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Foraging Ecology of Twelve Ardeid Species at Lungh Lake, Pakistan

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ABSTRACT

Ardeids are wading birds that play an important role in aquatic habitats, i.e., they are pest-control agents of amphibians, insects and small rodents and serve as bioindicators. They face overwhelming threats such as water pollution due to organic and inorganic contaminations that often are released from industrial plants, domestic sewage and mining effluents discharged into the waterways, habitat loss and degradation resulting from the conversion of lakes into agricultural fields, as well as water diversion and abstraction for agricultural purposes Observations on foraging ecology, habitat choices and prey items of Ardeids were conducted monthly, from January 2018 to December 2019. Birds were observed with a spotting scope (V 20x80mm), binoculars (10x50mm) and direct observations. A total of 2420 observations of 12 species were recorded and 13 behaviours documented. The little egret (*Egretta garzetta*) (18.8±6.5 individuals/ha), intermediate egret (*Mesophoyx intermedia*) (15.8±5.6 individuals/ha) and eastern cattle egret (*Bubulcus coromandus*) (14.0±5.6 individuals/ha) were the most abundant species. The cinnamon bittern (*Ixobrychus cinnamomeus*) (3.0±2.5 individuals/ha) and black–crowned night–heron (*Nycticorax nycticorax*) (2.7±3.1 individuals/ha) the least abundant. All Ardeids foraged in habitats where water was present. Only the eastern cattle egret foraged in grassy areas and adjacent agriculture fields. All ardeids fed on a variety of prey. All species utilized at least seven foraging techniques, only the black–crowned night–heron used three techniques. The little egret (45 probes/minute) and eastern cattle egret (35 probes/minute) were the most active foragers. Together with the intermediate egret they were the most aggressive species. Overall, ardeids use a variety of foraging techniques, and vary in food selection and habitat selection. Our results illustrate the diversity of Ardeid species utilizing Lungh Lake, Qambar Shahdadkot District, near Larkana, Sindh Province, Pakistan. In conclusion, Ardeids employed a broad variety of foraging tactics when capturing food items and exploiting various foraging grounds where prey items concentrated particularly in shallow waters, lake edges, and thick matts of sedges.

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Key words
Habitat, Waders, Behavior, Trophic structure, Water, Lungh Lake

INTRODUCTION

In recent decades the world has undergone substantial social, economic, and ecological changes (O'Connell, 2000). Wetlands have been lost or degraded while the remaining ones are under heavy pressure due to human interventions. Habitat loss and degradation, water pollution, excessive hunting, introduction of invasive species, and climate change (Woodward and Wui, 2001; Kingsford and Thomas, 2004; Wei *et al*., 2008) have resulted in a 23% decline of water bird populations and 19% becoming threatened (Birdlife International, 2017; Wang *et al*., 2018). Pakistan possesses a variety of wetlands, despite its predominantly arid and semi-arid topography (Rais *et al*., 2011). Many climatic and vegetation zones within a relatively small area (IUCN, 1989) have resulted in different types of wetland systems, with more than 225 wetlands in Pakistan (Ali *et al*., 2018).

Foraging is one of the most essential activities of avian behavior, through which birds obtain food for their survival and reproduction. Most avian species spend most or part of their time searching for food (Morrison *et al*., 1990). Ardeids, e.g., egrets, bitterns, and herons, forage using a variety of methods to catch prey (Kushlan and Hancock,

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2005). Foraging is an aggregation activity as they utilize similar food resources and aquatic habitats known as a guild or functional group. Ardeids employ up to 41 foraging techniques (Frederick, 2002; Kushlan and Hancock, 2005; McKilligan, 2005) and utilize different wetland habitats, such as rice fields, freshwater marshes, salt marshes, rivers and estuaries (e.g. Kazantzidis and Goutner, 1996; Custer *et al*., 2004). The foraging technique may vary depending on the species and habitat, the availability and richness of food resources, structure and composition of vegetation, and water depth (Kushlan and Hancock, 2005). Ardeids may use different prey–capturing strategies to catch their prey. For example, lean forward and wait motionless, stand and wait, walk slowly, walk quickly, follow prey by running, open wing feeding, double wing feeding, food snatching, bill vibrating or tongue flicking, using rafts/perches, wing flicking, foot stirring or shuffling or raking, hovering or skimming over the surface, dipping, legs trailing in water and foot dragging or paddling to lure the fish, jumping and hopping (Kushlan, 2011; Aboushiba *et al*., 2013). Dimalexis *et al*. (1997) determined the strike rate, foraging efforts per minute, foraging efficiency, and prey capture success rate among three ardeid species, e.g., grey herons (*Ardea cinerea*), great egrets (*Ardea alba*), and little egrets (*Egretta garzetta*) in Greek wetlands and found that they used walk slowly, walk quickly, and stand and wait foraging tactics to catch prey along shallow waters and wetlands. The same results were also reported by Nefla and Nouira (2016) in herons inhabiting Ichkeul National Park, Tunisia. Similarly, Modal and Maheswaran (2021) analyzed the foraging ecology of the white-bellied heron *(Ardea insignis*) in Namdapha tiger reserve, Arunachal Pradesh, India and found that strikes/hour, caught/hour, and capture efficacy varied in the egret species.

Interspecific foraging strategies are the most prevalent way for ardeids to capture and consume their prey. This study is based on the specific research hypothesis that ardeids don't overlap in trophic structures while exploiting the food resources available to them. Using the niche partitioning hypothesis, the study examined whether ardeids exploiting Lungh Lake in Larkana varied in their prey capture and food consumption. Lungh Lake is a natural lake, designated as a Wildlife Sanctuary since 1984 (Ali-Brohi and Rasheed, 2016). It is located on the Indus Fly Zone that serves as a middle Asian flying route for migratory birds and is connected to West Asian and East African flying routes (Umar *et al*., 2018). As such, it is a refuge for migratory waterfowl in the wintering months, acting as a stopover for around 20,000 water birds, migrating from Siberia on their way to India (Ali-Brohi and Rasheed, 2016). Land–use and land cover changes at the lake and its surrounding areas from 1988 to 2020 show significant shrinkage of the lake area due to agriculture expansion, and an increase in vegetation by 72%. Therefore, there is an urgent need for the development of a management plan for the lake (Ditta *et al*., 2021). Moreover, there is a scarcity of studies on water birds utilizing the lake. The goal of this study was to ascertain the differences in foraging ecology among Ardeid species to inform conservation strategies. We investigated the choice of habitats, prey items and foraging techniques used by the birds and envisage that this information will assist in the conservation of the lake and its biodiversity.

MATERIALS AND METHODS

Study area

Lungh Lake (68^0 03' E, 27^0 30' N; Elevation: ~54 meters above sea level) is located at Qambar Shahdadkot District, near Larkana, in Sindh Province, Pakistan (Fig. 1). It covers an area of 39.66 ha (3.96 km^2) and is dominated by aquatic vegetation such as cattail (*Typha angustifolia*), giant reed/elephant grass (*Arundo donax*), common/soft rush (*Juncus effusus*), coontail/hornwort (*Ceratophyllum demersum*) and common reed (*Phragmites australis*). The lake edges are covered by gum arabic/babul/kikar trees (*Vachella nilotica*), Indian jujube/beri *(Zizyphus mauritiana*), athel tamarix/ghaz/farash (*Tamarix aphylla*), and twigy shrub/lai (*Tamarix dioica*). The wetland is surrounded by agricultural fields and human settlements. The lake can be divided into three habitat types: (1) open water with *Typha* and *Juncus* on the edges, (2) swampy areas dominated by *Tamarix* and (3) surrounding rice fields with predominant *Juncus* sp. (Ali-Brohi and Rasheed, 2016). The microclimatic conditions vary throughout the year; temperatures range from 2.2 ^{o}C to 48.5 ^{o}C. The summer season lasts for four months (from April to July) and winter lasts three months (from December to February). The relative humidity ranges from 37% to 85% and the mean annual rainfall is 178 mm/year during the monsoon season (Rajpar *et al*., 2022).

Foraging behavior

Field observations of the foraging behavior of Ardeid species were documented using a spotting scope (Vanguard Platinum; 20 x 80mm), binoculars (Olympus; 10 x50mm) and direct observations, depending on visibility. The area was scanned and the Ardeid species were identified and counted. Suitable locations were selected along the wetland edges for the observations. Foraging behavior was recorded on an hourly basis, from 0700 to 1800 hours, to identify daily activity patterns. The foraging behavior of twelve Ardeid species was recorded for 2880 hours (i.e., 10 hours/day, 12 days/month, and 24 months). For each

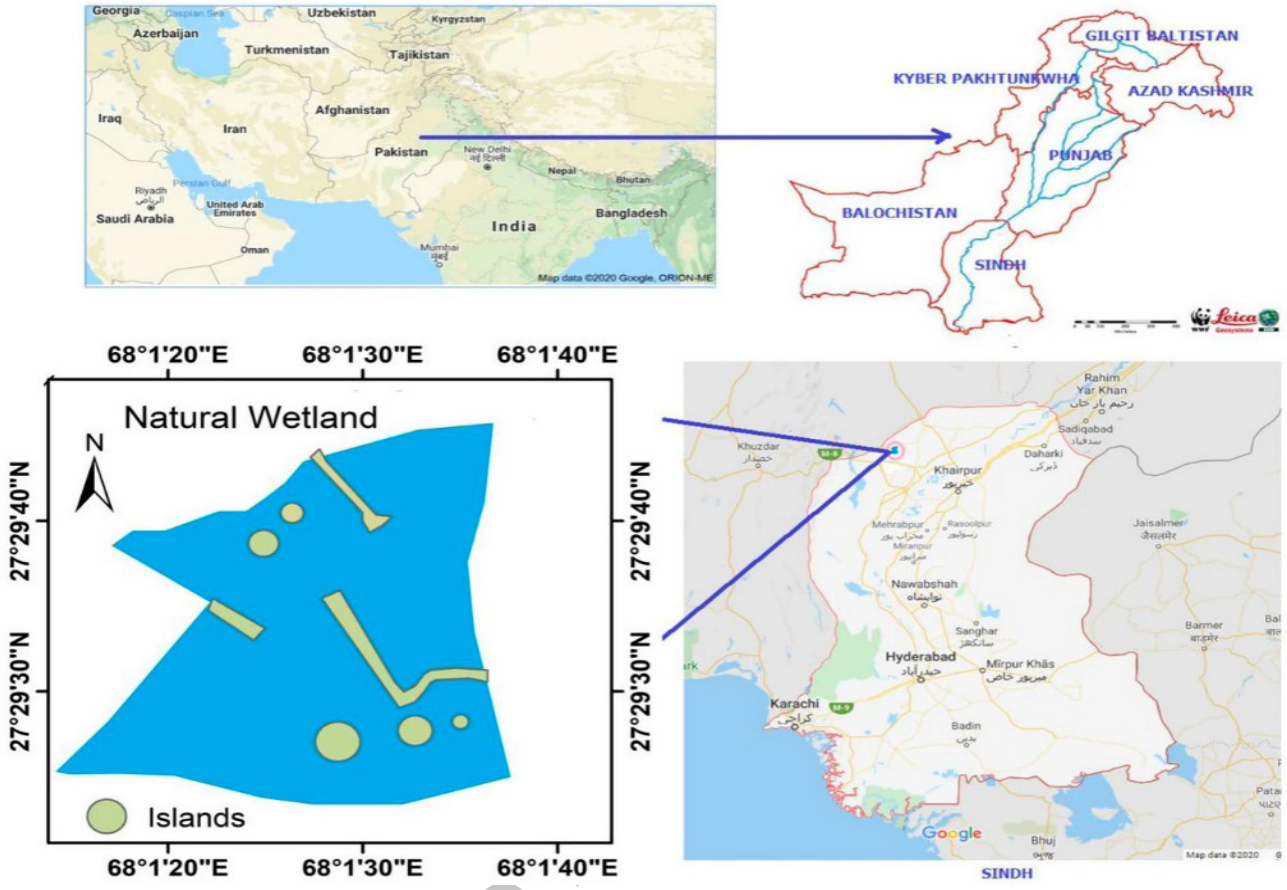

Fig. 1. Map showing Lungh lake (Natural Wetland) in Northwest Pakistan.

day, we focused on recording the behavior of one species chosen randomly. The Ardeid species were classified as either solitary (preying alone) or gregarious (foraging with other species). Capturing of food was referred to as prey occurrences, the type of food consumed was referred to as prey selection frequency, and the preferred site for foraging was referred to as habitat preference. Observations were recorded monthly, from January 2018 to December 2019. The methodology is described in detail by Kushlan (2007), Choi *et al*. (2008), and Sharah *et al*. (2008). Foraging behavior of the ardeids was divided into 13 categories based on major food selection, tactics employed while foraging and habitat preference as suggested by Degraaf *et al*. (1985), Ehrlick *et al*. (1988) and Thorngate *et al*. (2006).

Statistical analysis

Relative frequency is the percentage of each behavior used by ardeids, food consumption, and movement at Lungh Lake while exploiting food resources using a wide range of techniques (Anderson, 2017). The relative frequency of each bird species was calculated by a given formula;

$$RF = \frac{Isi}{\sum Nsi} \times 100$$

Where, Isi = total number of individuals of each identified bird species, /∑Nsi = total number of detected bird species in the study area.

In addition, the relative frequency movements, food consumption, and foraging behavior of ardeids was compared using a Kruskal-Wallis Nonparametric H test and Tukey's Honestly Significant Difference (HSD) test using Statistics 8.1 Analytical Software; Version 8.1 (Steel and Torrie, 1997; McGraw-Hill, 2008).

The Kruskal-Wallis H Test was used to compare the foraging techniques, movement behavior, food preference and habitat selection among the Ardeid species. It was performed according to the formula;

$$H = \frac{12}{n(n+1)} \sum \frac{R^2 i}{ni} - 3(n+1)$$

Where, "n" = the total number of observations, "R" = is the sum of the ranks of each species, and "ni" = number of each detected items.

RESULTS

Ardeid abundance

In total, 2420 observations from 12 Ardeid species were recorded. The little egret (18.8 ± 6.5 individuals/ha), intermediate egret (15.8 ± 5.6 individuals/ha) and Eastern cattle egret (14.0 ± 5.6 individuals/ha) were the most abundant species. The cinnamon bittern (3.0 ± 2.5 individuals/ha) and black–crowned night–heron (2.7 ± 3.1 individuals/ha) the least abundant (Table I).

Table I. Population size (mean ± SD) and number of foraging observations of 12 Ardeid species recorded monthly (Jan 2018-Dec 2019) at Lungh Lake, Pakistan.

Scientific name (Common name)	Population Mean ± SD	Number of foraging observations
Egretta garzeta (Little egret)	18.8 ± 6.5	452
Mesophoyx intermedia (Intermediate egret)	15.8 ± 5.6	380
Bubulcus coromandus (Eastern cattle egret)	14.0 ± 5.6	338
Ardea alba (Great egret)	12.5 ± 6.6	305
Ardeola speciosa (Javan pond heron)	8.9 ± 4.3	214
Butorides striata (Striated heron)	6.5 ± 3.7	155
Ardeola grayii (Indian pond heron)	5.3 ± 3.2	127
Ardea purpurea (Purple heron)	5.1 ± 3.3	123
Ardea cinerea (Grey heron)	4.4 ± 3.1	105
Ardeola bacchus (Chinese pond heron)	3.6 ± 3.1	86
Ixobrychus cinnamomeus (Cinnamon bittern)	3.0 ± 2.5	72
Nycticorax nycticorax (Black-crowned night heron)	2.7 ± 3.1	63
Total observations	2420	

Foraging observations

Out of the 12 Ardeid species, eight are solitary foragers and four are gregarious feeders. Most species are resident and partial migrants, except for the striated heron, that is the only migrant, and the Javan pond heron and Indian pond heron, are exclusively residents (Table II). Food selection and consumption among the ardeids varied, with each species consuming a variety of items. Notably, fishes (20.9%) were the most preferred food item, followed by frogs (12.3%), grasshoppers (10.2%), beetles (9.2%), water striders (8.3%) and flies (6.6%); whereas rodents (0.8%), salamanders (0.7%), and snakes (0.3%) were occasionally eaten.

Furthermore, based on the food capturing success rate, little egrets and great egrets are the most prevalent species that consume a wide variety of foods. However, the black-crowned night heron mainly consumes fishes, reptiles and amphibians. All ardeids foraged in a variety of habitats where water was present. Eastern cattle egrets are the only species that exploited grassy areas and adjacent agriculture fields instead of water.

Using the Kruskal–Wallis non–parametric one-way analysis of variance (ANOVA) a significant difference in the food consumption of the 12 Ardeid species was found; $F_{15,191} = 27.00$, $p < 0.05$. There were seven groups (A, B, C, D, E, F, and G) with means that differed significantly from each other (Table III).

Foraging techniques

All Ardeid species used a combination of 13 foraging techniques, i.e. behavior/activities, while foraging for food (Tables IV, V). All species utilized at least seven techniques, apart from the black–crowned night–heron that used only three techniques, i.e., lean and wait (30.2%), stand and wait (52.4%) and stand and feed (17.4%). The black–crowned night–heron and the purple heron never chased their prey but waited for the prey to come close to them. The little egret was the most active forager, using prey chasing (14.6%), toe shuffling (18.0%), and walking quickly (12.8%) more often than the other heron species. Five species, the great egret, striated heron, black–crowned night–heron, cinnamon bittern and Javan pond heron, never used the wing flick behavior. Notably, the little egret was the only species that used toe–shuffled, and the Eastern cattle egret the only species that used gleaning. Four species never exhibited aggressive behavior, i.e., the black–crowned night–heron, cinnamon bittern, Indian pond heron and Javan pond heron.

Food snatching

Food snatching, i.e. stealing food from other individuals (Table V), was recorded separately from aggressive behavior, i.e. fighting for territory or food acquisition (Table IV). The Eastern cattle egret (16 %), little egret (14.6%) and intermediate egret (9.8%) exhibited the highest food snatching behavior (Table V) and were also among the most aggressive species (Table IV). The black–crowned night–heron, cinnamon bittern and striated heron avoided food snatching altogether (Table V).

Table II. Habitat preferences, foraging style, diet composition and occurrence of 12 Ardeid species recorded monthly (Jan 2018–Dec 2019) at Lungh Lake, Pakistan.

Scientific name	Habitat preference	Foraging style	Diet composition (number of prey items)																Occurrence (source)	Area %
			Fishes	Beetles	Flies	Sedge moths	Grass bug	Grasshoppers	Water Boatman	Damsel Bugs	Backswimmers	Water striders	Earthworms	Snails	Rodents	Salamanders	Snake	Frogs		
Egretta garzeta	Swampy areas, shallow water, water inlets, water body edges, muddy areas, emergent vegetation, ditches	Gregarious pursuit and ambush predator	322	148	134	76	65	175	35	49	89	102	92	75	12	6	2	102	Resident, Partial migrant	60
Mesophoyx intermedia	Saturated soil dominated with sedges and grasses, shallow water, wetland edges, swampy areas	Gregarious forager	240	110	76	56	32	112	10	8	64	78	40	61	3	1	0	180	Resident, Migrant	30
Bubulcus coromandus	Water body edges, grassy areas, adjacent agriculture fields	Cosmopolitan and terrestrial forager	100	180	165	0	190	230	8	56	98	55	120	84	14	10	5	230	Resident Partial migrant	30
Ardea alba	Muddy swamps, shallow water, wetland edges, dead fallen objects in wetland, thick mats of vegetation, reedbeds	Congregator ambush predator	260	89	40	54	40	75	40	42	74	96	34	40	14	20	6	120	Resident, Partial migrant	40
Ardeola speciosa	Marshy areas, wetland edges, thick mats especially water hyacinth, shallow water, wetland edges, wetland inlets and outlets	Solitary forager	289	156	98	32	75	140	20	26	74	88	40	67	8	4	1	180	Resident	45
Butorides striata	Shallow water, wetland edges, fallen objects	Solitary forager	152	65	39	24	36	23	34	28	60	100	20	42	9	4	3	98	Migrant	20
Ardeola grayii	Wetland inlet and outlet, water edges, marshes, mats, emergent vegetation	Solitary forager	243	126	102	66	85	132	18	22	68	134	55	78	6	3	0	124	Resident	50
Ardea purpurea	Shallow water, wetland edges	Solitary ambush predator	202	64	16	58	38	96	23	16	55	120	43	56	15	18	8	147	Resident, Partial migrant	15
Ardea cinerea	Shallow water, wetland edges, dead fallen trees, island edges, swampy areas	Solitary forager	240	45	10	26	23	88	32	20	74	86	34	42	13	14	6	150	Resident, Partial migrant	25
Ardeola bacchus	Swampy areas, wetland edges, muddy areas, grassy areas along the wetland edges, ditches	Solitary forager	289	95	100	46	20	100	22	38	64	110	65	87	7	2	2	110	Resident, Migrant	30
Ixobrychus cinnamomeus	Emergent vegetation, wetland edges, swampy areas dominated with sedges, fallen objects	Solitary forager	140	129	84	44	100	120	15	24	53	86	120	90	6	4	1	88	Resident, Migrant	60
Nycticorax nycticorax	Shallow water, wetland edges devoid of vegetation, dead fallen objects, muddy substrates, sedges, island edges	Solitary ambush predator	260	0	0	0	0	40	20	0	0	34	26	40	0	2	1	74	Resident, Migrant	40
		Sub-Total	2737	1207	864	482	704	1331	277	329	773	1089	689	762	107	88	35	1603		
		Grand Total	13077																	

Table III. Kruskal–Wallis pairwise comparisons test of observations by habitat.

Name of food item	Mean value	Homogenous group
Fishes	181.79	A
Frogs	159.25	AB
Grasshoppers	141.75	ABC
Water striders	134.67	ABCD
Beetles	133.67	ABCD
Snails	109.25	ABCDE
Flies	107.67	ABCDEF
Backswimmers	105.79	ABCDEF
Earthworms	99.208	BCDEF
Grass bug	92.917	BCDEFG
Sedge moths	77.750	CDEFG
Damsel bugs	62.958	CDEFG
Water boatman	57.538	DEFG
Rodents	32.875	EFG
Salamanders	28.875	FG
Snake	18.000	G

Alpha value, 0.05; Critical value, 2.638; Critical value for comparison, 80.067.

Food probing

The frequency of food probing, i.e. the number of times an individual bird probed the water with their bill to capture food, differed among species. The little egret (45 probes/m) and Eastern cattle egret (35 probes/m) were the most active foragers. In contrast, the purple heron (4 probes/m), cinnamon bittern (4 probes/m) and striated heron (2 probes/m) rarely foraged through probing (Table V).

Using the Kruskal–Wallis non–parametric one-way analysis of variance (ANOVA) a significant difference in foraging techniques was detected; $F_{10, 131} = 20.60$, $p < 0.05$. There were three (A, B, and C) with means that were not significantly different from each other (Table VI).

DISCUSSION

In this study, 12 of the 18 Ardeid species found in Pakistan (Mosvi *et al.*, 2019), were observed at Lungh Lake, Qambar Shahdadkot District, near Larkana, Sindh Province. The little egret, intermediate egret and Eastern cattle egret were the most abundant species while the cinnamon bittern and black–crowned night–heron were the least abundant. We have shown that ardeids employ a variety of foraging behaviors, which is in agreement with other studies (e.g. Aboushiba *et al.*, 2013; Kasprzykowski and Golawski, 2024). Each species has its own usual behaviours, but in addition can use others to catch abundant or easily taken prey (Voisin, 2010). In our study, great egret, purple heron, grey heron, pond heron, cinnamon bittern and black-crowned night-heron, were solitary foragers. In contrast, little egret, intermediate egret, and Eastern cattle egret

Table IV. Foraging techniques (percentage of technique used per species) employed by 12 Ardeid species observed monthly (Jan 2018- Dec 2019) at Lungh Lake, Pakistan.

Scientific name	Wing flick	Prey chasing	Toe shuffling	Perching	Walking slowly	Walking quickly	Lean and wait	Stand and wait	Stand and feed	Aggressive	Gleaning	Minutes observed
Egretta garzeta	4.4	14.6	10.2	8.2	18.2	12.8	5.8	8.4	14.2	3.2	0	301
Mesophoyx intermedia	3.2	8.8	0	5.4	30.6	4.8	15.6	20.2	8.6	2.8	0	111
Bubulcus coromandus	3.4	9.2	0	5.4	28.2	5.4	9.4	12.5	17.8	3.2	5.5	233
Ardea alba	0	3.2	0	4.8	36.4	4.6	18.2	24.6	6.4	1.8	0	189
Ardeola speciosa	0	5.8	0	6.4	40.8	4.6	7.2	25.4	9.8	0	0	72
Butorides striata	0	4.2	0	4.6	36.4	5.6	18.5	22.5	5.4	2.8	0	107
Ardeola grayii	2.6	8.2	0	9.6	47.3	3.2	4.8	22.9	8.6	0	0	256
Ardea purpurea	2.8	8.8	0	7.2	29.2	3.8	14.6	18.2	12.6	2.8	0	73
Ardea cinerea	1.8	2.5	0	6.2	35.3	3.4	14.4	24.6	9.4	2.4	0	50
Ardeola bacchus	2.3	5.4	0	7.4	38.8	4.7	14.4	20.2	5.2	1.6	0	86
Ixobrychus cinnamomeus	0	6.2	0	8.8	34.4	2.6	18.2	24.6	5.2	0	0	63
Nycticorax nycticorax	0	0	0	0	0	0	30.2	52.4	17.4	0	0	105

See Table I for common names of birds.

Table V. Food snatching and food probing employed by 12 Ardeid species observed monthly (Jan 2018-Dec 2019) at Lungh Lake, Pakistan.

Scientific name	N	Food snatching (%)	Probing/ minute
Egretta garzeta	233	14.6%	45/m
Mesophoyx intermedia	111	9.8%	18/m
Bubulcus coromandus	301	16.0%	35/m
Ardea alba	189	2.2%	8/m
Ardeola speciosa	72	6.5%	6/m
Butorides striata	107	0	2/m
Ardeola grayii	256	6.8%	19/m
Ardea purpurea	73	4.8%	4/m
Ardea cinerea	50	8.2%	9/m
Ardeola bacchus	86	2.3%	22/m
Ixobrychus cinnamomeus	63	0	4/m
Nycticorax nycticorax	105	0	6/m

See Table I for common names of birds.

Table VI. Kruskal–Wallis all–pairwise comparisons test of observations by habitat

Name of activity	Mean value	Homogenous group
Walking slowly	112.13	A
Stand and wait	109.71	A
Lean and wait	93.542	A
Stand and feed	84.417	AB
Perching	71.250	ABC
Prey chasing	68.750	ABC
Walking quickly	60.792	ABC
Wing flick	40.625	BC
Aggressive	40.417	BC
Gleaning	26.083	C
Toe shuffling	23.792	C

Alpha value, 0.05; Critical value, 3.317; Critical value for comparison, 51.799

often foraged in mixed flocks. While some Ardeids have been considered as solitary feeders, a few as group feeders and some as both solitary and group feeders (Kushlan and Hancock, 2005) it seems that most species may switch between solitary vs group-feeding, depending on the habitat and prey availability (e.g., Wiggins, 1991; Dimalexis *et al*., 1997; Kazantzidis and Goutner, 2008). We also found that the little egret and Eastern cattle egret were the most active foragers, which is supported by other studies (e.g. Aboushiba *et al*., 2013). Furthermore, these two species, together with the intermediate egret, were the most aggressive, which may be an indication of increased aggressiveness in group-feeding vs solitary foraging (e.g. Post, 2008).

Our results also indicate that ardeids are habitat specialists, similar to Choi *et al*. (2008). For example, the great egret, grey heron and purple heron preferred deep water devoid of vegetation, probably because they feed on larger–sized prey, often waiting patiently for their prey to come within the range of the beak and neck (Voisin, 2010). The little egret, intermediate egret, little heron, Chinese pond heron, Indian pond heron and Javan pond heron utilized the wetland edges and tended to congregate in shallow waters, especially in ditches, where water was shallower than the length of the tarsus, to catch fish fingerlings, aquatic invertebrates, i.e., backswimmers, mollusks, orthopteran larvae, and even amphibians. In contrast, the cinnamon bittern selected emergent vegetation to hide in and hunt for aquatic insects resting on the vegetation (e.g. Paszkowski and Tonn, 2000; Gawlik, 2002). The Eastern cattle egret was the only species that frequently used the agricultural fields and grassy areas for foraging. They often followed the cattle to feed on grasshoppers, crickets, mole crickets and beetles that hide in ground vegetation and disperse with the movement of animals (Kour *et al*., 2014).

These differences in habitat selection reflect differences in tarsus length and beak morphology (Voisin, 2010). Additionally, vegetation composition and structure, water depth, and prey size and richness also influence habitat selection in wading birds (Wiens, 1989; Bancroft *et al*., 2002; Gimenes and Anjos, 2006; Stolen, 2006). In general, the abundance and diversity of food resources influence the spatial and temporal fluctuation of bird populations (Butler and Vennesland, 2000; Gaines *et al*., 2000) and indicate the productivity and suitability of habitats (Gimenes and Anjos, 2006). Overall, differences in foraging techniques and habitat use within a guild are an indication of resource partitioning (Weller, 1999; Gatto *et al*., 2008; Lopez de Casenave *et al*., 2008) also observed among ardeids (e.g. Ye *et al*., 2021; Abbasi and Khan, 2023).

Lungh Lake is a small freshwater lake, in an ancient arm of the Indus River, fed by surplus water from the surrounding rice paddies. The wetland has almost disappeared because of overgrown vegetation and is listed among the most threatened wetlands of the area (Izhar–uI–Haq *et al*., 2016). We have shown that Lungh Lake is a highly productive and attractive habitat for Ardeid species. It is part of the wetland complex of the Central Indus Plain where a multitude of human activities, including harmful fishing methods, overfishing, extensive use of agro–chemicals,

urban and industrial wastes, hunting and removal of flora are causing serious damage to the wetlands and associated biodiversity in this region (Khan and Arshad, 2014). The biodiversity of Pakistan's wetlands reflects the passage of the Indus River, spanning from high mountains to the lowland areas that finally drains into the sea (Chaudhry, 2010). It has great potential to generate sustainable revenue, such as eco-tourism, which can provide earnings for the inhabitants who largely depend upon the wetland resources of the region (Khan and Arshad, 2014). Pakistan supports over 780,000 hectares of wetlands, covering 9.7% of the total land area, including 225 nationally significant sites, out of which 19 are Ramsar sites (Chaudhry, 2010). The wetlands of Pakistan are under tremendous stress due to unsustainable human practices (Khan and Arshad, 2014). A lack of awareness about their ecological services is a major threat to their conservation, and there is an urgent need for National and Regional Wetland Management Plans to be drafted (Chaudhry, 2010; Khan and Arshad, 2014; Izhar–uI–Haq *et al*., 2016). Therefore, we propose that the conservation of Lungh Lake habitat is essential for Ardeid protection. Our study confirms the niche partitioning hypothesis, in which Ardeids don't overlap their foraging strategies to catch and consume their prey, meaning they often select heterogeneous locations and different water depths to do so.

CONCLUSION

Based on the findings, Ardeids employ a wide range of foraging techniques while capturing different food items and exploit different habitats where prey items often concentrate, particularly in shallow waters, lake edges, and thick matts of sedges.

DECLARATIONS

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Ethical statement and IRB approval

Verbal approval was obtained from Wetland Sanctuary Warden in charge for data collec-tion. In this study, bird data were collected using the Distance Sampling Point Count Method. Da-ta on wild birds was collected in accordance with guidelines for wild bird research. The stress on birds was minimized at all costs. The Vanguard Platinum spotting scope (20 x 80mm) and binoculars (Olympus; 10 x 50mm) were used for direct observations, which did not cause stress to birds.

Generative AI and AI-assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Statement of conflict of interest

The authors have declared no conflict of interest.

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