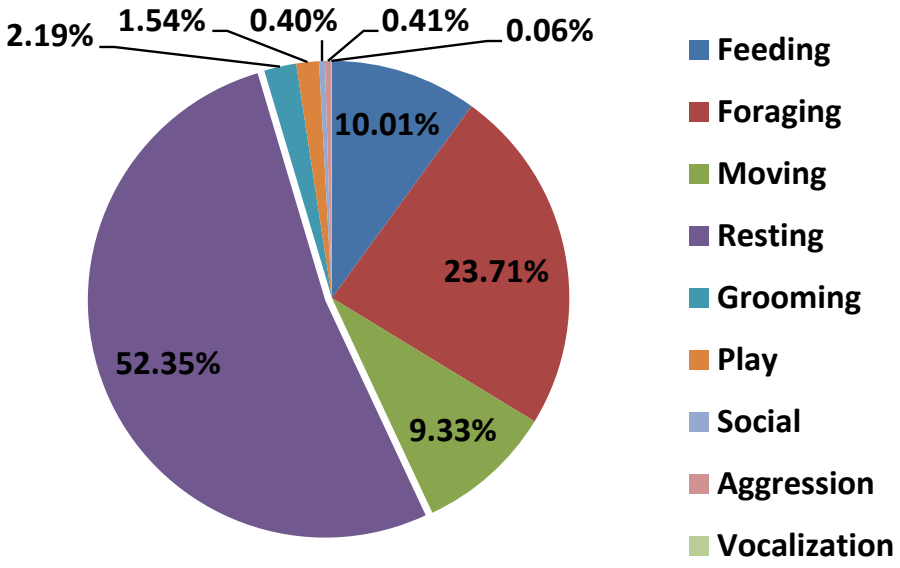

Figure 2. Activity budget of *Mandrillus leucophaeus.*

is recorded."Behavioral data can be collected in several ways (Altmann, 1974). In categorizing these methods, Martin and Bateson (1986) distinguish between sampling rules (whose behaviour is watched and when) and recording rules (how the behaviour is recorded). For this study two recording methods were simultaneously used because it was important to know both: First is how the animals spent their time (activity budgets); and, how social behaviours were patterned, that is, who does what to whom, and how often. Hence, the scan sample data for this survey was collected after every 10 min (Altmann et al., 1993). Between the 10 min of scan sampling a focal sample was conducted for 5 min. All the scan observations were done from right to left throughout the study. The focal animal was randomly selected for the day, based on the age-sex class. The drill behaviours were recorded during the scan and focal. The following behaviours were recorded; feeding, foraging, locomotion, social behaviours and resting (Table 1).

Data analyses

The data sheets were transcribed to Microsoft Excel spreadsheets for each data type (scan and all-occurrences) from the group. The frequency data generated were analysed by the use of exploratory statistical distribution tool for each observed behaviour in the study. Pearson chi-square was also used to compare the different activity budget for the behaviour of each sex-age class in the drill group.

RESULTS

Activity budget of drill monkeys

Drill time budget involves a spectrum of much behaviour; resting, foraging, movement, feeding and social behaviours. A total of 288 observational hours were made, and 7534 individuals' activities were recorded in the group of 95 drill monkeys. Figure 2 shows activity budget for the drill group. Resting was the most frequent behavior 52.54%, followed by foraging 23.70%, feeding 10.0%, movement 9.30%, grooming 3.70%, play 1.54%,

Table 2. Activity budget for each age-sex classes.

Age-sex class	Activity									
	Feeding	**Foraging**	**Moving**	**Resting**	**Grooming**	**Playing**	**Social**	**Aggression**	**Vocalization**	**Total**
Female adult	303	931	341	1443	138	11	9	6	1	3183
Activity budget (%)	9.52	29.25	10.71	45.33	4.34	0.35	0.28	0.19	0.03	100
Male adult	185	260	131	1342	6	3	8	21	2	1958
Activity budget (%)	9.45	13.28	6.69	68.54	0.31	0.15	0.41	1.07	0.10	100.00
Juvenile	110	265	97	312	11	84	2	-	1	882
Activity budget (%)	12.47	30.05	11.00	35.37	1.25	9.52	0.23	-	0.11	100
Mature Male	117	152	84	656	3	5	6	4	0	1027
Activity budget (%)	11.39	14.80	8.18	63.88	0.29	0.49	0.58	0.39	-	100
Sub-adults	39	179	50	193	7	13	5	-	-	486
Activity budget (%)	8.02	36.83	10.29	39.71	1.44	2.67	1.03	-	-	100.00
Total	754	1787	703	3946	165	116	30	31	4	7536
activity budget	10.01	23.71	9.33	52.36	2.19	1.54	0.40	0.4	0.05	100
Total (%)	100.	100	100	100	100	100	100	100	100.	100

Table 3. The age-sex class and behavioural relationship.

Activity	Age –Sex Classes			
	FA-MA	**FA-JU**	**MA-JU**	**FA-SA**
Foraging	X^2= 173 df=1 p=0.0000	X2=0.21 df=1 p=0.0000	X^2=113.4 df =1 P=0.0000	X^2=84.8 df=1 P=0.0000
Feeding	X^2=0.007 df=1 P=0.93	X^2=6.59 df=P=0.001	X^2=5.9 df=1 P=0.015	X^2=3.0 df=1 P=0.08
Resting	X^2=262.9 df=1 P=0.0000	X^2=27.9 df=1 P=0.0000	X^2=275 df =1 p=0.0000	X^2=106.7 df=1 P=0.0000
Moving	X^2=23.5 df=1 P=0.0000	X^2=0.058 df=1 P=0.001	X^2=15.3 df=1 P=0.0000	X^2=5.4 df=1 P=0.019
Grooming	X^2=72.2 df=1 P=0.0000	X^2=18.65 df=1 P=0.0000	X^2=9.04 df=1 P=0.003	X^2=39.2 df=1 p=0.0000
Playing	X^2=1.09 df=1 P=0.0000	X^2= 254.8 df=1 P=0.0000	X^2=179.8 df=1 P=0.0000	X^2=0.40 df=1 P=0.5
Social	X^2=0.58 df=1 P>0.445	X^2=0.08 df=1 P=0.77	X^2=9.5 df=1 P=0.002	X^2=0.3 df=1 P=0.159
Aggression	X^2=18.13 df=1 P<0.0000	X^2=1.66 df=1 P=0.197	X^2=0.573 df=1 P=0.444	X^2=1.32 df=1 P=0.250
vocalisation	X^2=1.04 df=1 P=0.308	X^2=0.943 df=1 P=0.331	X^2=0.007 df=1 P=0.931	X2=0.30 df=1 P=0.57

FA = Female adult; MA = Male adult; JU = Juvenile; SA = sub adult.

social 0.40%, Aggression 0.41%, and vocalization (Figure 2).

Table 2 gives the age-sex class activity budget for all behavioural categories. Female adults executed more grooming and foraging than any other age-sex class (N=138 and N=931) respectively. Adult male rested more than any other category (N=1342) and juvenile performed more playing than any category (N=84).

From Table 3 there is a significant difference for resting between adult male and juvenile (X^2=273.2 df=1 P<0.05), also there is a significant difference for resting between female adults and juveniles (X^2=27.58 df=1 P<0.05). In addition there is a significant difference for resting female and male adults (X^2=261.469 df=1 P<0.05). There exist a significant difference between behaviours executed and the different age-sex classes (X^2=262.9 df=1 P< 0.05). Male adult spent more time resting than any other categories (X^2=277.5 df=1 P<0.05). Female adults spent more time foraging than male adult (X^2=173.7 df=1 P<0.05) and there is no significant difference between female adults and male adults for feeding (X^2=0.007 df=1 P=0.9). Female adults spend more time grooming than other categories(X^2=72.3 df=1 P<0.05), juvenile spend more time playing than the other categories (X^2=420.2 df=1 P<0.05). Male adults spend more time on aggressive behaviour than any other age-sex class(X^2=28 df=1 P<0.05). Moreso, there is no significant difference between female adults and sub-adults on behaviours like socialization, movement, aggression and vocalization. Sub-adults spend more time playing than female adults There is a significant difference between male adults behaviours and all sex-age classes (X^2=30.1 df=1 P<0.05). There is a significant difference in feeding for juvenile and female adults (X^2=6.427 df=1 P=0.011),

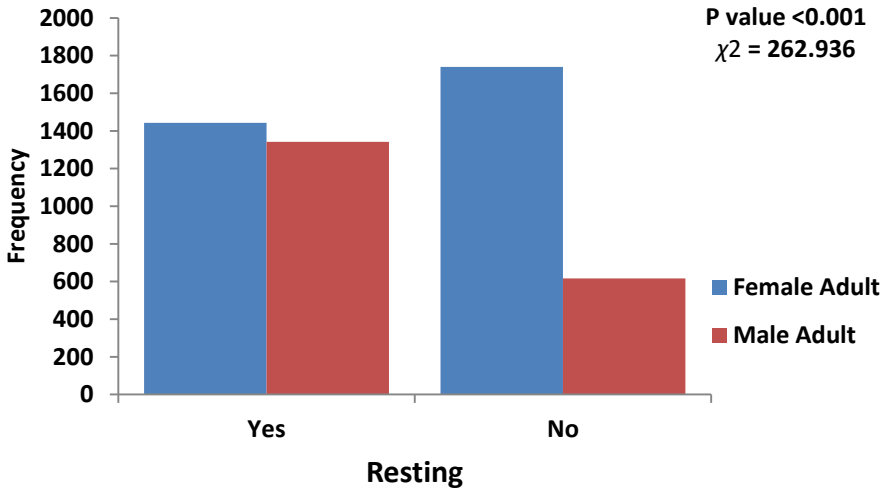

Figure 3. Adult male and female resting.

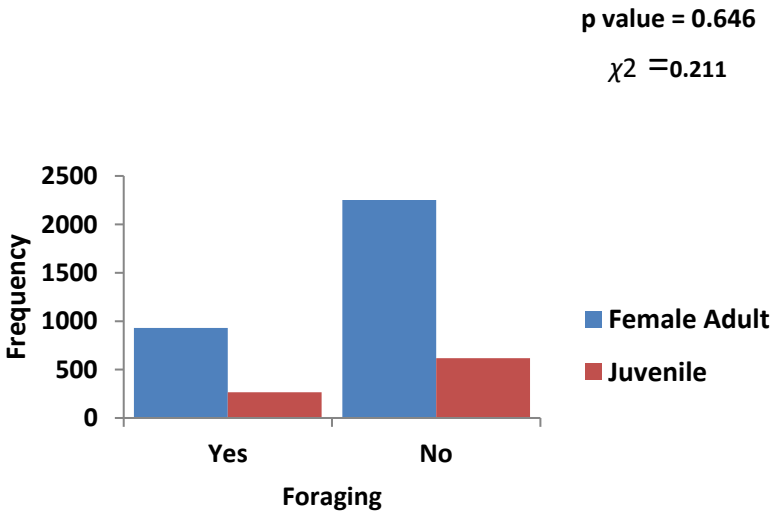

Figure 4. Adults females and juvenile foraging.

implying that male adults feed more frequently than juveniles.]

From Figure 3 male adults spend a significant time resting. “Yes” show bar chart counts for resting and “No” show bar chart counts for non-resting, male adult had “Yes” counts (N=1342) and No counts (N=616). Female adults registered Yes counts (N=1443) and no counts (N=1740). From these values it is clear that male adults spend more time resting than female adults.

From Figure 4, “Yes” represents bar charts counts for foraging and “No” show bar charts counts for non-foraging. Female adult had (N=931) for foraging and (N=2252) for non-foraging. Juvenile scored (N=265) for foraging and (N=617) for non-foraging.

From the Figure 5, female adults were mostly closest to juvenile and male adult; they spent most time at 0 to 1 m apart (53%). Adult males and juvenile were mostly at 2 to 3 m from each other (48.7%).

DISCUSSION

Studies of behavioral ecology can provide significant contributions to conservation through evolutionary and ecological perspectives of how animals adapt to their environment (Krebs and Davies, 1993). Zoos provide advantages to researchers by allowing for longitudinal studies of behavior and reproduction, as well as

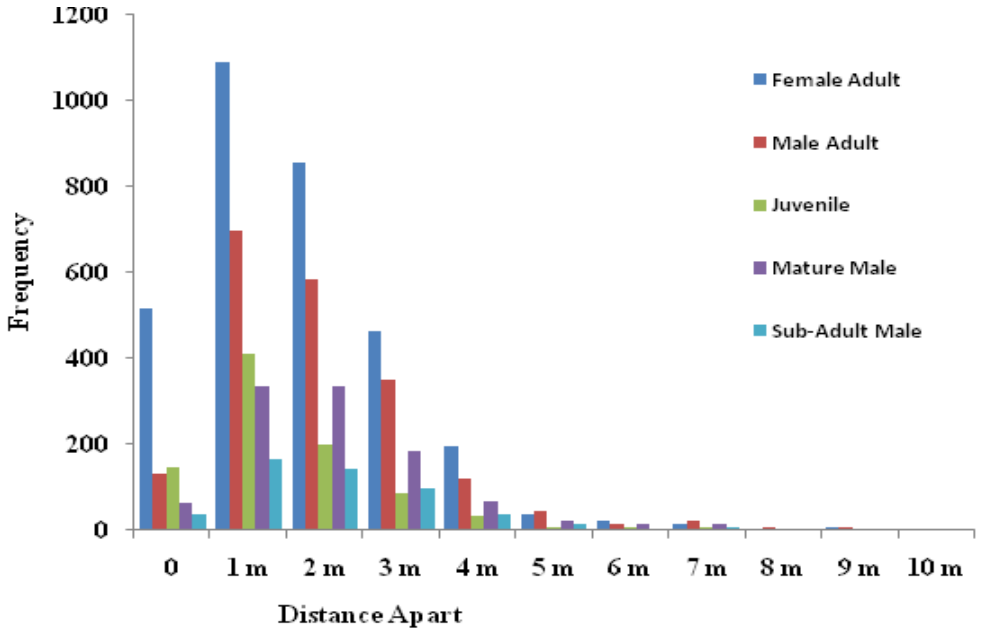

Figure 5. The mean distance between the age-sex category.

opportunities for gathering data on all aspects of life history (Hardy, 1996). Preserving the behavioral and developmental diversity of animals maintained in captivity allows for zoos to achieve their full potential in conservation. Captive propagation efforts and reintroduction programs are dependent on captive animals exhibiting normal reproductive and behavioral repertoires. To thrive in captivity, a species must adapt their behaviors to the altered environmental conditions (Carlstead, 1996). Zoos are typically underrated as research resources, although the amount of research conducted at zoos has increased over the past twenty years (Stoinski et al., 1998). They provide a key role in the conservation of species, specifically primates, and have become focal points for research by academic and zoological scientists. Researchers are able to study animals closely in zoological facilities as well as have control over environmental and social variables (Hosey, 1997; Stoinski et al., 1998). Improvements on animal management, including breeding, handling, transporting, and caring for animals, are developed usually in zoos before being applied in natural habitats. Much of the information acquired through zoo research is of great relevance to conservation generally and to the conservation of species and habitats in particular. Understanding how a species behaves in wild is important for the maintenance of natural behaviors and life history characteristics of those kept in captivity. An important advantage that primates have in the competition for survival is their practice of living in societies which have a constant close association of young and old through long life duration. The young learn survival skills from experienced, knowledgeable adults. The result is that by the time primates are grown, they are usually proficient in dealing with each other and the environment. While primate instinctive survival skills are minimal, their social skills are unusually effective. Acting together in groups, they often can avoid or intimidate predators. Groups of primates also have a greater opportunity in discovering and controlling food sources.

In captivity, Drill monkeys spent 23.5% of their time digging the soil, scratching the wall of the fence, turning stones, catching insects and arthropods. The environment in which drills are habituated can greatly affect their activity budget; food is provided two times a day only, protein is also added as a supplement to their diet. In a related study of drill in a semi-free area showed drill spend 50% of it time foraging (Terdal, 1996). Adult females foraged more than male adult, this agrees with Feistner (1988). Male adult were actively involved in aggressive activities than any age-sex class. The drill group was frequently masked with aggressive behaviour within the adult males, dominance in rank is believed to be the major cause of these aggressive interactions. Male adults were rarely found performing affiliative behaviours like grooming and playing, while the female adults spent more time grooming than any age-sex class. Sometime grooming of lactating mother by other adult females was used as a strategy to gain access to their infants that were newly born Feistner (1988). The juveniles spent most of their time playing than any age-sex class. They devoted little time on other activities but

they were often seen catching insects. From Table 3, 72.4% of playing was executed by juvenile. Shanee and Shanee (2011) stated that juveniles could be expected to feed more and play more since they are growing. Little time was spent moving, the fact that the enclosure size was small this might have affected the movement.

Although it is valuable for the zoo going public to see primates like drills surrounded by the native vegetation, it would be more beneficial for the public to see them engaged in natural activities that are more indicative of a wild state. Simulating natural behaviors involves providing the animal with an environment that mimics the wild habitat to encourage behavior expression while stimulation relies on environment enrichment to evoke the behavior regardless of the enclosure (Fábregas et al., 2011; Grandia et al., 2001). Zoos are particularly important component of the reintroduction process for animal species, as they are “pre-adapted” to maintain populations of threatened species due to their histories of keeping, breeding and transporting animals.

The low success rate of reintroductions (ranging from 11 to 54%) requires a reexamination of how we maintain species in captivity (Kleiman and Beck, 1994; Kleiman, 1989). Evidence suggests that reintroductions using wild stock are more successful than those use captive stock (Jule et al., 2008). Evaluating and meeting the behavioral needs of captive animals allows managers to fulfill their roles as stewards, and provide valuable educational opportunities for zoo visitors (McPhee, 2003). The lack of multi-institutional behavioral studies conducted in zoos does not allow animal keepers, administrators, or researchers to determine how the captive condition alters the behavioral profile of a population of captive animals. Single zoo studies are essential for establishing better husbandry protocols, breeding programs, and enclosures for individual institutions but do not address the role of the zoo in conservation or loss of behavior (Carlstead, 2002; Shepherdson and Carlstead, 2001). Animal welfare guidelines ensure that individuals are provided with stimulating environments, but these guidelines do not encourage behavior maintenance (AZA, 2009a, b).

Conclusion

Wildlife conservation in Cameroon and other countries in Sub-Saharan Africa is facing enormous challenges, mainly due to rainforest fragmentation and poaching for bushmeat. For this reason so many wildlife species are highly threatened and are at the edge of regional extirpation. The Drill monkeys are known to be endemic in Cameroon forest zone and neighbouring Nigeria, but its population is declining at alarming rate, creating a conservation research attraction. The Drill monkey population in LWC is the confiscations made by the Cameroon Government Forest and Wildlife authorities for preservation and future reintroduction programmes. The examination of activity budget of these monkeys was aimed at understanding the different interactions within members in the formation of sub-group associations. Through these group associations, their reintroduction into the wild would have a head way and limit rampant aggressions within the group caused by the adult males for dominance.

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

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Breeding biology of red wattled lapwing (*Vanellus Indicus*) from Southern Punjab, Pakistan

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This study documented some aspects of breeding biology of Red Wattled Lapwing (*Vanellus indicus)* such as breeding season, nest structure, clutch size, incubation period, hatching and fledgling success in Bahawalpur District. We selected 6 sites for the observation; barren, open, cultivated, grassy, area along road sides, and constructed areas with the common vegetation of *Cynodon dactylon, Ziziphus mauritiana, Albizia procera, Cincrus ciliarus, Cincrus biflorus, Arva jawanica, Eucalyptus camelduleńsis, Acacia nilotica, Prosopis juliflora* and *Conocarpus spp.* During the breeding season, the male selects territory. Breeding season starts from April to June. Both male and female participate in nest formation, incubation and other parental duties. Clutch size was mostly 4 and the mean of the clutch size was 4±0.0 (range 0-4). The incubation period of the eggs was 25-28 days and the average of the incubation period was 27.1±0.4. Total eggs were 24 in 6 nests, out of which 22 were hatched. The percentage of hatched eggs was 91% and the mean hatching rate was 91.6±5.2 per clutch. Fledgling success was 79.1±7.6 and the percentage of the fledging was 79%. Predation rate in red wattled lapwing was also observed; it was very high due to anthropogenic activities.

Key words: Red wattled lapwing, breeding biology, *Vanellus indicus*, Southern Punjab.

INTRODUCTION

Birds estimate the biodiversity values of a region (Prendergast et al., 1993). Birds are assumed to be an excellent indicator of an ecosystem (Gregory et al., 2004). *Vanellus indicus* (Red Wattled Lapwing-RWL) belongs to the family Charadriidae of the order Charadriiformes. This species occurs geographically and generally from Iran, Iraq, the Arabian/Persian Gulf to all South Asia including India, Pakistan, Afghanistan, Nepal and Bengladesh (Ali and Ripley, 2001; Birdlife International, 2009). RWL, in Pakistan is mostly present in all irrigated fields and area near wetland in all five provinces (Roberts, 1991; Mirza, 2007; Ghalib et al.,

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2009). Globally, conservation status of RWL is least concern (IUCN, 2018).

Both genders of RWL are indistinguishable; however, in males a more noticeable crest, facial wattles or spot wing spurs are present (Piersma and Wiersma, 1996). The chest, head and front part of neck are black. A red beefy wattle before each eye is also present. The beak is also red with dark black tip and the legs are long and yellow (Mirza, 2007; Grimmett et al., 2008).

The RWL prefers open fields close to wetlands, and mostly forages in freshly irrigated crop lands. It usually feeds on beetles, ants, caterpillars and vegetable residues (Grimmett et al., 2008; Ali and Ripley, 2001). RWL is also found in agricultural lands, for example, maize fields, plowed areas, gardens, and occasionally on grassy highway; it can be found in marshes, as high as 1800 m (Piersma and Wiersma, 1996).

RWL is monogamous bird and especially breeds in selected areas. During breeding season, mating site is carefully chosen by male. The female lapwing lays eggs in a little depression in open areas or ground and encompassed by pebbles or bits of hard earth normally bordered with goat or dairy cattle stools (Saxena and Saxena, 2013). The courtship behavior is displayed from mid-March to June. Firstly, male gives signs of courtship. The female responds through delivering breeding calls. Hatching is finished by both of the two guardians. Four eggs are laid by female. Nidifugous chicks, capable of leaving the nest, develop in 28 to 30 days, almost immediately after hatching, and are able to follow the parents in search of food. Both guardians secure nesting region, and also ensure that the young have developed full plumage (3 to 5 weeks) and have become strong fliers (Piersma and Wiersma, 1996; Saxena and Saxena, 2013; Muralidhar and Barve, 2013).

The male protects the female in the hot noon from predators by taking the task of incubating the eggs; the female can fly away from the nest. Incubation period takes 28-30 days, and both genders perform incubation obligations (Ali and Ripley, 1998; Desai and Malhotra 1976). Eggs of lapwings are lost because of a variety of predators (e.g. kites, mongooses, dogs and crows), because of human exercises (e.g. furrowing) and also as a result of crushing by grazing animals (Naik et al., 1961). After the first week, chick survival is improved.

Now, the RWL is not globally threatened with a strong world population that involves a variety of specialties and is likewise ready to endure regions which are thickly populated with people (Piersma and Wiersma, 1996). Red-wattled lapwing is a noisy bird and can also be heard at night (Hayman et al., 1986).

In Pakistan, few studies are accessible on understanding of the species–habitat relationship (Bilal et al., 2013; Rais et al., 2011; Rais et al., 2010). Data regarding habitat association and territory of RWL are insufficient in Pakistan. Present study was conducted to study the association of RWL with various territories and to determine breeding success in their preferred habitat.

MATERIALS AND METHODS

Study area

The study was conducted in Southern part of the district of Bahawalpur between 29.3957° N, and 71.6833° E. The period of the study was the breeding season of RWL from March to June, 2016; which is springtime; this is afterwards followed by hot summers until the onset of monsoons in July.

Methodology

Nest building started at the end of March, 2016. The nest was built during early morning up to noon and then in late afternoon on successive days. Nest building is a joint effort of both the parents with almost equal contribution. Observations were taken with full precautions without disturbing birds in different types of six habitats, as: barren land, open land, cultivated land, constructed areas, stony areas along the road side and grassland. Data were collected on daily basis; begin at the outset of breeding season by direct observation with the naked eye, and also by using binoculars (Bushnell, 7x35 mm), starting in early hours of dawn and ending with dusk. Nests were found by spotting lapwing's pairs while incubating the eggs, or foraging near nest. Photographs were taken through a Sony DSC-HX 10V digital camera. A Garmin eTerex 10 GPS navigator was used to take georeference of lapwing nests. Eggs that were laid by the birds were measured for size and weight with the help of electronic scale (SF-820) with range of 0.1 to 300 g; and a digital LCD vernier caliper was used to measure length and width of individual eggs in the nest, and average volume was calculated (Sethi et al., 2011; Khalil et al., 2016).

Statistical analysis

Data were statistically analyzed using one way ANOVA (Analysis of Variance) as described by Clark (2007).

RESULTS

Clutch size in Lapwing was observed to be four eggs. Eggs were laid on alternate days. Eggs were so arranged by the bird that their small ends meet in the center, making for even sitting and easier incubation by the parent. Parent bird was observed to rearrange the disarranged eggs. Eggs were of plover type, broad at one end and much pointed towards the other. Their colors vary from dusty off white to pale olive green with dark black spots.

Lapwings incubated the eggs by sitting on them. Incubation started with the laying of the first egg. Both the sexes shared the duty of sitting on the eggs. Mostly female did the duty but male assisted her some time. Incubation took 25 to 28 days. Young hatched out one after the other starting on 4 May, 2016, at an interval of 24 h, in the order in which they were laid. Hatching was synchronous. Lapwings kept the nest clean and tidy. Egg shells were removed from the nest providing both sanitation and concealment (Figure 1).

Figure 1. Red Wattled Lapwing with its clutch size and hatched chick in Barren land.

All lapwing nests were found on the ground in the vegetation, which mainly comprised *Cynodon dactylon, Ziziphus mauritiana, Albizia procera, Cincrus ciliarus, Cincrus biflorus, Arva jawanica, Eucalyptus cameldulensis, Acacia nilotica, Prosopis juliflora* and *Conocarpus spp.* (Table 1).

Shape of the nests varied from round to partially round and deep round in all sites, which we selected. Mean outer diameter of nests was 4.3±0.1 inches (range 3.8-4.6 inches); while inner diameter of the nests was 1.1±0.0 (range 1.1-1.3). However when compared no significant difference between the nest sites was observed. The color of eggs was dusty white to pale olive green with dark black spots; the texture was smooth while shape of eggs was oval. Eggs were different in weight and the mean weight of eggs was 18.7±2.9. Mean length of eggs in all sites was 12.2±2.3. While mean width of the eggs was 10.6±1.8 and the mean volume of the eggs was 152.7±40.5 (Table 2).

There was somewhat a difference in the egg laying period of the RWL; and the mean of egg laying period was 8±0.26 (range 7-9 days). There was no difference in the clutch size in all six sites; so the mean clutch size of the eggs was 4.0. The incubation period of the eggs was 25 to 28 days, and the average of incubation period was 27.16±0.48 (range 25 to 28 days).

Total eggs were 24 in 6 nests, out of which 22 were hatched. Two eggs were destroyed due to anthropogenic activities and trampling effect of cattle. The percentage of hatched eggs was 91% with the mean hatching rate of 91.66±5.27 per clutch. In the end, fledging success was 79.1±7.6 and percentage of the fledging was 79% (Table 3, Figure 2). The F-ratio of 12.8 is statistically significant ($p = 0.000068$).

Predation in RWL was also observed; predators included; house crow (*Corvus splendens*) and pariah kite *(Milvus migrans*) and anthropogenic activities. Out of 22 chicks only 19 chicks were fledged. 2 chicks died and 1

Table 1. Location and constitute of nesting material of Red Wattled Lapwing in the study area in the district Bahawalpur, Pakistan.

Nest number	Habitat type	Elevation (ft)	Coordinates	Nest material	Vegetation around nest location
1	Grass land	391	N29°22.444 E071°45.585	Grassy straws Pebbles Small mud stones Leaves of *Albezzia procera* and *Conocorpus*	*Albezzia procera* *Cynodon dactylon* *Cenchrus ciliarus* *Cenchrus biflorus* *conocorpus* *Callotropis procera*
2	Barren land	411	N29°22.399 E071°45.311	Leaves of *Eucalyptus cameldulensis* and *Acacia nilotica* Small and large pebbles Mud stones	*Eucalyptus cameldulensis* *Acacia nilotica* *prosopis julifolra* *Cenchrus biflorus* *Cenchrus ciliarus*
3	Cultivated land	381	N29°22.978 E071°45.610	Small pebbles Grassy straws *Cenchrus biflorus* Small mud stones	*cenchrus ciliarus* *Cenchrus biflorus* *aerva javanica* *Conocorpus*
4	Open land	360	N27°22.971 E071°45.644	Smooth soil Small and large pebbles Mud stones Grassy straws	*cenchrus ciliarus* *Cenchrus biflorus* *aerva javanica* *Conocorpus*
5	Stoney along road side	346	N29°23.039 E071°44.629	Construction material small and large pebbles stones	*cenchrus ciliarus* *Cenchrus biflorus* *aerva javanica*
6	Constructed area	415	N29°22.399 E071°45.311	Leaves of *Eucalyptus cameldulensis,*small and large mud stones,straws.	*Zizyphus mauritiana* *Cenchrus biflorus,Cenchrus ciliarus.*

was predated by a house crow.

DISCUSSION

Present study expresses that survival and hatching success of RWL in nests were higher on ground. While in a study it was observed that grazing animals damage the ground-nests of RWL (Hart et al., 2002). In two cases, we witnessed a herd of grazing sheep crushing the eggs of ground nesting Red-Wattled Lapwing (Fletcher et al., 2005). Additionally, on various occasions, ground-nesting parents were observed violently attacking grazing animals close to their nests. In ground-nests, damage to eggs by grazing animals was also observed (Beintema and Muskens, 1987; Hart et al., 2002).

As described here, it is well recognized that ground-nesting birds are susceptible to high rates of destruction of their eggs and young (Massey and Fancher, 1989; Armstrong, 1954; Salek and Smilauer, 2002).

Breeding season of RWL begins from April and lasts until June with the peak season of April. However, in a previous study, it was reported that in Northern India this species breeds March to July (Anil and Sharma, 2011); while another study shows that the peak breeding season began from April and lasts up to the end of June (Sujit et al., 2010). Moreover, the peak breeding season of RWL was also observed as April to June (Sethi et al., 2011).

Clutch size of Lapwings was four in the present study, accumulating during a span of seven to nine days; however, some workers have also reported three to five eggs (Conrad and Robertson, 1993). We observed four eggs in each nest in seven to nine days. While Adithi and Barve (2013) observed that cryptic four eggs were laid in

Table 2. Measurements of nests and eggs of Red Wattled Lapwing in observed habitats of district Bahawalpur, Pakistan.

Nest number (Habitat type)	Shape of nest	Outer diameter of nest (inches)	Inner diameter of nest (inches)	Shape of eggs	Colour of eggs	Surface texture	Weight of eggs (g)	Length of eggs (mm)	Width of eggs (mm)	Volume of eggs (mm^2)
1 (Grassy land)	Round	4.5	1.1	Oval	Dusty offwhite with black spots	Smooth	29.63	16.67mm 0.656in	14.83 mm 0.583 in	247.2
2 (Barren land)	Deep round	4.3	1.3	Oval	Offwhite with black spots	Smooth	18.86	2.08 mm 0.0818 in	2.78 mm 0.109 in	5.78
3 (Cultiavted land)	Partial round	4.5	1.1	Oval	Dusty offwhite with dark black spots	Smooth	17.04	13.20 mm 0.52 in	12.34 mm 0.485in	162.8
4 (Open land)	Partial round	4.6	1.2	Oval	Dusty offwhite and olive green with black spots	Smooth	7.31 Chick wt: 13.96	18.26 mm 0.718 in	15.12mm 0.595in	276.09
5 (Stoney along road side)	Round	3.8	1.2	Oval	Dusty offwhite with black spots	Smooth	21.34	12.17 mm 0.47 in	10.00mm 0.393in	121.7
6 (Constructed area)	Round	4.4	1.1	Oval	Dusty offwhite with pale yellow and olive green in colour	Smooth	18.41	11.34 mm 0.446 in	9.08mm 0.357in	102.96

Table 3. Breeding pattern of Red Wattled Lapwing in different habitats of district Bahawalpur, Pakistan during the period of 2016.

Nest number (Hbitat type)	Egg laying period (days)	Clutch size	Incubation period (days)	Hatching success (%)	Fledging success (%)
1 (Grassy land)	8	4	28	100	75
2 (Barren land)	7	4	27	75	75
3 (Cultivated land)	8	4	27	100	100
4 (Open land)	9	4	28	100	100
5 (Stoney along road side)	8	4	28	100	75
6 (Constructed area)	8	4	25	75	50

a period of four days.

The incubation period of 25-28 days was observed, while in another study it was reported to last for 28 to 30 days (Ali and Ripley, 1998; Desai and Malhotra, 1976). The incubation period we observed was as similar to another study in which incubation was 25 days in natural conditions without using hormone treatment (Smith, 1993).

Current observations show that RWL is adapting to urban settings and choosing a nest location to minimize human and livestock interference. Breeding success can be enhanced for this

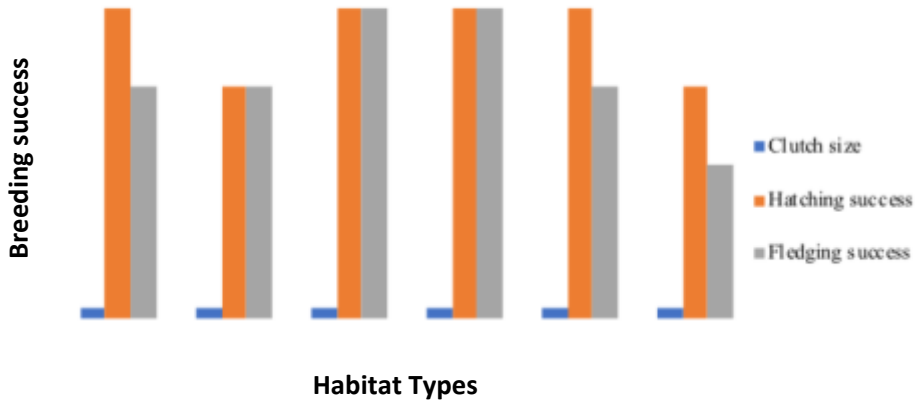

Figure 2. Breeding success (clutch size, hatching and fledging success) of Red Wattled Lapwing in the district Bahawalpur, Pakistan.

precious bird by improving its habitat and by raising awareness at the local level, so that it would ultimately be helpful for conservation of RWL throughout its area of distribution.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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