INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

Seasonal variation in feeding behaviour and foraging success of Indian pond heron (*Ardeola grayii*) in different habitats

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OPEN ACCESS

Received: 03-05-2020

Accepted: 28-05-2020

Published: 24-06-2020

Editor: Dr. Natarajan Gajendran

Citation: Dwivedi A, Elangovan V, M, misra PK (2020) Seasonal variation in feeding behaviour and foraging success of Indian pond heron (*Ardeola grayii*) in different habitats. Indian Journal of Science and Technology 13(22): 2203-2213. https://doi.org/10.17485/IJST/v13i22.473

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Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

Abstract

Objectives: The present study was focused on feeding behaviour and foraging success of Indian pond heron (*Ardeola grayii*) in different seasons and habitats. **Methods:** The study was carried out in three habitats, lake, pond and marshy area from September 2016 to December 2017. All activities such as feeding behaviour, foraging success, prey abundance, success ratio, feeding frequency (foraging attempt and success) of *A. grayii* were compared in three habitats with three seasons by using binocular and video recorder. **Statistical analysis:** Data were analysed by SPSS (21 version) and graph pad prism. In this study, prey abundance and foraging success in three habitats and season differed statistically significant ($p < 0.05$). By using non-linear regression on foraging attempt and success in three habitats three curve (exponential, cubic, growth and power) best fitted to analyzed data sets. These curve shows variation in feeding pattern. **Findings:** Stand and wait is dominant feeding behaviour followed by walk slowly and walk quickly in all three habitats and season. Prey was abundantly present during monsoon, as a result feeding frequency and success ratio maximized. Structure of habitats, vegetation, and water depth also influenced foraging success of *Ardeola grayii*. Thus, overall finding showed that Indian pond heron feeding behaviour and foraging success affected by structure of habitats and seasons.

Keywords: Habitat; season; feeding; frequency; behaviour; prey

1 Introduction

Feeding is a crucial activity of the bird's life which is vital for its survival however the demands of food acquisition impose significant challenges to both physiology and behaviour of birds. The bird species, directly and indirectly, depends on different habitats for feeding, breeding, nesting and resting. Wading birds are most commonly associated with wetlands, streams, and other aquatic habitats such as ponds, lake etc. The members of family Ardeidae are medium to large wading birds, consist of 9 species viz.

Ardeola grayii (Indian Pond Heron), *Nycticorax nycticorax* (Black-crowned Night Heron), *Ardea cinerea* (Grey Heron), *Ardea purpurea* (Purple Heron), *Egretta garzetta* (Little Egret), *Bubulcus ibis* (Cattle Egret), *Mesophoyx intermedia* (Median egret), *Casmerodius albus* (Large egret) and *Ixobrychus cinnamomeus* (Chestnut Bittern). All those large wading birds captured prey by employing stand and wait for strategy (1; 2), or by walking slowly towards the prey and waiting for surprise attack (3).

Various feeding behaviour of *Ardeola grayii* were observed by many authors such as; walk slowly, surprise attack (3), fish baiting using bread crumps (4), scavenging behaviour (5), stand and wait (2), probing (6), floating behaviour (7). Feeding behaviour and feeding frequency of herons are affected by several factors, including; prey density and prey availability (8), seasons (9), habitat characteristics (10) and height of vegetation (11).

Seasonal variation in food abundance often influences the use of different habitats while seasonal rainfall changes the availability of food, geomorphology of habitats and seasonal crops (12; 13; 14). Seasonal variation in resource availability plays a dominating role in the evolution of species and communities (12; 13; 15). For most of the wading birds, critical seasonality is a wet and dry cycle of weather (16). Availability of aquatic prey may vary with seasons but this also depends on the fluctuation in water level condition. The availability of prey directly or indirectly affected by wet and dry conditions of weathers (16; 17), that can be a major limiting factor of avian populations (18; 19). Many studies have shown that prey availability within a habitat is important in determining wading birds' for selection of a foraging sites (20; 21; 22; 23). Besides the season and availability of prey, water depth can also affect both accessibility of foraging habitat and the vulnerability of prey to wading birds.

A. grayii is a long-legged wetland bird species and commonly known as Paddy bird. *Ardeola grayii* is generally fed alone or with small groups in all types of wetlands (5; 24) by its long bill. *Ardeola grayii* (Indian Pond heron) mainly forages on insects, amphibians, annelids, crustaceans and plant material on the ground (25) but during breeding preferred to feed on fishes (5). There are no ample studies available on the foraging ecology of Indian pond heron, only a few studies documented (26; 27). In India, most of the work was done on their breeding biology, but very few study carried out on foraging behaviour including feeding success, food items and feeding behaviour of *A. grayii*. Therefore this study aimed to access the effect of seasonal changes on foraging success and feeding behaviour of Indian Pond heron (*A. grayii*). Here tested variables for completing aim of this study are; (i) prey abundance in different feeding areas of *A. grayii* (ii) Prey abundance affect foraging success in different seasons, (iii) the foraging attempt and success (success ratio) in three habitats and season, (iv) Feeding behaviour in different habitats.

2 Methods

2.1 Study area

Field observations were carried out from September 2016 to October 2017 in the foraging habitats of *A. grayii*. The whole study period was divided into three seasons: monsoon (July - October), winter (November - February) and summer (March - June). The study was carried out in Lucknow (26.8470 N and 80.9470 E), and its associated areas (up to 50km). Three types of Wetlands Lake, pond and marshy area were selected, these all were manmade wetlands. According to Ramsar convention 2008, these wetlands were defined as Marshes which are periodically saturated flooded, or ponded with water characterized by herbaceous plants which fluctuate seasonally with wet and dry conditions. In this study site, marshy areas were flooded during rainy and sometime it dried out for grasses, rushes and low growing shrubs to flourish.

Lake is deep water body surrounded by woody and non-woody tree habitats of many flora and fauna. In this study site, the lake is surrounded by *Azadirachta indica, Eucalyptus globules*, *Mangifera indica, Vachellia nilotica, , Ipomoea carnea, Eichhornia crassipes, Pithecellobium dulce* etc.

Pond is shallow, permanent or semi-permanent water with little flow; in this study site, the pond is near to temple with many surrounding trees such as *Ficus benghalensis, F. virens, F. racemosa, Mangifera indica, Azadirachta indica* etc.

2.1.1 Feeding frequency (Foraging attempt /success)

Feeding activities of A. grayii was observed using binocular (Celestron Upclose G2, 6.8°/354FT/118m (10×50X) and digital camera (Sony and Nikon Coolpix). Feeding frequency of *A. grayii* recorded for three hours per day for five days every month without disturbing their activities. Feeding frequency was counted with a stopwatch and whenever possible through visually for each 15 min feeding bout (15-minute observation whether a prey species was captured by pond heron or not). A 15 min foraging attempt was considered successful if *A. grayii* caught any prey items, and was considered unsuccessful if it failed to do so. For calculating success ratio, foraging success was divided by foraging attempts (success/attempts) for every 15 minute of observation.

Success ratio = No. of foraging success/ No. of foraging attempt (for every 15 minute success and attempt was calculated)

2.1.2 Feeding behaviour

The different feeding behaviour of *A. grayii* was recorded for five days in every month, in this study feeding behaviour terms was followed by kushlan and many authors (3; 6; 7; 8; 16; 28; 29). Feeding behaviour such as a stand and wait, walk quickly, diving, bill dipping, crouched position, neck movement and Hopping were recorded. The recorded video was played back in slow motion and frequencies of every feeding behaviour were assessed for every 15 minutes.

2.1.3 Prey abundance

For the seasonal variation in prey availability, aerial prey and benthic prey were collected in foraging sites on all three study sites once in a fortnight. The prey species were identified and recorded. Prey items were sampled by 5 sweeps (30; 31) of a long-handled net from the water edge randomly between 0 and 5 meters, distance from water edge was measured by meter stick. Fishes were collected with the help of fisherman. Aquatic insects and fishes were identified following (31; 32) respectively. The size (length and weight) of prey items was measured with a scale, and released at the site of capture.

2.1.4 Statistical analysis

All statistical analysis was performed using SPSS (version 21.0). Normality and homogeneity were evaluated for the distribution of data sets. $P < 0.05$ was considered as statistically significant. Prey abundance of lakes, ponds and marshy area was found normally distributed ($p > 0.05$) except amphibians of lakes and annelids of ponds ($p < 0.05$). Data of foraging success of Indian pond heron in all three seasons in lakes and ponds for amphibians, annelids and molluscs for the lake, ponds and marshy area were found not normal ($p < 0.05$) while the rest of them were normally distributed ($p > 0.05$). Crouch position and Neck movements were found not normally distributed ($p < 0.05$) while the rest of feeding behaviour were found normally distributed ($p > 0.05$). For normally distributed data set ANOVA and for not normal data set Krushkal walis H-test were used to evaluate the differences in prey abundance, foraging success and feeding behaviour of *A. grayii* in three different habitats and seasons. We used curve fitted model to show different pattern of foraging attempt and success in different seasons and habitats.

3 Results

3.1 Prey abundance

In the current study, five types of prey items were recorded in three feeding habitats of *A. grayii* (Table 1). These three habitats comes under city area, and their distance to each other are as follows; distance between lake and marshy area is 4km, lake to pond 10km, marshy to pond 8km. Main prey items were insects (Belostomatidae, Argyroneta aquatica, Theatops californiensis Eurymerodesmus), annelids (Pheretima posthuma, Hirudo), fish (Channa punctata, Channa striatus, Clarias batrachus, Punctius chola, Chela atpar, Labeo rohita), Amphibians (Rana tigrina) and Mollusc (Snail). Insects were most abundant prey items (48%, 45% and 37% in lake, marshy and pond respectively), while of fishes were second most abundant (27%, 25% and 17% in pond, lake and marshy area respectively) in feeding habitats of *A. grayii*. Annelids (17%) and Molluscs (9%) were highest in marshy area followed by pond (12% and 10%) and lake (10% and 7%).

Prey abundance varies seasonally. Insects (34.58±12.37), fishes (20.55±6.54), amphibians (13.08±7.31), annelids (14.58±8.01) and molluscs (8.04±3.19) were most abundant in monsoon in all three habitats, while lowest prey abundance was in winter (Table 1). There were statistically significant differences in prey abundance of pond in three different seasons ($p < 0.05$, Table 1). Insects ($F = 6.03$, $p < 0.05$), fishes ($F = 6.41$, $p < 0.05$) and molluscs ($F = 3.64$, $p < 0.05$) differed statistically significant for all three seasons in lake (Table 1), but in marshy area only fishes ($F = 4.53$, $p < 0.05$) and annelids ($F = 5.29$, $p < 0.05$) differed seasonally (Table 1).

Table 1. Prey abundance in three different habitats at different seasons

	Prey	Summer	Monsoon	Winter	F/H*	p
	Fishes	14 ± 5.97	19.25 ± 7.32	9.12 ± 2.74	6.445	0.007
	Insects	24.87 ± 8.99	37.37 ± 12.22	20.25 ± 9.05	6.031	0.009
Lake	Amphibians	7.62 ± 12.38	7.5 ± 6.50	2.75 ± 0.70	0.232*	0.63
	Annelids	5.875 ± 6.03	8.12 ± 2.74	3.62 ± 1.18	2.678	0.092
	Molluscs	4.25 ± 2.05	5.12 ± 2.41	2.62 ± 0.74	3.641	0.040
	Fishes	14.75 ± 4.97	19.75 ± 5.47	10.75 ± 2.76	7.826	0.003
	Insects	14.12 ± 3.48	31.12 ± 8.37	15 ± 4.07	22.254	0.001
Pond	Amphibians	5.37 ± 7.58	16 ± 5.09	3.12 ± 1.15	13.448	0.001

Continued on next page

Table 1 continued

	Prey	Summer	Monsoon	Winter	F/H*	p
	Annelids	4.5 ± 4.37	12.87 ± 7.45	2.5 ± 0.75	10.128*	0.006
	Molluscs	3.12 ± 3.64	9.75 ± 2.60	2.25 ± 1.03	19.107	0.001
	Fishes	7.75 ± 13.57	22.25 ± 6.84	4.75 ± 0.95	4.529	0.044
	Insects	23.5 ±10.27	35.25 ± 16.52	25 ± 9.48	1.047	0.39
Marshy	Amphibians	6.5 ± 11.70	15.75 ± 10.34	2 ± 0	4.891	0.037
	Annelids	6.5 ±11.70	22.75 ± 13.84	4.5 ± 0.57	5.298	0.03
	Molluscs	4.75 ± 3.09	9.25 ± 4.57	5.5 ± 0.57	2.262	0.16

* Kruskal Wallis-H Test

Over all abundance of prey in all three habitats did not differ significantly (Table 2) except insects in all three habitat (F = 3.2, p < 0.05).

Table 2. Over all prey abundance in three differenthabitats

Prey	Lake	Pond	Marshy		
Fishes	14.13 ± 6.85	15.08 ± 5.75	11.58 ± 11.27	2.941*	0.23
Insects	27.50 ± 12.23	20.08 ± 9.69	27.92 ± 12.55	3.2	0.048
Amphibians	5.96 ± 8.07	8.17 ± 7.65	8.08 ± 8.28	0.708*	0.702
Annelid	5.88 ± 4.16	6.62 ± 6.63	11.25 ± 11.61	3.128*	0.209
Mollusc	4.00 ± 2.08	5.04 ± 4.26	6.50 ± 3.55	4.822*	0.09

*KruskalWallis- H test

3.2 Foraging attempt and success (Success ratio) of *A. grayii*

Feeding success ratio of *A. grayii* differed seasonally. The feeding frequency was recorded in morning to evening in all three habitats of *A.grayii*. During summer (Figure 1A), in all three habitats it started feeding in morning hours the first peak of feeding was recorded at 8:00 A.M. While second peak at 11:00 A.M. and after 14:00 P.M. third peak of feeding was obtained and feeding continued till late in evening. In case of monsoon season (Figure 1B) first peak of feeding was obtained at 7:00 A.M. and at 8:00-11:00 A.M. Feeding activity continued i n same pattern neither increases nor decreases in all three habitats, second peak of feeding was recorded at 12:00 P.M. and third at 15:00 P.M. During winter (Figure 1C), there was more fluctuation than other two season, because of temperature and availability of food. First peak of feeding was recorded at 8:00 A.M. While second and third peak at 11:00 A.M. 13:00 P.M. respectively. After 13:00 P. M. feeding activity continued with low frequency in all three habitats.

To see if there were any relationship between foraging attempt and success of *A. grayii* in all three habitats and seasons, some models were used to described it. Out of 11 models (Tables 7) applied to identify for the attempt and success relationship of *A. grayii*, the best fit models were cubic, exponential, growth and power.

The exponential model was found the best fit in monsoon and winter for lake and pond, and marshy land in winter; initially the curve increased steeply and grows until it approaches stability attaining the asymptote.

The growth model (Table 7) was found to best fit model in summer season for marshy land and pond. In growth model curve, initial point of curve was lower, and with time foraging attempt and success of pond heron increasing and after a certain point, it stabilized. Growth curve represents that in mid of summer season, due to rainy started there was abundant prey available so the peak of the curve was reached a maximum in mid-point. The cubic model (Table 7)was found to best fit model in summer season for the lake. In cubic curve, itcurve was in stationary phase and after 13:00 there was exponential growth.Power model was found to best fit model in monsoon season in marshy land;in power curve, there was a proportionate increase in both variables (foraging attempt and success).

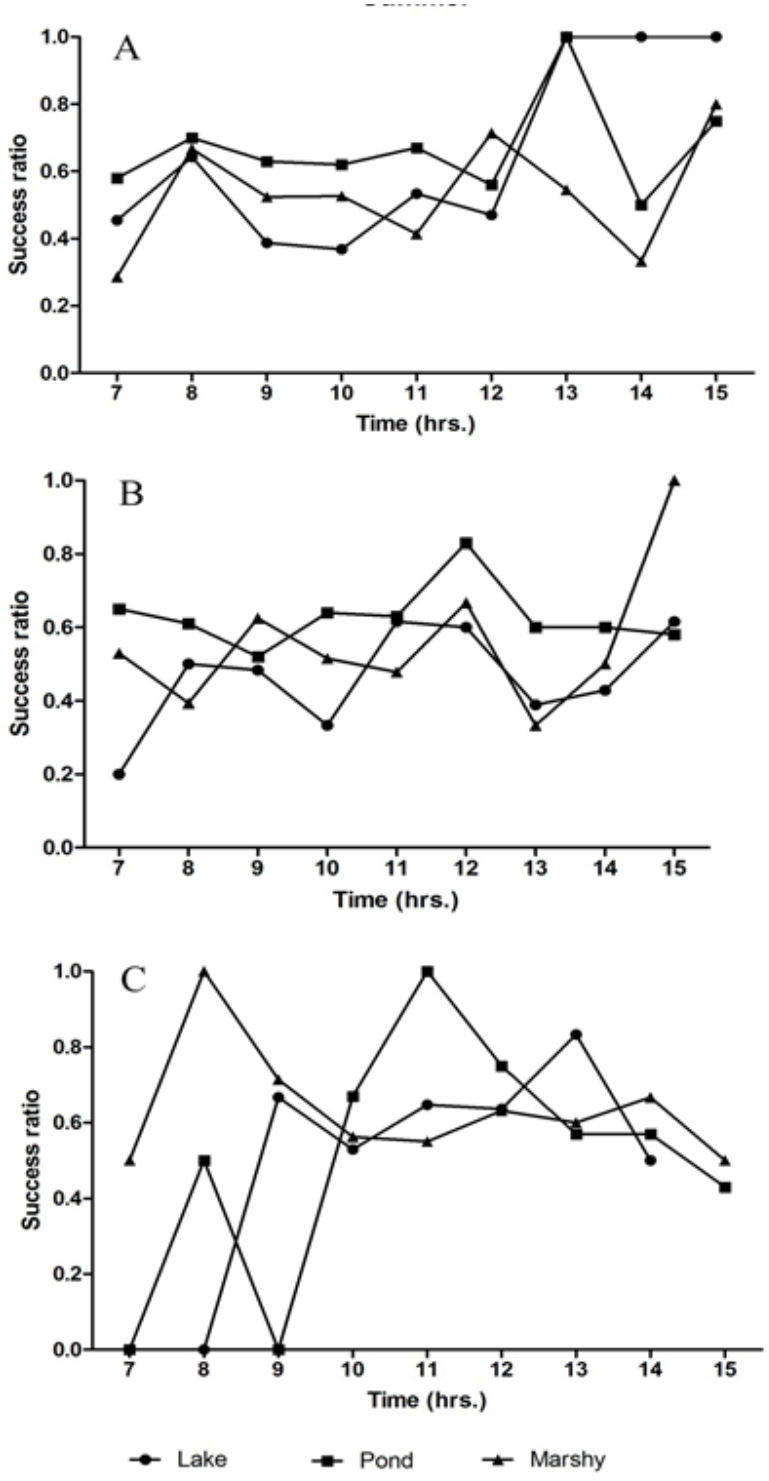

Fig 1. Represents success ratio of *A. grayii* during Summer (A), Monsoon (B), and Winter (C) seasons

3.3 Foraging success with reference to prey abundance

Foraging success of any birds depend on selection of habitats and prey. But some factors also influence its activity such as foraging ground, vegetation, and depth of water which influence the foraging success of *A. grayii*. It was observed that it preferred to feed near edge of water body or if any aquatic vegetation such as water hyacinth present then perched on that for feeding. *A. grayii* preferred habitat if water depth was 10-17cm, that's why it never feed in flooded water body. The structure of foraging habitat is also a determining factor for their foraging success, habitats rich with trees, shrubs, grasses mostly choosed for their daily activities.

The foraging success was highest in pond (33.60 ± 29.30) followed by lake (31.87 ± 30.85) and marshy area (11.13 ± 11.61). Foraging success also differ seasonally, it was observed that foraging success of *A. grayii* maximum in monsoon and lowest in winter in all three habitats (Table 3). The current study revealed that foraging success of *A. grayii* differed significantly for fishes ($F = 9.82$, $p < 0.05$), insects ($F = 27.82$, $p < 0.05$), amphibians ($H = 17.28$, $p < 0.05$), annelida ($H = 13.06$, $p < 0.05$), and mollusc ($H = 8.32$, $p < 0.05$) in ponds (Table 3), while in lake fishes ($F = 5.07$, $p < 0.05$) and insects ($F = 4.15$, $p < 0.05$) and in marshy fishes ($F = 4.03$, $p < 0.05$) and annelids ($F = 5.39$, $p < 0.05$) differed significantly (Table 3).

Table 3. Foraging success of Indian pond heron in three different habitats and seasons

Habitats	Prey	Summer	Monsoon	Winter	F/H	p
	Fishes	4.75 ± 3.01	7.25 ± 3.53	2.75 ± 1.58	5.068	0.016
	Insects	9.75 ± 3.10	13.37 ± 4.56	8.12 ± 3.35	4.153	0.03
Lake	Amphibians	1.87 ± 2.47	2.62 ± 3.12	1 ± 0	3.844 *	0.146
	Annelida	1.87 ± 1.80	1.87 ± 1.12	1 ± 0	4.519*	0.104
	Mollusca	1.12 ± 0.35	1.37 ± 0.74	1 ± 0	2.277*	0.32
	Fishes	2.75 ± 4.85	7.75 ± 3.59	1 ± 0	4.034	0.05
	Insects	8.75 ± 4.78	13 ± 5.71	9.5 ± 4.79	0.786	0.485
Marshy	Amphibians	2.5 ± 4.35	5.25 ± 3.77	1 ± 0	3.775	0.065
	Annelida	2.25 ± 3.82	8.25 ± 5.18	1 ± 0	5.394	0.029
	Mollusca	1 ± 0.81	1.5 ± 1	1 ± 0	1.114*	0.573
	Fishes	6.5 ± 2.87	9.25 ± 2.91	3.62 ± 1.59	9.818	0.001
	Insects	4.87 ± 1.95	13.87 ± 3.52	5.12 ± 2.53	27.823	0.001
Pond	Amphibians	1.87 ± 2.47	5.37 ± 3.20	1 ± 0/	17.285*	0.001
	Annelida	1.62 ± 1.40	5 ± 4.10	1 ± 0	13.057*	0.001
	Mollusca	1.6 ± 1.34	2.37 ± 1.50	1 ± 0	8.316*	0.016

*Kruskal wallis H-test

When we compare foraging success of *A. grayii* for prey items as: insects, fishes, amphibians, annelids and molluscs in three different habitats, we found that foraging success of *A. grayii* only differs in case of fishes ($H = 6.49$, $p < 0.05$, Table 4).

Table 4. Foraging success of Indian pond heron in different habitats

Prey	Lake	Pond	Marshy	F/H	p
Fishes	4.92 ± 3.29	6.46 ± 3.37	3.83 ± 4.34	6.488*	0.03
Insects	10.42 ± 4.21	7.96 ± 5.01	10.42 ± 5.01	1.963	0.15
Amphibians	1.83 ± 2.31	2.75 ± 2.95	2.83 ± 2.76	4.021*	0.13
Annelida	1.58 ± 1.24	2.54 ± 2.99	3.92 ± 4.42	3.088*	0.21
Mollusca	1.17 ± 0.48	1.70 ± 1.26	1.25 ± 0.62	2.663*	0.26

*Kruskal wallis H test

3.4 Feeding behaviour of *A grayii*

In the current study, nine types of feeding behaviour of *A. grayii* recorded in different seasons and habitats : stand and wait (SW), walk slowly (WS), walk quickly (WQ), crouched position (CR), diving (DIV), bill dipping (BD), neck movement (NM),

hopping (HOP) and probing (PROB). We found that stand and wait was frequently used behaviour followed by walk slowly, walk quickly, crouched position, diving, bill dipping, neck movement, hopping and probing at different habitats (Table 5). *Ardeola grayii* did not used bill dipping in marshy and probing in pond. Stand and wait (SW) ($F = 5.25$, $p < 0.05$) and bill dipping (BD) ($F = 3.18$, $p < 0.05$) statistically differed in all three habitats (Table 5), while WS, WQ, CR, DIV, BD, NM, HOP and PROB showed no significant differences in lake, pond and marshy area ($p > 0.05$, Table 5).

Table 5. Variation in feeding techniques of Indian pond heron at different habitats

Behaviour	Lake	Marshy	Pond	F/H	p
SW	34.17 ± 6.87	25± 12.18	36.08 ± 6.68	5.25	0.01
WS	7.75 ± 2.7	6.17 ± 4.17	6.33 ± 4.22	0.64	0.53
WQ	5.42 ± 2.02	4.50 ± 2.9	4.33 ± 2.96	0.57	0.56
CR	2.33 ± 1.15	2.33 ± 1.61	2.67 ± 2.01	0.19	0.90
DIV	4.0 ± 1.80	3.0 ± 1.63	2.75 ± 1.81	1.53	0.23
BD	4.08 ± 2.15	1± 0	3.17 ± 2.36	3.18	0.05
NM	9.08 ± 9.34	3.67 ± 4.57	4.42 ± 3.57	5.45*	0.06
HOP	3.50 ± 2.17	2.33 ± 1.43	2.83 ± 1.52	1.04	0.36
PROB	3.50 ± 2.87	3.33 ± 2.22	1 ± 0	2.61	0.09

*Kruskal wallis H-test

In lake, *A. grayii* showed significant differences in hopping ($F = 20.63$, $p < 0.05$) and probing ($F = 14.54$, $p < 0.05$) for three season (Table 6), in all three season, hopping was least used feeding techniques in winter (1 ± 0), followed by summer (2.75 ± 1.70), and monsoon (6.75 ± 2.06), probing was used only in summer (2.75 ± 1.70), and monsoon (6.75 ± 2.06). In marshy, walk slowly ($F = 4.96$, $p < 0.05$), neck movement ($H = 8.89$, $p < 0.05$), hopping ($H = 7.85$,$p < 0.05$), and probing ($F = 5.54$, $p < 0.02$) differed significantly in three seasons. In marshy area, diving was used in monsoon season not in other two seasons. In pond, stand and wait ($F = 4.58$, $p < 0.05$), diving ($H = 6.09$, $p < 0.05$), and bill dipping ($H = 9.35$, $p < 0.05$) differed significantly in all three season. Overall results showed that in all three habitats and seasons, stand and wait was dominant feeding techniques used by *A. grayii*, these were depended on type of prey and structure of habitats.

Table 6. Seasonal variation in feeding techniques of Indian pond heron at different habitats

Habitats	Behaviour	Seasons			F/H	p
		Summer	**Monsoon**	**Winter**		
	SW	29.75 ± 2.06	35.50 ± 9.846	37.25 ± 5.56	1.39	0.29
	WS	6.25 ± 3.30	8.50 ± 3.10	8.50 ± 1.29	0.91	0.38
	WQ	4.25 ± 1.25	6.25 ± 2.36	5.75 ± 2.21	1.07	0.38
	CR	2 ± 0.81	2 ± 0.81	3 ± 1.63	1	0.40
Lake	DIV	4 ± 2.16	4.75 ± 1.70	3.25 ± 1.70	2.44	0.10
	BD	3.50 ± 3.10	5.50 ± 0.57	3.25 ± 1.70	1.41	0.29
	NM	11.75 ± 10.93	12 ± 11.34	3.50 ± 3.10	1	0.37
	HOP	2.50 ± 1.29	6.75 ± 1.70	1.25 ± 0.50	20.63	0.001
	PROB	2.75 ± 1.70	6.75 ± 2.06	1 ± 0	14.54	0.002
	SW	38 ± 6.37	31 ± 4.54	39.25 ± 7.04	2.13	0.17
	WS	2.25 ± 2.50	9.0 ± 4.39	7.75 ± 2.36	4.96	0.03
	WQ	2 ± 1.5	6.50 ± 2.88	5 ± 2.16	3.7	0.06
	CR	2.25 ± 1.89	2.50 ± 1.91	2.25 ± 1.50	0.02	0.97
Marshy	DIV	-	3 ± 1.63	-	-	-
	BD	-	3 ± 1.63	-	-	-
	NM	1 ± 0	1.25 ± 0.50	8.75 ± 4.99	8.89*	0.01
	HOP	1.75 ± 0.95	4 ± 0.81	1.25 ± 0.50	7.85*	0.02
	PROB	1.75 ± 0.95	5.50 ± 2.08	2.75 ± 1.70	5.54	0.02
	SW	34 ± 2.94	27 ± 12.49	14 ± 10.23	4.58	0.04
	WS	8.25 ± 3.86	7.75 ± 4.03	2.5 ± 2.38	3.3	0.08
	WQ	6.50 ± 3.10	4.50 ± 2.64	2 ± 1.41	3.26	0.08
	CR	4.0 ± 2.82	2.50 ± 1.29	1.50 ± 1	1.78	0.22
Pond	DIV	4.25 ± 0.97	2.75 ± 2.21	1.25 ± 0.50	6.09*	0.04
	BD	5.50 ± 1.73	3 ± 2	1 ± 0	9.35*	0.01

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Table 6 continued

Habitats	Behaviour		Seasons		F/H	p
	NM	3.75 ± 1.25	6.25 ± 5.96	3.25 ± 1.70	0.77	0.49
	HOP	4 ± 1.82	2 ± 0.81	2.50 ± 1.29	2.29	0.15
	PROB	-	-	-	-	-

Table 7. Seasonal variation in feeding frequency of (*A. grayii*) Indian pond heron at different habitats

Habitat	Seasons	Model	S2
Lake	Summer	Cubic	1.273
	Monsoon	Exponential	5.439
	Winter	Exponential	2.428
Pond	Summer	Growth	2.084
	Monsoon	Exponential	3.240
	Winter	Exponential	0.504
Marshy land	Summer	Growth	1.114
	Monsoon	Power	5.870
	Winter	Exponential	3.253

S^2 = Residual sum of square

4 Discussion

4.1 Prey abundance

In the current study *A. grayii* used lake, pond and marshy area for feeding activity. Insects were the most abundant prey items, while fishes second most abundant in all three habitats of *A. grayii*. Fishes and amphibians were highest in ponds while insects, annelids, and molluscs were in the marshy area. All three habitats having different structures therefore availability of prey items also varies (33). During summer prey availability decreases in lake, but as rainy starts availability of prey increases (34). Thus the availability of prey in the lake is maintained in every season. In the pond, mainly fishes are available in all seasons rather than other prey items. In all three habitats, the availability of all preys such as insects, fishes, annelids amphibians and molluscs were highest in monsoon (35), while lowest in winter. The availability of prey depends on both structure of habitats and seasons (36; 37). During monsoon (36; 38; 39), most of the fishes, amphibians, annelids and aquatic insects are in reproductive phase, so their number increases in all types of habitats (40), which guarantee a relatively high abundance of potential prey for *A. grayii* (27). The marshy area after winter dries rapidly and becomes inadequate for feeding site for *A. grayii*. These results suggest that prey diversity increased in number during monsoon, so all prey items were present abundantly while in summer and winter insects and fishes mainly present in all habitats.

4.2 Foraging attempt and success (Success ratio) of *A. grayii*

Prey abundance, the structure of habitats, variation in seasons determined the success ratio of *A. grayii* **.** In the summer season, due to high temperature all wetlands having scarcity of water, so there was less availability of prey, as a result, success ratio graph showed temporal variation in every hours of observation for every season. In summer, birds come in feeding ground early in the morning while in winter late in morning, and in summer feeding continued till evening. In monsoon, *A. grayii* having a diverse diet, because in monsoon it is a reproductive period for amphibians, insects, Annelida, and fishes. So their number was higher as a result success ratio of *A. grayii* was higher. In monsoon, foraging success did not only depend on prey abundance but also water level. If the water level was not approachable to *A. grayii*, it did not feed; as the water level goes down it started to feed. In winter, as temperature decreases very few preys available, so *A. grayii* success ratio decreases.

Exponential curve showed feeding pattern of *A. grayii* in winter and monsoon season in all three habitats. Exponential curve pattern shows in starting of winter foraging attempt and success was increased but as temperature decreases, availability of prey decreased as a result foraging frequency decreased. In case of monsoon. The availability of prey abundance increased but *A. grayii* was not easily approached to prey on them so initially there was low frequency of feeding, but as water level goes down the feeding frequency again raised.

Growth curve represents the feeding pattern of *A. grayii* in summer season in both pond and marshy land. Such type of pattern of curve was due to availability of prey in habitats, in summer. The starting of summer season is the starting of breeding period of *A. grayii*. Most of the time, it was observed busy in searching suitable place for nest construction, so the feeding frequency becomes low. But as the part of breeding is over, its feeding frequency gradually increases (27).

The cubic curve showed the feeding pattern of *A. grayii* in the lake during the summer season. The cubic curve showed the initial frequency of feeding as slow but after sometimes it increases. In summer, the availability of prey was not abundant as monsoon season, but the requirement of energy for *A. grayii* was high in summer due to breeding period so the foraging attempt in that case increased. Power curve represents the feeding pattern of *A. grayii* in marshy land during monsoon season. In this curve, both foraging attempt and success is in equal proportion due to availability of prey abundantly.

4.3 Feeding behaviour of *A grayii*

A. grayii varied their feeding techniques according to habitats (33) along with several environmental factors such as water depth (40) , the height of vegetation (41; 42), and availability of prey (40). *A. grayii* mainly used the stand and wait technique in all three habitats. However, in addition to stand and wait, *A. grayii* also adopted the walking slowly, similar techniques also adopted by Great egrets and Little egrets (5; 43; 44). *A. grayii* used walk slowly for capturing sedentary or slow-moving prey in shallow water, marshy and vegetated area (6; 43; 45). Stand and wait is better for capturing large prey in deep water or for finding hidden prey (46). Crouched position, hopping and probing was very least preferred techniques by *A. grayii* for foraging in all three habitats. Time spent in Stand and wait technique differ in ponds, lakes and marshy area, while time spent in other techniques did not differed in all three habitats. *A. grayii* did not use bill dipping in marshy and probing in the pond. Feeding techniques used by *A. grayii* did not varied with seasons, only hopping (HOP) and probbing (PROB) varied in lake and marshy while diving (DIV) and bill dipping (BD) in ponds.

In this study, it was observed that pond was generally choosen during breeding period by *A. grayii*, because in that period it had to construct nest, feed male to female, female to male during rearing, and chick also. So near pond many trees were available for construction of nest, and fishes (5) available as food. That's why near pond mostly these three techniques (stand and wait, diving and bill dipping) used by them. The present study indicates that prey availability, habitat structure, feeding techniques, all depend on variation in season, which ultimately affects feeding activities of *A. grayii*.

5 Conclusion

In this study, it was concluded that *A. grayii* employs different behaviour for feeding, but stand and wait was dominant feeding behaviour. Insects were present abundantly in all three habitats. So foraging success for insects were higher than other prey items. But during summer and starting of monsoon fishes were mostly preferred by *A.grayii*. Monsoon season was the favourable season for feeding of herons due to availability of prey. So in all three habitats, foraging success was higher in monsoon. In this study it was observed that insects were mostly consumed prey by *A. grayii*. So it plays a significant role in controlling the population of insects and other invertebrates on which they fed and supports the farmers. However, the rapid urbanization and development of the area for living and other human purposes may create a threat to these birds by the destruction of natural habitats through anthropogenic activities. Thus, if any disturbances occur in habitats of *A. grayii*, its feeding activity will affect; as a result, their breeding activity will hamper and finally decrease their populations. Not only *A. grayii* but all wetlands dependent birds will also be affected. Thus proper conservation the wetland bird species is important for the conservation of entire ecosystem.

Acknowledgment

The authors acknowledge department of Biostatistic (Mr. Subhash Yadav, Assistant professor) for suggestion in data analysis part in this study. Research work is not funded by any National or International bodies.

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