

Studies on the Reproduction and Growth of Hoopoe (*Upupa epops*) in District Gujrat, Punjab, Pakistan

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ABSTRACT

Background: Hoopoe, *Upupa epops* belongs to the family Upupidae. It is found across Asia, Europe and Africa. Its habitat includes grasslands, savannas, wooded steppes, and forests. Main threats to the survival of the Hoopoe are habitat loss and climate changes.

Objectives: The present study was planned in district Gujrat (32.7037°N, 73.9585°E), Punjab Pakistan. Due to habitat loss and cutting of Sheesham tree (*Dalbergia sissoo*), the natural nesting sites was very scarce.

Methodology: Thirty three nested sites of Hoopoe were spotted and checked for chick's presence regarding timing and breeding at the interval of one week. Egg size was measured using Dial clipper and weighed with electrical weighing balance.

Results: The percentage clutch size 7.04 ± 0.64 , brood size 1.76 ± 0.70 and nesting success of 81% was recorded. The following trees provided the nesting sites as hole/cavities *Ficus benghalensis* (Barh) (23.5%), *Dalbergia sissoo* (Shisham) (35.2%), *Acacia nilotica* (Kikar) (11.7%), *Ficus religiosa* (Peepal) (14.7%), *Mangifera indica* (Mango) (8.8%).

Conclusion: More trees should be planted and wooden nest boxes should be provided at the human dwellings so that they can coexist with man.

Keywords

Hoopoe, Nesting, Habitat, Breeding, Reproductive Success, Conservation.

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INTRODUCTION

Hoopoe (*Upupa epops*) commonly known as “Hudhud” in Pakistan, belongs to the family called Upupidae. Distribution range of this magnificent bird include across Asia, Africa, Europe and Madagascar. It is found in forests, grasslands, savannas, wooded steppes and widely distributed in agricultural lands. In Holy Qura’an, Hoopoe is described as a courtier of Prophet Hazrat Sulayman (A.S) and in ancient Egypt it is considered as a sacred bird. By IUCN, Hoopoe is listed as a “least

concerned” species, but its population is decreasing generally by over hunting, habitat loss and degradation. Main causes for this include, human construction activities, climatic changes and/or availability of food resources. Eight sub species of Hoopoe are found in Asia, Sub-Saharan Africa and Madagascar. It is commonly observed that Hoopoe is nesting in holes of tree barks, old buildings, abandoned places, drainpipes, nest boxes or wells etc. Hoopoe may use same nest for several

season as a nesting site. In Hungary, during the year 2015, it was declared as the “Bird of the Year” which elaborates its importance for conservation priorities¹.

It lays egg in late April or in early May in Southern and Central Europe, but in canaries it lay eggs in January. It primarily preys on insects and their larvae/pupae or on other small invertebrates. Hoopoe is territorial breeder, pair as monogamous and live solitary, in some places it also shows extra-pair paternity². Population growth in Hoopoe is related with rate, survival of juveniles and fecundity, this reflects that the demographic components affecting the migration of individuals in a population are playing a vital role in population dynamics than the demographic components³. Breeding dispersal in Hoopoe is more common among bird species, (as female disperse more as compare to male Hoopoes) and this dispersal is somewhat affected by age or previous breeding history of the female⁴. After agriculture intensification and the use of insecticides, which reduces the availability of insects (as the Hoopoe is insectivorous bird), the reproductive success is greatly affected⁵. Therefore, due to the scarcity of food and habitat loss, the population of Hoopoe is declining, thus, for future conservation the use of insecticides should be minimize, and artificial nest boxes should be provisioned.

Upupa epops is a good example of a bird that searches food on the ground. Important cues for breeding habitat selection can be food availability, availability of nest sites, and presence of mates, predation risk, or combinations thereof. A good breeding home range offers all kinds of resources (e.g. food, partners, nest sites, shelters from predators) in enough supply. If one of the required resources is lacking or insufficient, the reproductive output would be comparatively low, i.e. the home range is sub-optimal⁶. Because food is usually patchily distributed within a home range, different parts of the home range are not used evenly. Other resources being equal, results in increased visiting of places with high amount of food than places where food is scarce or of lower quality. If food resources are dense and clumped, the size of the home range can be small, with an excellent costs/benefits ratio favoring reproductive output⁷. Roosting in closed sites, such as cavities in winter provides more thermal benefits⁸ and better protection from predators⁹⁻¹⁰ than roosting in open sites such as tree limbs. In human-

altered landscapes where natural tree cavities may be limited, some secondary cavity nesting species use other available closed roost sites such as human-made structures, e.g. barns, sheds, or abandoned buildings, and nest boxes as roosts in the nonbreeding season¹¹.

Therefore, although nest boxes are typically posted to increase breeding productivity, nest boxes may also create important roost sites that lead to improved overwintering survival and beneficial population-level effects. Nest boxes should be placed to cope with an increasing rate of deforestation. This will be helpful to provide the more nesting sites to Hoopoe with an increase in population. The effectiveness of nest box programs as a management tool typically necessitates that nest boxes either decrease nest site limitation or create improved productivity relative to natural cavities¹². Without careful placement, nest boxes may become ecological traps¹³.

Despite a well-documented preference for open and semi-open farmland, the precise microhabitat requirements of Hoopoe's are still poorly understood. This lack of information hampers the formulation of appropriate conservation action plans. The main goal of this study was to assess patterns of reproduction, habitat selection and foraging in population of Hoopoe's in Gujrat, Punjab, Pakistan.

MATERIALS & METHODS

Thirty-three (33) nests of Hoopoe were spotted by observing the parents with binoculars (10x50) (Nikon cooperation) from a suitable distant vantage point; the help of local shepherds/nomads was also being taken in locating the nests and the nests encountered accidentally. The nests were checked for chick's presence regarding timing and success of breeding, at interval of one week; care was taken to record the data without disturbing the pairs. The egg size was measured with dial caliper and weight with electric balance. The annual reproductive success (ARS) of the Hoopoe was calculated by following Murray (2000)¹⁴. The comparison of ARS was made between the populations of the Hoopoe during the study period.

Study Area and Data Collection

The Hoopoe (*Upupa epops*) is a good example of a bird that searches for food (mainly arthropods) on the ground

and is secondary cavity nesting bird¹⁵. The present study was conducted in district Gujrat (32.7037°N, 73.9585°E), Punjab, Pakistan. Nests were checked on weekly basis. To check the brood phenology and breeding success the nests were visited after an interval of three days, to get comprehensive information of a nest. Breeding birds were captured from their nest after the chicks were of six days by mist nets and cavity entrance trap or by grabbing a brooding female in her nest. Captured individuals were sexed either by plumage color or by prominent uropygial gland on female.

The nest success and egg success were calculated as follows:

Nest success = No. of clutches that produce young / Total number of clutches

Egg success = No. of young that leave the nest / Total number of eggs

Diet of Nestlings

During the study period of January 2016 to April 2017, the prey items brought to the nests by parents were noted in about 10 nests with considerable efforts. The study on breeding population was carried out with help of binoculars and cameras. To feed chicks, parent bird was observed to bringing a single type (species) of insects. For chick feeding, mostly a single item of prey was observed, brought to the nests by parent. Sometimes it was difficult to recognize a prey due to the position of bird's bill with orientation to nest opening.

Nest Location & Reproductive Success

The data for young fledged was recorded for possible nests. Data on same site over next brooding site was independent of the next recordings during the study period.

RESULTS

In total, 33 nest sites were examined to study nesting behavior of Hoopoe. In the study area, main tree sites observed by Hoopoe for nesting were *Ficus benghalensis* (Barh) (23.5%), *Dalbergia sissu* (Shisham) (35.2%), *Acacia nilotica* (Kikar) (11.7%), *Ficus religiosa* (Peepal)

(14.7%), *Mangifera indica* (Mango) (8.8%), that provide more suitable nesting cavities/holes.

During the study, 33 nests were observed in different locations of study area. The nesting sites were located in building pipes (42.4%), building walls (24.2%) and cutting banks (33.3%). Table 1 shows the detail of nesting sites as holes for Hoopoe. Banyan fig (*Ficus benghalensis*) 23.5%, Sheesham (*Dalbergia sissu*) 35.2%, Gum arabic (*Acacia nilotica*) 11.7%, Bodhi tree (*Ficus religiosa*) 14.7% and in Mango (*Mangifera indica*) 8.8%. The maximum hole nests were found in Sheesham (*Dalbergia sissu*) as 35.2%, and minimum in Mango (*Mangifera indica*) i.e., 8.8%.

Table 1. Nesting Sites Used by Hoopoe in Trees.

Hole Nesting Used by Hoopoe on Trees		
Tree Species	No. of Trees (N)	%
Banyan fig (<i>Ficus benghalensis</i>)	08	23.5
Sheesham (<i>Dalbergia sissu</i>)	12	35.2
Gum arabic (<i>Acacia nilotica</i>)	4	11.7
Bodhi tree (<i>Ficus religiosa</i>)	5	14.7
Mango (<i>Mangifera indica</i>)	3	8.8

The percentage of hole nesting used by Hoopoe on building sites (Table 2) was 42.4% in building pipes, 24.2% in building walls and 33.3% in cutting edges. Parameters of nesting sites with their complete characterization is mentioned in Table 3.

Table 2. Hole Nesting Used by Hoopoe on Building Sites in Study Area (Gujrat).

Hole Nesting Used by Hoopoe on Building Sites			
S. No.	Tree Species	N	%
1	Building pipes	14	42.4
2	Building walls	08	24.2
3	Cutting edges	11	33.3

Table 3. Nesting Sites and Habitat Characteristics of Hoopoe in Gujrat District, Province Punjab-Pakistan.

S. No.	Parameters of Nesting Sites (cm/m)	Characteristics of Nesting Sites (Mean ± SD)	
		Nesting in Trees	Nesting in Building Walls
1	Height of nesting (m)	3.3 ± 1.43	8.9 ± 1.40
2	Nest location (m)	5.1 ± 0.15	6.3 ± 1.27
3	Nest Diameter (cm)	19.4 ± 2.32	23.2 ± 9.0
4	Hole/Cavity Depth (cm)	40.4 ± 2.53	46.4 ± 13.74
5	Number of nest sites	1.5 ± 0.22	1.4 ± 0.51
6	Distance to nearest tree (m)	2.8 ± 0.23	3.1 ± 2.21
7	Distance to Agricultural lands (m)	12.1 ± 0.21	88.3 ± 30.12
8	Distance to Water Source (m)	15.9 ± 2.62	19.5 ± 6.41
9	Distance to nearest human Dwellings (m)	71.2 ± 1.23	49.5 ± 12.34
10	Distance to Nearest buildings (m)	31.2 ± 1.37	34.0 ± 9.41
11	Distance to Nearest roads (m)	78.2 ± 1.24	70.2 ± 18.41

Table 4. Clutch and Brood Size and Nesting Success of Hoopoe in the Study Area.

Year	Nest Sites	Clutch Size	Brood Size	Nesting Success (%)
		Mean ± SD	Mean ± SD	
2016	14	7.03 ± 0.63	1.8 ± 0.57	67
2017	10	7.1 ± 0.58	1.6 ± 0.86	67
Total	24	7.04 ± 0.64	1.76 ± 0.70	81

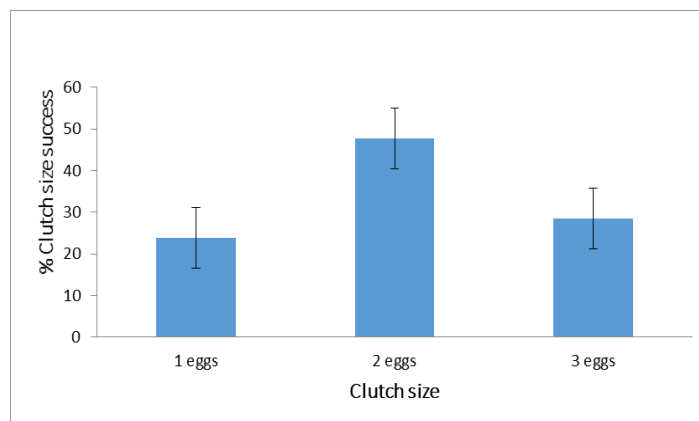


Figure 1. Percentage of Clutch size in Hoopoe during the study period of 2016-17 in Gujrat, Punjab, Pakistan.

A total of 24 nesting sites were observed 14 in the year 2016 and 10 in 2017 survey. The clutch size was 7.03 ± 0.63 and 7.03 ± 0.63 ; brood size was 1.8 ± 0.57 and 1.6 ± 0.86 with nesting success of 81% during the study period (Table 4; Figure 1).

For the hatching and fledging success of Hoopoe, a total of 43 eggs were laid by Hoopoe during the study period of 2016-17 (Table 5). Out of 31 eggs hatched, 25 young fledged with an average fledging success of 81 percent.

nestlings produced after each reproductive attempt. Predation often affects the reproductive success by causing nest loss and the rate of predation is directly related to the type of nest used for breeding, hole-nesting species. Hole nesting species mostly face less predation rate as compared to the open nester species¹⁹. This is the reason that hole-nesting birds tend to invest their energy on one or two large clutches instead of several small ones and the only reason for a larger clutches and more broods

Table 5. Hatching and Fledging Success of Hoopoe in the Study Area Gujrat During 2016 and 2017.

Year	Total No. of Eggs Laid	Total No. of Eggs Hatched	Hatching Success (%)	No. of Young Fledged	Fledging Success (%)
2016	24	19	79	14	74
2017	19	12	63	11	92
Total	43	31	72	25	81

DISCUSSION

Hoopoe (*Upupa epops*), a hole nesting bird prefer to inhabit trees as mentioned in Table 1 and wall cavities in farmlands where they can forage on insects¹⁶. They are also found in thin or cleared forests, and use multiple habitats due to their bimodal distribution i.e. they can adjust them in open fields and in forests as well¹⁷. Hoopoe provides food items to the brooding female and nestlings for first week of incubation. After this period both parents participate for feeding to nestlings but female feeds to young nestling after receiving the prey items from male. Hoopoe are residing in variety of hole-nests, mainly located below 3m in height, such a height is accessible for some predators like snakes, small mammals or lizards etc., (Table 2 and 3). Nestlings of Hoopoe have developed anti-predatory mechanism by the production of copious amount of faeces and bad-smelling fluid from oil glands.

Normally Hoopoes lay on average 7 eggs with an interval of 24hours and in rare cases of 48hours interval (Table 4). Incubation is started after first or second egg is laid. Hatching is asynchronous with an interval of 24hours, in contrast to this, hatching in African sub-species is entirely synchronous¹⁸.

Avian reproductive success is related with the number of breeding attempt and on the number of successful

than expectations to the open nesters. It is suggested that this special reproductive pattern of such non-excavator species is related with availability of the suitable nesting sites to have a more reproductive success when more secure nesting holes are available. Basically, the efficiency of a reproductive success depends on the clutch size and the number of eggs reared by the pair. When sufficient food resources are available Hoopoe increase their clutch size by laying more eggs so that they could easily rear their nestlings²⁰. In wild habitat the Hoopoe's are entirely insect eating birds, they use their long beak to explore insects for their meals. Mostly the Hoopoe's feed on waxworms, mealworms, crickets and other available insects as a food source²¹.

Hoopoe's pair for a single season, are monogamous and territorial birds. Male show his ownership for a territory by advertising calls. The male calls frequently to advertise his ownership of the territory. Dominancy is established by chasing and fight between males, which occasionally results in blindness in males and bills are used to stab the competitors. Sometimes females also fight for males. Mostly, the nest is located in hole of a tree or a wall with narrow entrance. Only female incubates eggs. In current study, the clutch size recorded was about 7 eggs with a weight of 4.5grams.

Reproductive success is a crucial factor which drives the population dynamics of Hoopoe and most probably the

second clutch is an important parameter of its reproductive success. Therefore, variations in double brooding behavior of Hoopoe contribute a potential role in population dynamics of a Hoopoe. Some preliminary studies on double brooding behavior of Hoopoe describe a positive effect on egg laying date with strophe length of male songs and the chances of second clutch production, however no distinction in fledging numbers of first and second clutch²². The incubation period of Hoopoe is about 15-18 days; it starts after the first egg laying. Thus, chicks produced are asynchronous. Chicks hatch with a downy feather which turn to adult feathers after three to five days. The chicks also excrete a foul-smelling liquid from uropygial gland; probably to distract the predator. Female brood chicks for 9-14 days and male bring food to the nest, after this period female also join the male for food gathering. After 26-29 days the young fledge and remain for one week more with parents for grooming.

It is recommended that the survival of Hoopoe and other birds in study area of Gujrat, Panjab, Pakistan, be ensured by providing them nest boxes, planting more trees, reducing the deforestation rate and minimizing the use of insecticides. A further detailed research is recommended on breeding behavior, Hoopoe's prey insects' distribution and ecology of Hoopoe and insects for a biological control mechanism on vast agricultural intensification practices in country.

CONCLUSION

Hoopoes *Upupa epops*, once a commonly found bird in various areas of Pakistan, is now facing a decline in its population. Timely reproduction of an individual is primarily determined by its reproductive success which in turn is governed by availability of habitat, nesting sites, availability of food resources and seasonal fluctuations in an area. With increasing constriction activities, intensive use of insecticides and rapid deforestation, the timing and conditions of migration and reproductive performance of Hoopoe and other birds has been affected. Further studies should be conducted to determine the changes in resources availability and how the reproductive performance of these birds should be increased to enhance the population size of Hoopoe, so it might be used as an effective component in agriculture to control insect's population in biological control.

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CONTRIBUTORS STATEMENT

Muhammad Idnan involved in manuscript drafting and research work, Muddasir proof read the manuscript, Asif Shahzad and Jamil conducted field survey for this study. Arshad Javid supervised the research project and approved the final draft and Asma Naeem contributed for technical help.

LIST OF ABBREVIATIONS

SD	Standard Deviation
IUCN	International Union for Conservation of Nature
ARS	Annual Reproduction Success

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