Nesting Ecology and Breeding Success of Little Bittern in Wular Lake Kashmir, India.

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Abstract: Some parameters of nesting ecology and breeding success of little bittern were studied for three successive years (2007-2009) in the lake Wular Kashmir, India. Breeding occurred from late April to August and was initiated by nest building. Nesting sites were chosen in bushy willows and dense growth of emergent reeds where average reed density was 52.2 ± 4.2 per m^2 and average reed height 1.4±0.26.The effect of initial water level on distribution of nests in different habitats is given. Maximum percentage of nests (65.56%) was in reeds and among reeds *Saccharum spontaneum* patches were mostly preferred for nesting (23.34% nests).Distance of the nests to open waters averaged 30.25±4.6m. Different types of nests were built in different habitats by both the sexes in 4-12 days and average water depth near nests was 1.67 ± 0.34 m.The nests on willows differed significantly both in diameter and in depth from those in reeds($P<0.05$). In 73% clutches the eggs were laid on alternate days between 6 hours and 13 hours and peak laying was in the month of June. Average clutch size was 5 and mean egg measurements were 34.5 ± .866 x 25.9 ± .668 mm. Breadth and volume of eggs differed significantly between early, intermediate and late clutches. Incubation was performed by both sexes and varied from 16-19 days. Over all egg survival during incubation was 0.61. Hatching period ranged from 1-2 days and precocial hatchlings weighed on an average 9.500 ±0.560g. The hatching and fledging success was 63.55% and 78.67% respectively. Fledging period varied from 20-25 days. Nestling survival during nestling period was 0.80 and breeding success calculated from exposure was 0.46. It was observed that predation was main cause of low breeding success. Recommendations for conservation of bitterns and designing of management plans are given.
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1. Introduction

Bitterns belonging to subfamily Botaurinae of family Ardeidae comprises of two genera, *Botaurus* with four species and *Ixobrychus* with eight species. Of the four species of *Ixobrychus* reported from South East Asia, *I. minutus* is the only breeding migrant species (Fazili *et.al*. 2010) that prefers to breed in the lakes, wetlands, rivers and ponds of the valley (Ali and Ripley 1968). The little bittern *I. minutus minutus* has its breeding range extending from Europe to about 80º east. Besides, it breeds in suitable localities along the outer Himalayas as far east as Nepal and is winter visitor to Punjab (Baker 1929). Although there are many studies on this bird in Europe (Groebbels 1935; Steinfatt 1935; Wackernagel 1950; Grosskopf and Graszynski 1958; Braschler *et al.* 1961) but there are no detailed reports from Indian subcontinent except a few from Haigam wetland Kashmir (Holmes 1983; Fazili *et.al.* 2010). Further, there are no detailed studies on its nesting ecology and also the bird has not been studied in Lake Wular, a Ramsar site, which provides most suitable breeding ground to it where it enjoys most favourable climate and after raising its new generation leaves back to the plains of India for wintering. The nesting studies are of paramount importance in designing conservation plans for maintenance and regulation of bird populations, as a good nesting site generally provides protection against predators, offers adequate stability and materials to support and construct the nest, and also influences hatching success (Ludwig *et al.* 1994; Kazantzidis *et al.* 1997; Hilaluddin *et al.* 2003) and fledging success (Buckley and Buckley 1980). The objective of the present paper is therefore to describe some of the aspects of nesting ecology of the bittern in relation to the lake ecology and to visualize whether there is any effect of nest-site parameters on the hatching success, fledging success and overall breeding success, of this migrant bird species from the data collected during three consecutive breeding seasons from 2007-2009 from Wular lake, Kashmir (India). Bitterns being the marsh birds generally prefer reed beds as their nesting habitat and reeds as nest construction materials (Bates and Lowther 1952; Shah1984; Fazili *et.al*. 2010). So the possible reasons for shifting of nesting habitat from reeds to submerged willows have also been tried to elucidate. Further, quantitative data of this bird species is not available but certain studies have shown that there has been marked decline in the number of wetland birds including little bittern (Ahangar F.

2008; Shah 1984). The main cause of their decline can be attributed to the habitat loss as most of the valleys wetlands and marshy areas have been filled for human habitation. In view of this certain recommendations for conservation and designing of management plans for long term survival of this bird species and the wetlands as a whole have been suggested.

Material and methods

2. 2a. Study area

The study was conducted from 2007 to 2009 at Wular Lake (34º15′ to 34º25′ N, 74º32′ to 74º42′ E), a Ramsar Site in the Baramulla and Bandipore districts of Jammu & Kashmir, India. The lake has a maximum depth of 4.9 m with an area of 111.71Sq. Km (Latief 2012), that remains covered with dense growth of free floating and emergent vegetation during the major part of the year. The common species are *Trapa bispinosa, Nymphoides peltatum, Nelumbo nucifera, Ceratophyllum demersum, Hydrilla verticillata, Potamogeton indicus, P. lucens, Butomus umbellatus, Carex sp., Phragmites communis, P. elephantoides, Typha angustata, Myriophyllum verticillatum, Sparganum ramosum, Lemna sp. and Saccharum spontaneum.* The dense floating vegetation and reed beds are partitioned by a series of boat channels varying in width between 1–6 m. There is a protective bank mostly on the southern and eastern sides of the lake. Inside the bank and at some places outside the bank there are dense willow plantations of both tall and bushy *Salix* tree species that provide best roosting and breeding grounds to a wide variety of resident and non-resident birds. In addition, outside the bank on southern side of the lake there are two large marshy areas attached to the lake locally known as Rakhi Saderkote and Rakhi Muqdemyoor. These rakhs (morases) have dense growth of reeds and emergent and free floating vegetation of *Phragmitis communis, P. elephantoides, Typha angustata, Saccharum spontaneum, Sparganum ramosum, Eleocharis palustris, Carex species and Butomus umbellatus.* These morases also harbour a wide variety of aquatic bird species. Besides several springs that are occasionally seen bubbling up to the surface and streams, especially, Erin, Mudhumati, and Ningal Nallah, the lake is mainly and chiefly fed and drained by the river Jehlum. It flows into the Wular on its south-eastern side, near the middle of the lake and leaves the lake at its south-western corner near Sopore (Figure 1).

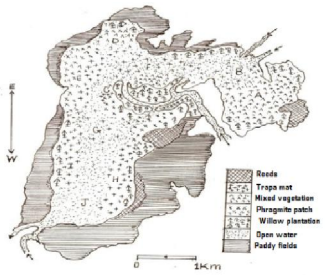

Figure 1. Wular Lake

2b.Methods of observation

To observe the nesting behaviour, the lake was visited regularly during the breeding season, March–October. The activities of birds were recorded on every visit. Nesting site was defined as an area where mating, nest building, adult incubating and brooding occurred. Nests were searched systematically throughout the wetland.The nests of bitterns were generally located in the study area by wading through reeds. Any residing place of a bird with one or more eggs was classified as a nest. Slender willow stakes flagged with strips of red cloth were used to mark nest locations so that nests could be relocated (Klett *et.al,* 1988). Nest numbers were marked on the flags with waterproof ink. In some cases plastic numbers were tied to the nest material and placed a few feet away from the nest. When a nest was spotted the following parameters were recorded: location, nesting material, plant species in the immediate vicinity of the nest and, water depth at the nesting site. In addition, at each nest, the type, height and density of vegetation cover and its condition; shape, size and the position of the nest and concealing arrangements were recorded. To monitor outcome, the nests were visited thrice in a week. A nest was defined as successful if there was at least hatching of one chick in the nest or the presence of piping hole on the egg made by the chick. The newly laid eggs were weighed to an accuracy of 0.1 gm using digital balance. To determine egg laying and hatching intervals, the eggs were marked with waterproof ink and placed properly without disturbing the arrangement of other eggs in the nest. Morphometric measurements of eggs were taken to 0.1 mm using digital Callipers. The length and width were measured at highest points of the egg, obtained by sliding the callipers gently on the egg. The Volume and egg shape index were calculated by using the formulae V (cc) = K × L × B² (Hoyt 1979), where L is the length, B is breadth and K is constant the value of which is equal to 0.51and IS = (W/L) × 100 (Coulson 1963), Where W is egg width (cm) and L is egg length (cm). To find whether there is any variation in the egg dimensions of early and late clutches, they were

divided into three groups (only 3 egg clutches). The clutches laid from May 20th to June10th were considered as early clutches, the clutches laid from June 11th to July 5th were considered as intermediate clutches and the clutches laid from 6th July to 2nd August were considered as late clutches. Incubation period was defined as the period since the laying of last egg of clutch until the hatching of first egg (Gill 1994). Hatching, fledging and breeding success were defined as the probability that eggs laid would hatch, the probability that hatchlings would fledge and the probability that eggs laid would survive from laying to fledging. These calculations were done as per Mayfield (1975).

On hatching, each chick was weighed to nearest 0.1 gm using digital balance. Hides were constructed at distances of 6–10 m from the nests to record the behaviour of breeding pairs and chicks. Observations were made in shifts of at least two hours each, from egg laying till nestlings fledged. A camera with a 210 mm teli-lens was used for photography.

Statistical analyses

Measurements of early, intermediate and late clutches were compared with one way ANOVA followed by post-hoc Tukey's test.Independent samples t-test was used to determine statistical significance in the difference of average nest heights, their diameter and depth in different habitats. Probabilities were two tailed, and significance level was set as 0.05. All statistical analysis was performed using SPSS16. Correlation between initial water level and nest distribution in different habitats was determined using MS Excel.

3. RESULTS

3a. Nest site characteristics

Nesting sites were characterized by a thick growth of emergent vegetation and bushy willows dense enough to provide cover and protection to the nest and at the same time sufficient support to hold the nest. Initial water level played a significant role in nest site selection; it showed specific relation with the distribution of nests in different habitats. In reeds the number and distribution of the nests were negatively related to the water depth with correlation coefficient r =-0.994 and positively relat ed on willows with correlation coefficient r =0.942 (Figure 2).

Generally reeds were preferred sites for nesting as 65.56% (n=59) nests were built in reeds and 34.44% (n=31) nests on willows. Among reeds the greatest density of nests was found in *Saccharum spontaneum* (23.34%) followed by *Typha angustata* (16.67%), *Sparganium ramosum* (14.44%) and *Phragmites elephantoides* (11.11%) (Table1). Average reed density at the nesting site was 52.2±4.2 per m^2 and reed height ranged from1.0-2.05m with an average of 1.4±0.26m (Table1).The nests on willows were located significantly higher than on reeds t (30) =25.2 P<0.005. The average distance of the nest to open water was 30.25 ± 4.6 m and 33.5±15.6m in different habitats and water depth 1.67±0.34 in reeds and1.5±0.6m in willows. Water near nests in reeds was not significantly deeper than those near willows (P>0.005). Nest building activity which was performed by both the sexes, was initiated in the last week of April in 2008 and 2009 but in 2007 it was delayed till third week of May due to lake inundation (Figure 3). The time taken to complete the nest before laying the first egg varied from 4-12 days. Two types of nests were built. In reeds substantial platforms of dead reeds, and bowl shaped nests on willows. The bowl shaped nests had significantly greater depression for holding the eggs than those in the reeds t (43.86) = 21.4 P<0.005. Nesting material in the nests located in reeds comprised of *Sparganium ramosum, Phragmites communis, Typha angustata* and *Saccharum spontaneum* but those in willows had fine *Salix* twigs and their leaves. The nests in reeds were larger with significantly greater diameter than those on willows t (85) = 16.99 P<0.005(Table 1).

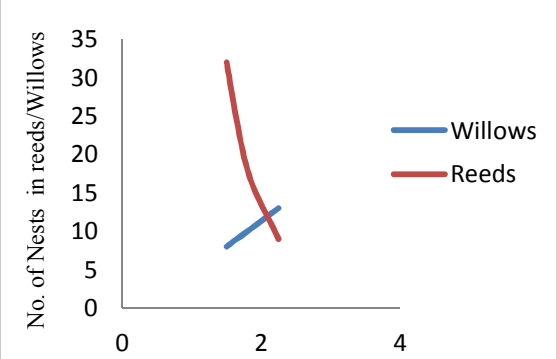

Figure 2. Correlation between nest establishment and water depth

3b. Clutch and Egg Biometry

The clutch size greatly varied from 3 to 7 eggs but mean clutch size of 5 eggs was recorded (Table 2). Mean clutch size also varied at different periods of laying season. With the exception of three nests eggs were laid daily.

Table 2: Eggs per clutch/ No. of clutches in little bittern

Year	Clutch Size					Total	Mean Clutch Size ± SD
	3	**4**	**5**	**6**	**7**		
2007	-	4	9	8	1	22	5.27±0.8
2008	3	6	11	7	1	28	4.89±1.0
2009	3	11	14	10	2	40	4.93±1.02
Total	6	21	34	25	4	90	5±0.98

Laying was initiated in the third week of May except for first season during which it was delayed by a fortnight. Laying was brisk in June (Figure 4). Hourly counts of the number of eggs laid revealed that 76% eggs were laid between 6.00 hours and 13.00 hours. Freshly laid eggs are smooth glossless white with pale bluish tinge. They were regular ovals with one pole slightly broader than the other and weighed on an average12.560±0.59g.

Table 3: Shape size and weight of eggs in little bittern

	Min.	Max.	Mean ± SD	No. of eggs measured
Weight of Un-incubated eggs (g)	10.600	13.500	12.00 ± 0.599	100
Weight of incubated eggs (g)	8.900	11.600	10.400 ±0.572	100
Length (mm)	33.1	36.8	34.5 ±0.866	55
Width (mm)	24.3	26.8	25.9 ±0.668	55
Shape index	72.8	76.3	74.8 ±0.955	55

Average dimensions of eggs were 34.5±0.866 x 25.9± 0.668mm and shape index 74.8± 0.955 (Table 3).

Table 1: Nest Site Characteristics of Little Bittern Wular Lake Kashmir

Vegetation Cover											**Location of Nest**				**Nest Dimensions**			
Type	Variety	No. of Nests			Density /m^2/100m^{2**}		Height of Vegetation(m)	Water Depth (m)			Distance to open Water (m)		Height of Nest (cm)		Diameter (cm)		Depth (cm)	
		No.	%	Total	Range Mean ± SD	Overall	Range Mean± SD	Range Mean±SD	Overall		Range Mean± SD	Overall	Range Mean ± SD	Overall	Range Mean±SD	Overall	Range Mean±SD	Overall
Reeds	*Saccharum spontaniu m*	21	23.34	**65.56**	53-65 58±13	**52.2± 4.2**	1.18-1.25 1.20±0.2	**1.4±0.26**	1.65-2.10 1.8 ±0.1**a**	**1.67±0.34**	15-45.8 28.5±10.2	**30.25±4.6**	12-14 13.0±0.8**a**	**14.8±1.9**	18 -21 19.7±1.2 **a**	**21.07±1.09**	1.2-2.8 2.06±0.6 **a**	**2.09±0.84**
	Typha angustata	15	16.67		41-57 50±7		1.00-1.35 1.22±0.1		1.75 - 2.50 2.0 ± 0.3a		18.5-40.4 30.6±11.5		12.3-13.6 13.5±0.6**a**		18.4 -25 22.1±2.8 **a**		1.0-2.9 2.0±0.8**a**	
	Sparganum ramosum	13	14.44		33-58 46.8± 9		1.39-1.69 1.5 ± 0.3		1.3 –1.95 1.7±0.4**a**		10.6-30.8 25.5±6.6		13.6-17.3 15.8±21.8 **a**		19 -24.5 21.4±0.9 **a**		1.1-3.0 2.2±0.9**a**	
	Phragmites communis	10	11.11		43-65 54±7		1.43-2.05 1.75± 0.4		1.05-1.4 1.2 ±0.2**a**		13.6-48.9 36.4±14.2		16 -18 17.2 ±1**a**		19.2- 2.3 21 ±1.2**a**		1.6-2.8 2.1±0.9**a**	
Willows	*Salix spp.*	31	34.44	**34.44**	13-35 25.5± 8	**25.5± 8**	2.42-7.76 4.7± 2.2	**4.7±2.22**	1.38-2.00 1.5±0.6**a**	**1.5±0.6**	15.3-50.6 33.5±15.6	**33.5± 15.6**	112 – 156 137±18.8 **b**	**137± 18.8**	15.3-17.6 16.3±1 **b**	**16.3± 1.0**	4.5-6.7 5.8±0.9 **b**	**5.8±0.9**

{(***In case of *Salix)* Comparison of nest heights, diameter and nest depths between nests in reeds and on willows using independent samples t test. Columns sharing same letters are not significantly different}

Table 4: Hatching, fledging and breeding success in little bittern

Year	No. of nests	No. of eggs	Hatching success		Fledging success		Breeding success
			No.	%	No.	%	%
2007	22	116	71	61.21	55	77.46	47.41
2008	28	137	101	73.72	89	88.12	64.96
2009	40	197	114	57.87	81	71.05	41.12
Total	90	450	286	63.55	225	78.67	50.00

The clutches were divided into early intermediate and late clutches on the basis of their laying sequence and dimensions of their eggs when compared showed that breadth and volume of eggs differed significantly between early, intermediate and late clutches (Breadth:$F_{2,99}$=22.698,P<0.001;Volume:$F_{2,99}$=8.806,P<0.05).However, the length remained the same (Table 6).

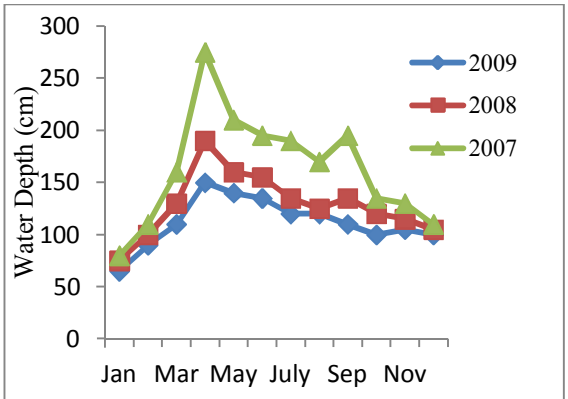

Figure 2. Monthly Fluctuation in Water Depth

3c. Incubation and Hatching

Both sexes incubated eggs. Incubation was initiated after the laying of first egg. It was irregular during laying but after completion of clutch the eggs were hardly left unattended (Figure7). Incubation period varied from 16-19 days. Of the 50 clutches studied for this purpose, incubation was completed in 16 days in 19, 17 days in 21, 18 days in 7 and 19 days in 3 nests (average 16.9 ± 0.86 days).On incubation there appeared an average weight loss of 16.67%.

Hatching was asynchronous as the eggs hatched in the order they were laid. Small cracks in the broader half near the pole with occasional audible piping sounds are the indications of hatching. Average hatching period was 1.5 ±0.4 days (range1-2 days). Egg shells were disposed by attending bird that dipped large pieces in water and consumed small ones. Hatching and hatching success showed both inter and intra-annual variation (Figure 5).70.6% hatching occurred between third week of June to second week of July (Figure 5). Hatching success varied from 57.87% to 73.72% with an overall hatching success of 63.55% (Table 4). Hatching success also varied in different habitats (Figure 6). It was 52.94% in willows and 69.02% in reeds. Over all egg survival during incubation was 0.61(Table 5). (Table 4). Breeding success calculated from exposure was 0.46 (Table 5).

3d. Chick Survival and Breeding Success

The freshly hatched precocial chicks weighed on an average 9.500 ±0.560g (range 8.460g – 10.980g).Their beaks and tarsi measured on an average 9mm (range 8mm – 10mm) and 10mm (range 9mm -11mm) respectively. They were delicate and could hardly hold their heads up for a few seconds. By the second day the chicks could move clumsily with wings as levers and support. They tried to peck their parents' beak to elicit regurgitation. Three days old chicks grasped parents' beak and the beak seizing became vigorous as they grew old.

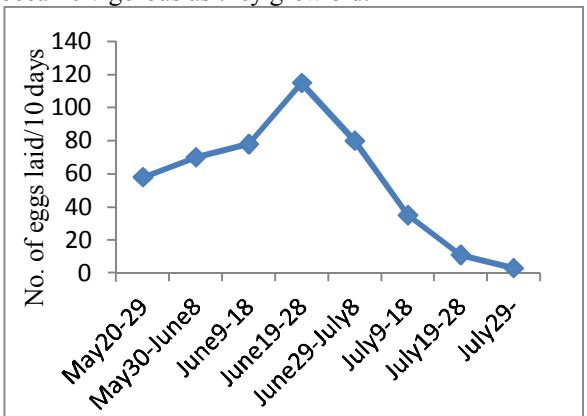

Figure4. Peak egg laying in little bittern

By the fifth day chicks wandered in the adjacent reeds. Chick mortality varied at different hatchling stages: 4.2% chicks (n=12) died within a day of their hatching perhaps because of congenital defects or reasons unknown; 6.29% chicks (n=18) died between the ages.

Table 5: Mayfield survival probability for different stages of little bittern

	Exposure Days	No.of eggs /nestlings	No.of eggs /nestlings failed	Daily survival	Success Rate
Incubation	5396	286	164	0.97	0.61
Nestling	4950	286	61	0.99	0.80
Breeding	10346	450	225	0.98	0.46

Table 6: Comparison of egg measurements between early, intermediate and late clutches using one way ANNOVA followed by post-hock Tuckey's test. Columns sharing the same letter are not significantly different.

	Length (mm) ±SD	Breadth (mm) ±SD	Volume (Cm^3) ±SD	Shape index ±SD
Early (n=25)	35.25 ±1.15 **a**	25.89 ±.68**a**	11.9 ± .99**a**	74.80 ±.98**a**
Intermediate(n=50)	34.911 ±.10**a**	25.63 ±.70**a**	11.7 **±1.**13**a**	73.90 ±.89**a**
Late(n=25)	35.030 ±.589**a**	24.77 .±36**b**	10.93 .± 42**b**	74.91± 1.87**a**
F	1.092	22.698	8.806	0.119
P	ns	<0.001	<0.01	Ns

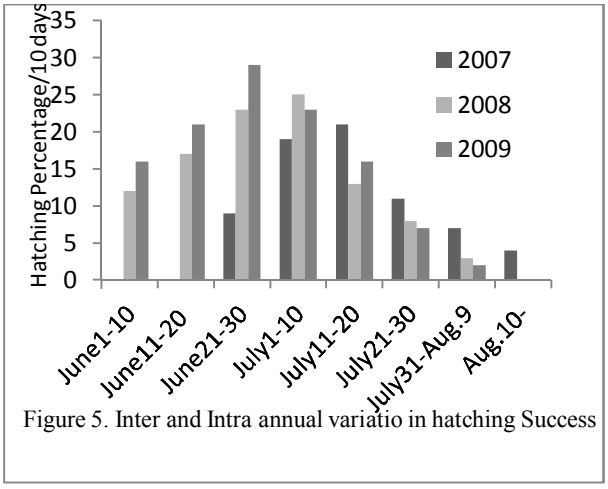

Figure 5. Inter and Intra annual variatio in hatching Success

4. Discussion

The size, structure, shape, and orientation of the nest site are important in providing shelter against adverse weather, particularly high winds, gales, and storms (Kim et al. 1998). A good nesting site generally provides protection against predators, offers adequate stability and materials to support and construct the nest, and is located near adequate feeding areas (Thompson 1977; Beaver *et al.* 1980; Hafner and Britton 1983; Gibbs *et al.* 1987;Hafner *et al.* 1987;Hafner and Fasola 1992). Lack of suitable nest sites may be a critical limiting factor in bird populations so first noticeable activity among bitterns after establishment of pair bonds was their engagement in selection of suitable nest sites that not only provided better concealment and support to the nests but also protection to their nestlings from predators. In many temperate species onset of breeding season depends largely on the availability of nest sites and most aquatic birds often breed in relation to water level and suitable nesting material (Frith and Davis 1958; Sudgen 1979 and Shah1984).Nesting habitat was so chosen by the bitterns that there was sufficient emergent vegetation to support the nest and provide efficient cover and protection and was restricted to reed marshes. Some preferred bushy willows for construction of their nests. As bitterns generally prefer reeds for the construction of their nests but willows were mostly used during non availability of suitable nesting sites due to heavy rains and lake inundations as during such conditions greatest percentage of nests was found on willows and there was a specific correlation between nest distribution in different habitats and water level. Many studies have reported similar nesting sites for the bitterns (Baker 1929; Bates and Lowther 1952; Hoeher 1972; Fazili *et al.* 2010).

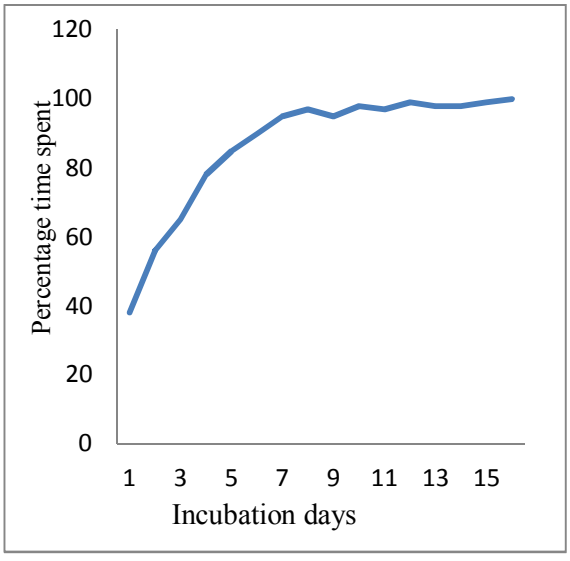

Figure 7. Time spent in egg incubation

During most vulnerable period in the life cycle, birds construct their nests to protect themselves, their eggs and particularly their developing young from predators and from adverse climatic conditions (Wetly 1979). Generally water birds resort to a great variety nesting sites; herons use large trees and make artificial platforms of twigs (Yoccum1952).American coots, gallinules and terns construct simple platforms composed of aquatic plants on floating vegetation above the shallow water (Shah 1984). In little bittern the nests located in the reeds were fairly substantial platforms of dead reed stems with slight depression and lined with finer stems of *Sparganium ramosum, Phragmitis communis* and *Typha angustata.* But in willows nests were made up of fine twigs and were with marked depression. These types of nests provided safe place for the eggs as strong winds could not disturb them and are being prevented from falling. Almost similar nest have been reported earlier in bitterns (Wackernagel 1950; Bates and Lowther 1952; Langley 1983 and Fazili *et al* 2010*).*

It is generally true that the clutch size of each bird species has been adapted by natural selection to correspond with the greatest number of young the parents can normally raise (Lack 1947-48). A marked variation in the clutch size of bitterns was observed. It varied from 3-7 eggs with an average of 5 eggs per clutch. Different workers have also reported different clutch size of little bittern. Oorte (1922) 7-8 eggs; Steinfatt (1935) 3-6 eggs; Gross Kopf and Graszynski (1958) 7-8 eggs; Witherby et.al (1937) 10 eggs; Bates and Lowther (1952) 7 eggs but 5 eggs the common clutch size Holmes (1983) 4-5 eggs and Fazili *et a*l (2010) 5.67. The variation could be due to variation in food supply, climatic conditions and variation in the age of the females that may have direct influence on the laying of these birds. Coulson and Horobin (1976) have reported lowest clutch size in the youngest and old aged arctic terns and maximum in 6 to 8 year old terns. The breadth and volume of eggs were smaller for late clutches. Egg volume is related to the Chicks' survival as larger eggs produce heavier chicks that survive better than their lighter siblings (Amat *et al.* 2001a).However, there are opposite selective forces that may counterbalance this tendency as clutch with large eggs may take longer to complete and this may be particularly important for species that experience heavy nest predation (Amat *et al*.1999,2001a). In birds, females apparently acquire nutrients and energy for egg laying just before or during egg laying (Erckmann 1983), so the conditions to which the females are exposed during this period may influence egg dimensions. This means that the food availability and female body condition (Amat *et al*. 2001b) may have decreased by the end of the season. The fact that egg dimensions were similar between willows and reeds suggest that these two types of habitats are similar in relation to food resources and quality of breeding females. The egg measurements obtained during this study for 55 eggs were 34.5±0.866 x 25.9±0.668 mm. Bates and Lowther (1952) have reported egg dimensions of 34.3 x 25.5 mm; Ali and Ripley 1983 gave measurements as34.1 x 26.0 mm and Baker (1929) as 34.0 x 26.0 mm while Cramp (1977) quoting Schonwetter (1967) gave 26 x 36 mm and Hoeher (1972) 34.7 x 26.5 mm; Fazili *et al (*2010) 34.3 x25.5mm; Langley (1983) as 34.6 x 36.6 mm for European race of little bittern *I. m. payesii*. This variation in the dimensions can be due to varied no. of eggs measured, age and health conditions of the gravid females, food availability, ecological and the climatic conditions prevailing in the study areas etc.

The incubation in little bittern started with the laying of first egg and both sexes took active part in the process. In European race of little bittern however, incubation started with the laying of first egg or second egg (Witherby et. al.1937).The period during which eggs were incubated varied from 16-19 days with an average of 16.9± 0.86 days. However, varied incubation periods have been reported earlier by different Workers for little bittern (18-19 days, Groebbels 1935; 19days, Wackernagel 1950; 16-17 days, Ali and Ripley 1983 and 16-18 days, Fazili *et al* 2010). This fluctuation in the incubation period can be attributed to varied climatic conditions prevailing in the corresponding years of study and in their respective study areas. During incubation there was loss of 16.67 % in egg weight of little bittern, due to evaporation. Irrespective of size, eggs generally lose 15-18% of their initial mass as water as incubation proceeds till hatching (Brown 1994).

Hatching was asynchronous as the eggs hatched in the order in which they were laid, because incubation started prior to completion of the clutch just after laying of first egg. Asynchronous hatching has been reported in a wide variety of birds (Clark and Wilson 1981; Slagsvold 1985; Nisbet 1973).In addition to increase the density (Hussell 1972; Clark and Wilson 1981) or quality of young raised (Lack 1954; Nisbet and Cohen 1975) asynchronous hatching seemed to be beneficial to the females as they could comfortably feed the asynchronous chicks and got full assistance from their males in raising their brood. The overall success of breeding was 50%.This low percentage of breeding was due to high effect of predators which was highest among the seven days or above aged chicks. This is the most vulnerable stage as at this stage the chicks are mostly attacked by avian predators like crows, kites and marsh harriers as they generally expose themselves to become visible

to parents to be fed. Bitterns bred in two types of habitats, the reeds and willows and fledging and breeding success showed great variation between them. No consistent differences in other breeding parameters between these two habitats were found. The characteristics of each site are presumably more important to explain the breeding and fledging success than habitat type. As for example the willows are less dense and are mostly used by the predators for nesting and roosting which may help them to easily locate their prey, their nests and nestlings.

5. Recommendations for conservation of bitterns and designing of management plans

In terms of conservation this study suggests that: Marshy Areas within and outside the lake be prevented from human encroachment as these areas provide additional breeding and feeding grounds to the bitterns and other aquatic bird species and should be given the status of wetlands. Certain barren areas be demarcated for human settlements and construction of multi-storied apartments be allowed so as to reduce anthropogenic pressures on the marshy areas.

Human activities like fishing, grass cutting, fodder collection be restricted: alternative methods such as fish forming, cultivation of fodder crops at large scale be introduced among fisher men and formers residing around the wetlands and necessary finances be provided to them to establish such private units.

Grazing within the wetland should be restricted and poaching completely banned: wetlands should be separated from the adjoining pastures by installing barriers such as steel barbed wiring or digging of deep gorges or furrows so as to keep the cattle off from entering the wetland areas. Manpower in the wildlife protection department should be increased to guard the wetlands and keep vigil on the poachers and hunters.

Water level be regulated: during low rainfall seasons there being every apprehension of drying of the wetland areas and low growth of reeds and other emergent vegetation and free access of predators like Dogs, Jackals, and Mongoose etc. This can be overcome by constructing barrages at the outlets so as to regulate water level. It will also help to maintain the fish and aquatic insect diversity that serve as food for the aquatic birds.

Installation of Barriers near the inlets: these barriers will help to stop the carcasses from flowing into the wetland areas and help to keep the predators especially carnivores like dogs and jackals away.

Egg collection be completely banned: people living near the wetlands should be educated about the consequences of this activity by holding awareness programmes like film shows, TV programmes, Radio talks, Cultural programmes, etc. Alternative methods to overcome protein deficiency be devised like poultry forming, fish culture, Aviculture and low interest loans be provided to initiate these activities.

Plantation drives restricted to the margins/edges of the wetland: Plantation should be appreciated but the people and government agencies should be advised to plant at the outskirts of wetlands as within the wetland premises this activity encourages siltation and attracts the avian predators by providing them nesting and roosting grounds.

6. Conclusion

Little bittern a common summer visitor to the wetlands of Kashmir initiate their breeding from late April and complete by August. During this period they raise a single generation and leave back to the plains of India in October. Reeds were found the most preferred sites for nesting except during lake inundation. Both the sexes actively participated in breeding activity right from nest building to the raising of young ones. Eggs and chicks suffer heavy damage not only from mammalian predators but also from avian predators. Anthropogenic activities such as fodder collection and fishing disturb and harm this bird population the most. Recommendations for their conservation and planning of management policies need to be taken care of by giving due consideration on priority.

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