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Breeding Behaviour of Black-Winged Stilt, *Himantopus himantopus* (Linnaeus, 1758) in Agricultural Landscape of Punjab, India

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Abstract: During the breeding seasons (2017-2019), the hitherto little known aspects of breeding behavior of Black-winged Stilt, *Himantopus himantopus* were studied in the ploughed agricultural fields, village ponds and adjacent shallow pools located in rural outskirts in district Ludhiana, Punjab, India. Observations on nest structure, egg laying, incubation, hatching and other behavioural aspects of the parents/chicks were inferred from video-records, photographs and direct field observations made on 19 clutches containing 59 eggs. In the study area the breeding season extended from April to July. The mean clutch size was 3.29 ± 0.77 (range 1-4, n=19) that differed between the dry ploughed field clutches (3.4 ± 0.70 , range: 2-4, n=10) and wet pool/pond sites (2.78 ± 1.09 , range: 1-4, n=9). In the dry ploughed fields, the nest scrapes were lined mainly with the wheat rootlets/ straw pieces only. However, the nest material used in/around ponds and pools included predominantly dry twigs, decaying leaves and some thermocol chips. The egg length, breadth, weight, egg shape index and volume (n=54) measured 42.22 ± 2.50 mm, 30.71 ± 1.13 mm, 19.77 ± 2.34 gm, 72.88 ± 3.19 and 20.39 ± 2.36 cm³, respectively. The eggs hatched mostly synchronously after biparental incubation period of 25 or 26 days (n=4). As per traditional method, only 20.34% (12 out of 59 eggs) of the eggs hatched successfully and the hatching success calculated as per the Mayfield Method showed that it was only 2.07% in post-harvest field sites and 36.26% in non-agricultural sites (shallow water pools and edge waters of village ponds). The use of polluted sites as nesting grounds has been opined as a habitat shift and an adaptation in process.

Keywords: Black-winged Stilt, Breeding behavior, Egg parameters, Habitat, Incubation, Hatching

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Introduction

The Black-winged Stilt (BWS) *Himantopus himantopus* (Linnaeus), belongs to the Family Recurvirostridae, is a wading bird with straight

slender black bill, pointed black wings, and very long thin reddish legs (Ali and Ripley, 1987). Grimmett and Inskipp (2010) has considered it as

a not common winter visitor in Punjab, whereas, Arlott (2014) mentioned it as a resident bird in North-West and winter visitor elsewhere in India. It mainly affects marshes, jheels, village tanks, irrigation reservoirs, lagoons, salt pans and sometimes inundated ploughed fields (Ali and Ripley, 1987; Kazmierczak, 2000). The perusal of the relevant literature reveals that some aspects of breeding biology of BWS have been studied in Italy (Tinarelli, 1991), South-western Spain (Cuervo, 2003), Sahara Desert (Adamou *et al.*, 2009), Northern Iran (Ashoori, 2011), South-west Spain (Toral and Figuerola, 2012), Western Iran (Barati *et al.* 2014), Hungary (Pigniczki *et al.*, 2019) and Senegal in West Africa (Diallo *et al.*, 2019). The pioneer works (Whistler, 1941; Ali and Ripley, 1987) presented brief morpho-ecological notes on BWS from the Indian region. However, barring a few short communications documenting nesting record from Kumarakom in Kerala (Narayanan *et al.*, 2005) and plumage variations from Dwarka in Gujarat (Parasharya *et al.*, 2010), hardly any data is available on breeding behavior of BWS from India.

The information on the breeding behavior of birds is vital for improving and enriching information content about avian life-history theory and also for planning effective management and conservation strategies (Maurício *et al.*, 2013). The bird life history strategies generally vary among different habitats and the information on the critical nesting parameters (clutch size, incubation period and nestling period) is available only for one third of the all extant species of birds world over (Xiao *et al.*, 2017). Punjab is primarily an agrarian state with only 5.20 per cent area under forest cover (Grover *et al.*, 2017). During the past half a century, the local environment and agricultural land use pattern in Punjab have undergone a huge change due to intensification of agricultural practices, urbanization and other anthropogenic factors. Intensive agriculture has caused changes in the abundance and distribution of many avian species in Punjab (Kler, 2009; Kler and Kumar, 2012). The BWS is a biomonitor species for habitat

health (Tavares *et al.*, 2004) and may be a good wader species for studying breeding adaptations (Del Hoyo *et al.*, 1996). It feeds on invertebrates, mainly aquatic insects and their larvae (including Coleoptera, Trichoptera, Hemiptera, Odonata and Diptera), spiders, crustaceans, molluscs, worms, amphibian tadpoles and eggs, small fish and rarely some plant materials (Cramp and Simmons 1983; Dostine and Morton, 1989; Ueng *et al.*, 2009). In the agroecosystem of Punjab, despite being a component of bird assemblage associated with the agricultural fields and village ponds, there do not appear any previous studies on its status, clutch-size, egg characteristics, nesting habitats, hatching success and factors influencing breeding success in different habitats from the region.

Materials and Methods

The present study was attempted during three consecutive breeding seasons (2017-2019) in the rural and semi-urban outskirts of Khanna city in Punjab. Early in each season, regular field visits were undertaken and all the nests in the post-harvest agricultural fields (10 clutches/34 eggs) and pond/pool peripheries (9 clutches/25 eggs) were located following the behavioral clues of BWS breeding pairs. As the nests are never left unattended during mid-day hours, mid-day visits were conducted to mark the tentative location of nests that was confirmed in the following evenings. As per field requirements, the location of some nests were marked (Zámečník *et al.*, 2017) by placing some distinctive mud-lumps (in agricultural fields) and small twigs (muddy pool sites) at an indicative distance so that the nests were easily relocated during subsequent field visits. Of the 19 nests monitored during the present study, 10 nests were found during egg laying period and 09 nests after completion of egg laying. Regular visits were conducted twice a day in morning and evening, and from an appropriate vantage points, field observations on adult and chick behavior were also made using Olympus 10X50 DPS Binoculars. Field photography was done using a Sony A-77 DSLR camera fitted with Tamron 70-300 mm telephoto lens. Except for a

single egg and nest data collection visit that lasted for about 3 min, we quickly took a distant glance of the nest for few seconds during subsequent field visits, making our visits oblivious to the birds and care was taken not to disturb the bird/chicks in the nest (Phillips *et al.*, 2007). In this study, the breeding pairs were not captured and marked and the sexes were identified by the sexually dimorphic plumage coloration of the back and wings being black in males and brown in females (Grewal *et al.*, 2011; Vyas, 2015). A clutch containing three eggs (N1, Table 1) laid in edge waters of the village pond, Salaudi (Latitude: 30°45'28.39" N and Longitude: 76°14'11.93" E) was observed as a focal nest for making behavioural observations.

Nest and egg parameters were measured with SF-400C Digital Weighing Scale (Least Count 0.01 mg), Digital Vernier Caliper (Range 01-15 cm, Least Count 0.01 mm), a 12" ruler and a 50 m Open Reel Measuring Tape. Eggs Weight (W) was done to the nearest 0.01 g after completion of the clutch and Egg Volume (V) was determined using the equation $V=[0.51] \times [LB^2]$ given by Hoyt (1979). Egg Shape Index [ESI= (B/L) x100] was determined as per Stadelman and Cotterill (1995). Nest locations were recorded by a Global Positioning System of the camera. In the present study, Incubation Period (I.P) was taken as the number of days between laying to hatching of the last egg in a clutch (Kendeigh, 1963; Wesley, 2004; Wickramasinghe *et al.*, 2019). We defined the Egg Laying Period and Hatching Period as the number of successive days for completion of respective event. Details about nest building, incubation, hatching and other behavioural activities of the parents/chicks were inferred from video-records, photographs and direct observations. A nest was considered as a failure if it was found empty before the expected hatching or was damaged due to human activities or predation. Hatching success was estimated using traditional method (% age of eggs that hatched successfully out of the total eggs) and the Mayfield Method (Mayfield, 1975).

Results

Nest Sites and Nest Building:

The various nesting grounds of the BWS sites recorded during the present study (2017-2019) included the ploughed agricultural field, shallow water pools near village ponds, polluted ponds with dense growth of Water Hyacinth, and edge waters/ soil mounds in the village ponds (Fig. 1). A total of 19 nests (10 nests in ploughed fields, 7 nests in temporary water pools, 1 nest each in edge waters and interior mound in pond) were examined for documenting information about various nest parameters.

Except for one solitary nest made each in the edge water of pond, soil mound in the interior of pond and the ploughed fields, all other nests were colonial in nature. However, in both types of nesting grounds, the BWS pairs shared the grounds with Red-wattled Lapwing pairs.

The breeding pairs were sighted active at the nesting sites about a week before the nests were actually spotted. During nest building period, the males were observed more frequently and actively contributing material at the nesting site. The solitary nests in the shallow edge waters of the ponds were made on floating garbage items dumped in the pond periphery, near the domestic sewage discharge points (Fig. 1C). This polluted area served both as the nesting site as well as the feeding site.

The BWS breeding pairs did not conduct any specific sorties for collection of nest material. Depending upon the type of nesting ground, the pair used the material available in immediate surroundings of the nesting site. In the dry ploughed fields, the nest scrapes were lined mainly with the wheat rootlets and straw pieces (Fig. 2A) only and in one of these nests, some small mollusk shells were also placed. The nest material used in/around ponds and pools included predominantly dry twigs, decaying leaves and some thermocol chips. Components used in nest structure probably depend mainly on the features of the nesting ground and the availability



A: Temporary Shallow Pools near Ponds



B: Ploughed Fields



C: Floating Platforms in Pond Edges



D: Soil Mounds in the Ponds



E: Hyacinth Growth over Polluted Ponds



F: Grassy Waste Water Grounds

Fig. 1: Nesting Sites of Black-winged Stilt.

of different types of nesting material (Cuervo 2004; Barati *et al.*, 2012). No subsequent addition of the nest material was noticed during the incubation period, rather the nest boundary became a bit more disorganized with advancement of the incubation period. No perching sites for other birds were available in the surroundings of the nests placed in the dry ploughed fields. However, this threat was there for the nests located in/near the pools and ponds. The electric power supply line and the trees near these nesting sites served as a perch site for other birds especially the House Crows who were seen robbing the nests of Common Moorhen in the same area. The other threat was from the stray dogs and the cattle occasionally visiting the pond periphery. Owing to protective colouration and markings, all clutches were more or less concealed against the general surroundings. The nests were placed higher above water level on the exposed mud mounds in the pools.

Depending upon the location of the nest the scrape parameters like external diameter, internal diameter and depth are not always well defined in all the nests. In comparison to the nests made in/near the pools and ponds, the nests scrapes in the ploughed fields are located in between the soil boulders of varying size, and hence the nest parameters cannot be appropriately quantified in most of the cases. The approximate mean outer diameter of the nest scrape measured 14.93 ± 3.1 cm (range 10.5 - 20 cm, n=7) and the mean inner diameter was 11.2 ± 1.10 cm (range 10 - 13 cm, n=5). The mean depth of scrape was 2.84 ± 0.97 cm (range 1.5 - 4.6 cm, n=7). The colonial nesting included 4 nests of BWS and 1 nest of Red-wattled Lapwing in ploughed field, Rahoun (N6-N9, 2017); 4 nests of BWS and 1 nest of Red-wattled Lapwing in ploughed field, Lalheri (N11-N14, 2017); 3 nests of BWS in temporary muddy pool adjoining village pond, Rahoun (N3-N5, 2017) and 4 nests of BWS in temporary muddy pool adjoining village pond, Rahoun (N15-N18, 2018). There were 2 nests of Red-wattled Lapwing (70 m apart) at a distance of 30 m from the solitary nest of BWS in the ploughed field village Rahoun (N19, 2019). In the

ploughed fields, the distance between two adjacent BWS nests ranged from 10-35 m.

Egg Laying and Morphometric Measurements:

The breeding season of BWS extended from April to July and in the breeding seasons 2017 - 2019, a total of 19 clutches/59 eggs (Tables 1, 2) were monitored for making observations on egg laying and determination of egg morpho-metric data. In the nesting grounds, the pairs were seen engaged in mating in the evening hours (n=2). There were four eggs each in eight clutches (42.16%), 3 eggs each in six clutches (31.58%), two eggs each in four clutches (21.05%) and one egg in single clutch (5.26%). The mean clutch size was 3.29 ± 0.77 (range 1-4, n=19) and it differed between the dry ploughed field clutches (3.4 ± 0.70 , range: 2-4, n=10) and wet pool/pond sites (2.78 ± 1.09 , range: 1-4, n=9). These clutches were more concealed in the surroundings as seen from above. Although, the clutches were found at different stages of egg-laying, all subsequent eggs were laid one per day on successive days.

Except for a single variation in a four egg clutch (N1, Fig. 2B), the eggs were mostly pyriform, non-glossy olive green and marked with irregular sized brownish black blotches. In some of the clutches laid in muddy pools, the eggs were coated with mud-water, making them more concealed in the muddy surroundings. The mean egg shape index (ESI) measured 72.88 ± 3.19 (range 65.96-78.66). In the nest scrapes, the eggs were generally placed with narrower ends pointing towards the centre of the scrape. The mean egg length (L) and breadth (B) measured 42.22 ± 2.50 mm (range 35.43-47.69 mm, n=54) and 30.71 ± 1.13 mm (range 27.45-31.15 mm, n=54), respectively. The mean values of egg weight (W) and egg volume (V) were 19.77 ± 2.34 g (range 13.55-23.72 g, n=54) and 20.39 ± 2.36 cm³ (range 13.62-23.74 cm³, n=54), respectively. The comparison of the egg parameters viz. maximum length (L), maximum breadth (B), fresh weight (W) and Volume (V) showed that the mean values for these parameters (Tables 1, 2) are relatively

higher in case of eggs laid in wet nesting grounds than those laid in the dry ploughed fields.

Incubation and Hatching:

Both the members of the breeding pair were easily distinguishable on basis of the plumage difference. The incubation was biparental and largely synchronous. During the egg laying period, the parents were seen attempting incubation intermittently. However, the full incubation (Wang and Beissinger, 2011) started with completion of the clutch. For the four successful clutches (Table 1), the incubation period was recorded 25 days (n=2) and 26 days (n=2). As per the diurnal observations made during the full incubation days, the BWS pair followed long attentive periods (in the nest) and much shorter inattentive periods (off the nest). While one of the parents was incubating the eggs, the other one was there nearby, feeding and actively guarding the nesting area against any intrusion. Participation of the female parent in incubation was more pronounced in the first half of the day whereas in the second half male parent was more frequently observed in the nest. Further, the incubation shift changeovers were very quick, lasting for few seconds only and the eggs were not left unattended during day time. In the early morning hours, both the parents were seen feeding in close vicinity of the nest and hence they maintained a regular watch and guard around the nest even during these 'off the nest' periods when none of them was in the nest. It was interesting to record that there were several individuals of Common Moorhen, White-breasted Waterhen, Indian Spot-billed Duck, Common Teal and Little Grebe in the pond periphery. But none of them ever interfered in the incubation and feeding activity of the BWS pair. After facing a partial loss or robbery of an egg from the complete clutch, the BWS pair did not desert the nest, rather continued the incubation and also restored the deformed edges of the nest. The incubating parent was seen performing gular fluttering during the mid-day heat. The BWS pairs aggressively responded to any intrusion by humans and egg robbing raids by the House Crows. They were seen

aggressively calling and chasing away the crows from the nesting territory and distracting the humans, stray dogs and cattle through display of broken wing behavior and displacement brooding (Fig. 2D). In case of colonial nests, the group of breeding pairs together defended the nesting area against any intrusion. Availability of the food in the immediate surroundings of the nest helps in maintaining a strict vigil around the nest. No courtship feeding was noticed in the breeding pairs.

Amongst the successful clutches, synchronous hatching (Clark and Wilson, 1981; Podulka *et al.*, 2004) occurred in a single day in 2 clutches containing 2 eggs each and in two successive days (within 24 h) in 2 clutches containing 3 or 4 eggs (Table 2). The parents never left the nest unattended during the process of hatching. The pieces of empty egg shells were immediately picked up and thrown away from the nest by the parents. This behavior is similar to that observed in other studies on BWS (Sordahl, 1994; Ashoori, 2011), Red-wattled Lapwing (Kumar *et al.*, 2020a), Purple Sunbird (Kumar *et al.*, 2020b) and Brown-backed Indian Robin (Kumar *et al.*, 2021). This behavioural response displayed by the parents is induced by the presence of the egg shell in the nest (Nethersole-Thompson and Nethersole-Thompson, 1942). Tinbergen *et al.* (1962) conducted an experimental study on Black-headed Gulls and concluded that the most likely function of this behavior seemed to be the maintenance of the camouflage of the brood. The newly hatched chicks were precocial with fully opened eyes. Head and trunk were tinged brownish above with darker irregular spots and under surface of body was mostly white. This sort of plumage provided a cryptic pattern to the body against the general surroundings. They left the nest soon after hatching and were seen scanning and pecking on ground searching food in close vicinity of the nest. The adjacent short grass and bushes provided a safe environment for the chicks. The chicks responded quickly to the alarm calls given by the parents. On approach of an observer or disturbance near the pond edge, the parents while

flying low produced the calls and the chicks either crouched (Fig. 2F) and remained still in grass or under bushes, or ran fast for cover in vegetation. In this defensive behavior the male BWS was seen playing a dominant role. When the threat was over, the parent used to sit at the edge of the pond and lower its body by bending the knees. The chick/s then emerged out from hiding, came near the parent and was covered under the partly spread wings. The chicks were observed trying to climb up under the parent's wings with its legs hanging in air (Fig. 2E). After completion of hatching, within hours the entire family moved away from the nesting site.

Hatching Success and Habitats:

During the present study, out of a total of 19 clutches containing 59 eggs, 15 clutches containing 47 eggs were entirely lost during the incubation period. This included all the ten clutches containing 34 eggs laid in the ploughed fields. A single egg was lost from another successful clutch of three eggs laid in the pond edge (Table 1, N1). As per traditional method, only 20.34% (12 out of 59 eggs) of the eggs hatched successfully and this proportion is attributed to the clutches laid in/near the shallow pools and pond waters. As per the Mayfield Method, the estimated mortality for incubation period of BWS in present study was 0.075 (15 failures/199 nest days) failures per nest day. The probability of survival was 0.925 (1.0 - 0.075) per nest day. Conclusively, the probability of survival of a nest after an incubation period of 25.5 days was 0.1369 ($0.925^{25.5}$) indicating a hatching success of 13.69%. The hatching success calculated as per the Mayfield Method (Table 3) showed that it was only 2.07% in post-harvest field sites and 36.26% in non-agricultural sites (shallow water pools and edge waters of village ponds).

In the ploughed fields, the major reason for clutch loss was the preparation of fields for plantation of next crop mainly rice that run concurrently with the breeding season of BWS during the months of May to July. Just like the Red-wattled Lapwings, the BWS breeding pairs laid

clutches in the post-harvest wheat fields preferring them as favourable nesting grounds. However, the fields are left vacant only for 2-3 weeks after harvesting the wheat crop in April and then begins the paddy cultivation operations that continue till July. Hence, the clutches laid in agricultural fields were/are lost due to repeated ploughing and flooding of fields for rice cultivation. In the non-agricultural nesting grounds, the clutch loss occurred mainly due to trampling by cattle and predation by unknown predators. The BWS pairs were commonly seen chasing away the House Crows and mobbing the stray dogs frequenting the pools and ponds.

Discussion

For want of regional studies on BWS, its status in Punjab has been differently indicated in the available sources. It is a resident bird, breeding in suitable localities and migrating locally under stress of water conditions, throughout Indian Union, both Pakistan and Nepal (Ali and Ripley, 1987; Kazmierczak, 2000). Grimmett and Inskipp (2010) considered it as a not common winter visitor in Punjab. Although mentioned as a resident bird in North-West and winter visitor elsewhere in India, the distribution map given by Arlott (2014) also indicates it largely as a winter visitor in Punjab. In the present study, it has been noticed in higher number in winter season but its presence and breeding in the summer and monsoon months confirmed its status as a resident throughout the year.

The egg-laying period of BWS in the study area extended relatively late (3rd April to 5th July) in comparison to the period of 16th May to 8th June in Western Iran (Barati *et al.*, 2012), March to May for most Western Palearctic colonies (Snow and Perrins, 1998) and 2nd April to 30th May in Algeria (Adamou *et al.*, 2009). Narayanan *et al.* (2005) also found its active nests on 3rd July in Kumarakom, Kerala. The overall nesting season extends from April to August in India (Ali, 2012), a relatively longer period than May and June in Southwestern Spain (Cuervo, 2003, 2005), late April to early July in Northern Iran (Ashoori,



A: Nest in a Ploughed Field



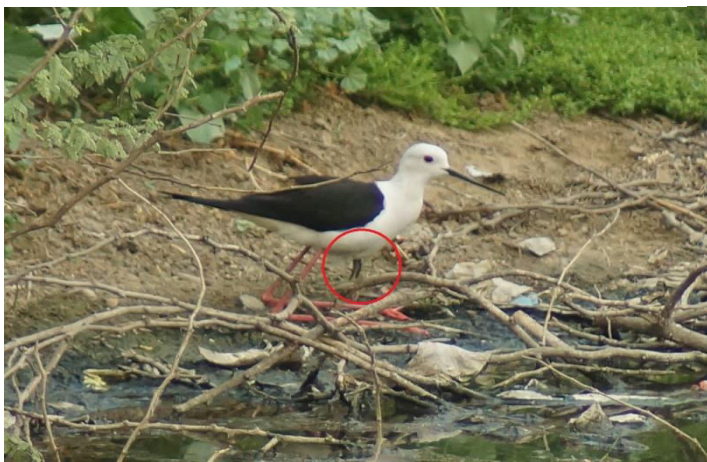
B: Variation in Egg Shape



C: Incubation by Male



D: Displacement Brooding Behaviour



E: Protection of Chick under Wings



F: Crouching behavior of Chick

Fig. 2: Eggs, Incubation and Protection in Black-winged Stilt.

Table 1: Data of Black-winged Stilt Clutches laid in Periphery of Village Ponds (2017-2019)

Nest No.	Nesting Site	Location Latitude & Longitude	Egg No./Chick	Laid on	Found On	L (mm)	B (mm)	W (g)	ESI (B/L)x100	Volume (0.51xLB ²) (cm ³)	Hatched on	IP (Days)
1.	Marshy Edge of Pond, Village: Salaudi	30°44'50.87" N 76°13'9.54" E	E-1	-	03.04.17	Egg measurements intentionally not recorded to avoid any damage to the nest placed on a floating platform in the marshy edge of the pond				One egg lost on 08.04.17 29.04.17 29.04.17		25
			E-2	-	03.04.17							
			E-3	04.04.17	-							
3.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'36.46" N 76°13'14.65" E	E-1	-	03.06.17	40.16	30.05	18.49	74.83	18.49	30.06.17	26
			E-2	-	03.06.17	41.86	29.94	18.04	71.52	19.14	30.06.17	
			E-3	04.06.17	-	40.19	28.31	16.01	70.44	16.43	30.07.17	
			E-4	-	05.06.17	38.97	27.65	14.80	70.95	15.19	01.07.17	
4.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'35.39" N 76°13'16.66" E	E-1	-	05.06.17	42.78	32.24	21.80	75.36	22.68	Clutch Lost after 06 days on 12.06.17 due to trampling by cattle	--
			E-2	-	05.06.17	44.15	32.41	22.94	73.41	23.65		
			E-3	-	05.06.17	43.81	30.84	21.05	70.39	21.25		
			E-4	06.06.17	-	42.13	31.45	21.18	74.65	21.25		
5.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'35.84" N 76°13'15.28" E	E-1	-	05.06.17	38.96	29.23	15.54	75.03	16.98	Clutch Lost after 3 days on 08.06.17 due to reasons unknown	-
			E-2	-	05.06.17	39.85	29.12	16.01	73.07	17.23		
10.	Grassy Mound in Pond, Village: Lalheri	30°43'11.82" N 76°14'51.25" E	E-1	-	26.06.17	Egg measurements intentionally not recorded to avoid any damage to the nest placed on an insecure mound in the pond				Clutch Lost after 04 days on 30.06.17 due to reasons unknown		-
			E-2	-	26.06.17							
15.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'35.70" N 76°13'16.68" E	E-1	13.06.18	-	41.33	29.96	17.24	72.49	18.92	09.07.18	25
			E-2	14.06.18	-	43.71	31.18	20.00	71.33	21.67	09.07.18	
16.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'36.21" N 76°13'21.24" E	E-1	-	14.06.18	40.72	29.58	17.76	72.64	18.17	10.07.18	26
			E-2	-	14.06.18	42.69	29.83	18.98	69.88	19.37	10.07.18	
			E-3	15.06.18	-	41.14	30.22	19.24	73.46	19.16	11.07.18	
17.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'36.21" N 76°13'21.24" E	E-1	-	14.06.18	44.34	30.32	18.95	68.38	20.79	Clutch Lost after 05 days on 21.06.18 due to trampling by cattle	
			E-2	-	14.06.18	37.64	29.13	16.45	77.39	16.29		
			E-3	15.06.18	-	39.60	29.94	17.96	75.61	18.10		
			E-4	16.06.18	-	35.43	27.45	13.55	77.48	13.62		
18.	Temporary Pool in Pond Periphery, Village: Rahoun	30°43'35.14" N 76°13'16.43" E	E-1	-	14.06.18	43.76	32.40	23.72	74.04	23.43	Lost on 15.06.18 due to predation by a crow	-
Mean Value of Egg Parameters of 7 Clutches comprising 20 Eggs						41.16±2.37	30.06±1.42	18.49±2.72	73.12±2.48	19.09±2.73		

Table 2: Data of Black-winged Stilt Clutches laid in Agricultural Fields (2017-2019)

Nest No.	Nesting Site	Location Latitude & Longitude	Egg No.	Laid on	Found on	L (mm)	B (mm)	W (g)	ESI (B/L)x100	Volume (0.51xLB ²) (cm ³)	Fate of Clutches
2.	Ploughed Field, Village: She	30°45'28.39" N 76°14'11.93" E	E-1	-	14.05.17	36.78	28.93	16.26	78.66	15.70	Clutch Lost after 05 days on 19.05.17 due to field ploughing
			E-2	-	14.05.17	41.85	30.72	20.44	73.41	20.14	
			E-3	-	14.05.17	40.59	30.28	19.03	74.60	18.98	
6.	Ploughed Field, Village: Rahoun	30°43'47.29" N 76°13'18.15" E	E-1	-	05.06.17	42.06	31.11	21.38	73.97	20.76	Lost on 08.06.17
			E-2	-	05.06.17	44.41	31.91	23.27	71.85	23.06	Lost on 12.06.17 due to predation by crows
			E-3	06.06.17		44.12	31.44	22.52	71.26	22.24	
			E-4	07.06.17		45.47	29.99	22.91	65.96	20.86	
7.	Ploughed Field, Village: Rahoun	30°43'47.41" N 76°13'16.65" E	E-1		05.06.17	42.64	31.28	21.06	73.36	21.28	Clutches Lost after 07 days on 13.05.17 due to field ploughing
			E-2		05.06.17	41.06	30.94	20.32	75.35	20.05	
			E-3	06.06.17	-	41.44	30.88	20.07	74.52	20.15	
8.	Ploughed Field, Village: Rahoun	30°43'46.79" N 76°13'15.77" E	E-1	-	05.06.17	43.46	31.81	22.78	73.19	22.43	
			E-2	-	05.06.17	42.44	31.96	22.07	75.31	22.11	
			E-3	-	05.06.17	42.51	30.86	20.85	72.59	20.65	
9.	Ploughed Field, Village: Rahoun	30°43'46.62" N 76°13'16.56" E	E-1	-	06.06.17	43.75	30.67	20.88	70.10	20.99	
			E-2	-	06.06.17	44.05	30.51	20.75	69.26	20.91	
11.	Ploughed Field, Village: Lalheri	30°43'47.02" N 76°14'27.97" E	E-1	-	04.07.17	47.69	31.06	22.24	65.13	23.46	Clutches Lost after 04 days on 11.07.17 due to flooding of the field for rice cultivation
			E-2	05.07.17	-	46.99	31.29	21.59	66.59	23.46	
			E-3	06.07.17	-	46.21	31.16	19.64	67.43	22.88	
			E-4	07.07.17	-	47.04	31.46	22.11	66.88	23.74	

12.	Ploughed Field, Village: Lalheri	30°43'47.21" N 76°14'27.71" E	E-1	-	04.07.17	42.85	32.36	22.10	75.52	22.88	Clutches Lost after 06 days on 11.07.17 due to flooding of the field for rice cultivation
			E-2	-	04.07.17	40.53	30.86	18.62	76.14	19.69	
			E-3	-	04.07.17	42.52	32.58	22.32	76.62	23.02	
			E-4	05.07.17	-	42.88	32.10	21.74	74.86	22.53	
13.	Ploughed Field, Village: Lalheri	30°43'48.32" N 76°14'27.63" E	E-1	-	04.07.17	41.07	30.73	18.47	74.82	19.78	Clutches Lost after 07 days on 11.07.17 due to flooding of the field for rice cultivation
			E-2	-	04.07.17	41.35	30.81	18.92	74.51	20.02	
			E-3	-	04.07.17	39.05	30.51	17.78	78.13	18.54	
14.	Ploughed Field, Village: Lalheri	30°43'46.81" N 76°14'29.21" E	E-1		04.07.17	40.44	31.03	18.54	76.73	19.86	Clutches Lost after 07 days on 11.07.17 due to flooding of the field for rice cultivation
			E-2	-	04.07.17	41.60	30.78	18.89	73.99	20.10	
			E-3	-	04.07.17	40.56	30.53	18.23	75.27	19.28	
			E-4		04.07.17	41.08	30.96	18.66	75.37	20.08	
19.	Ploughed Field, Village: Rahoun	30°44'17.57" N 76°13'38.82" E	E-1	-	14.06.19	45.42	31.42	21.25	69.18	22.87	Clutch Lost after 05 days on 21.06.19 due to flooding of the field for rice cultivation
			E-2	-	14.06.19	44.46	31.44	21.58	70.72	22.41	
			E-3	15.06.19	-	43.54	31.59	20.61	72.55	22.16	
			E-4	16.06.19	-	44.97	31.15	20.16	69.27	22.25	
Mean Value of Egg Parameters of 10 Clutches comprising 34 Eggs						42.85±2.38	31.09±0.70	20.53±1.71	72.74±3.56	21.16±1.75	

Type of Nesting Site	No. of Clutches/Eggs laid	No. of Nest Failures/Nesting Days	No. of Successful Clutches/Eggs	Hatching Success (%)	
				Mayfield Method	Traditional Method
Post-Harvest Field Sites	10/34	10/71	nil	2.07	nil
Pools and Pond Edge Sites	9/25	05/128	04/12	36.26	48
Total	19/59	15/199	04/12	13.69	20.34

2011) and April to June in Senegal, West Africa (Diallo *et al.*, 2019).

In the order Charadriiformes, the number of eggs in a clutch is known to show little variation and many species have constant clutch size of 4 eggs (Arnold, 1999; Maclean, 1972). As reported in other studies on BWS (Cramp and Simmons 1983; Cuervo, 2005; Adamou *et al.*, 2009; Ashoori, 2011; Barati *et al.*, 2012; Pigniczki *et al.*, 2019), four eggs was the dominant clutch size (42.16%) in the present study. The higher frequency of clutches containing four eggs is probably due to good food supply and high quality habitat (Ashoori, 2011). The mean egg length (L) × breadth (B) values of 42.22±2.50 mm × 30.71±1.13 mm recorded during the present study are lower than the corresponding average values of these parameters reported in other studies 43.80±0.06 mm × 31.10±0.05 mm in Sahara Desert (Adamou *et al.*, 2009) and 43.97±1.72 mm × 31.06±0.79 mm in Western Iran (Barati *et al.*, 2012). The egg parameters viz., maximum length (L), maximum breadth (B), fresh weight (W) and Volume (V) are relatively higher in case of eggs laid in wet nesting grounds than those laid in the ploughed post-harvest fields (Tables 1, 2). In some birds the egg size may be affected by the habitat quality and food supply (Christians, 2002) and the female birds may lay larger eggs when foraging conditions or food sources are good (Colwell, 2010). The BWS feed on invertebrates, mainly aquatic insects and their larvae, spiders, crustaceans, molluscs, worms, amphibian tadpoles

and eggs, small fish and rarely some plant materials (Cramp and Simmons 1983). Further, the feeding conditions are strongly influenced by the hydrological conditions in the habitat (Adamou *et al.*, 2009; Barati *et al.*, 2012). Ploughed fields can provide a rich source of invertebrates exposed at the soil surface (Wilson *et al.*, 1996). The study predicts that the post-harvest ploughed fields initially served as more open, safe and food-rich nesting grounds for the BWS pairs and this accounted for the better egg parameters.

In the present study from agricultural landscape in Punjab, the incubation period was 25-26 days (n=4) and is in broad concordance with 22 to 26 days for Senegal populations in West Africa (Diallo *et al.*, 2019) and 24-26 days in Northern Iran (Ashoori, 2011). The clutches laid in the ploughed fields were relatively safe from intruders like the humans, stray dogs and cattle, whereas, those laid in/near the village ponds were more vulnerable to these factors. All clutches laid in ploughed fields were primarily lost before the completion of incubation period due to flooding and reploughing of the fields for rice cultivation. This resulted in a poor hatching success of only 20.34% (12 out of 59 eggs) of the eggs. Despite serving an important ecological role for migratory and resident water birds, the village ponds do not benefit from any arrangements for their conservation and protection. The village ponds are mainly threatened by pollution due to domestic sewage, lack of fresh water recharge, reducing

depth due to non-removal of silt and a general neglect on part of the local community (Toor *et al.*, 2011). Most of the village ponds are shrinking due to encroachment by the local community. All these aspects warrant a serious attention, monitoring and habitat rehabilitation efforts to enhance the breeding success of BWS and other water birds.

As per the available information for the Indian region, the preferred habitat sites of BWS include marshes, jheels, village tanks, irrigation reservoirs, lagoons, salt pans and sometimes inundated ploughed fields (Whistler, 1941; Ali and Ripley, 1987; Kazmierczak, 2000) and especially in the Northern India it affects shallow waters of marshes, pools and lakes (Grimmett and Inskipp, 2010). In these studies, the polluted sites like the effluent pools, sewage drains and polluted ponds etc. do not find a mention in the areas affected by the BWS. Vyas (2015) in a study on birds of Rajasthan has remarked that its long stilt like legs allow it to wade deeper than other waders and it is much attached to filthy, smelly streams carrying city and human waste where it can probe in the mud for food.

Conclusion

During the past half century, the general landscape has got dotted with sewage pools in and around cities, most of the village ponds have become the domestic sewer receptacles and the agricultural scenario have also changed. The present study predicts that the nesting of BWS in polluted edges waters of village ponds, adjoining pools and relatively dry ploughed fields indicates a habitat shift with a nesting adaptation in process. Due to this habitat shift, the BWS pairs have started to breed in and around these polluted sites serving the dual purpose of feeding and breeding in the same territory.

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