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FORAGING BEHAVIOUR AND FEEDING SUCCESS OF THE BLACK IBIS (*PSEUDIBIS PAPILLOSA*) INHABITING RURAL AND URBAN AREA OF CHURU CITY, RAJASTHAN, INDIA

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Abstract

Foraging behaviour and feeding success of the Black ibis (*Pseudibis papillosa*) were studied during 2003 - 2006 in the rural and urban area of Churu city, Rajasthan, India. The bird is chiefly non visual tactile forager and exhibits various types of feeding behaviour viz. probing (shallow, deep, stepping, stationary and multiple), standing, walking, running, groping, pecking, standing fly catching, bill dragging and flipping. The studies were conducted in seven different microhabitats to which the birds were frequent visitors. They were waste water body (WWB), municipal garbage dumping station (MGDS), animal dead body dumping station(ADBDS), agriculture field (AF), sand dune (SD), forest area (FA) and grazing field (GF).The Black ibis also follows seasonal selection of various microhabitats depending on the food availability. As such the birds were found in the flock of 5 to 15 at the carcasses center in the winter season. Solitary (singleton) feeding was also noted at the municipal garbage dumping station, waste water bodies and sand dunes during aforesaid season. Contrary to this the Black ibis (*Pseudibis papillosa*) either solitary or in flocks of 5 to 7 feeds exclusively in the agriculture fields and grass lands during the rainy season. However, the bird either solitary or in small flocks of 3 to 7 occupy wide varieties of microhabitats during the summer season viz. sand dunes, waste water bodies, municipal garbage dumping station and carcasses center etc. Moreover, the feeding in the garbage and muddy shore of waste water pond are the common feature throughout the year.

Keywords: Foraging behavior, Black ibis, Rural and urban area, Churu, Rajasthan, India

Introduction

Any living organism requires considerable amount of energy for the survival and reproduction. Because, birds do not accumulate enough reserve food in their body as compared to high daily energy expenditure; constant food intake is essential on day to day basis to fulfill energy demand. Bird living in mosaic of natural habitat patches may face space and time constraints while securing their energy requirements. Therefore, foraging strategies adapted by birds are one of the major interesting fields.

Kushlan (1978 a) summarized various aspects of feeding ecology of wading birds. Vast literature on foraging ecology of wading birds exists, but Ibises are much less explored. Very little is known about the stomach contents (Mason and Lefroy 1912), feeding ecology of the Black ibis apart from general description given by Ali and Ripley (1983) and Hancock *et al*. (1992). Several studies have been conducted at Rajkot (Salimkumar 1982, Seshukumar 1984, Vyas 1996), Junagah (Chavda 1988), Churu (Soni 2008) and at Jamnagar (Lathigara 1989). These studies revealed that habitat utilization by the Black ibis is non-stereotypic and varied in different localities. It evinced to the problem of habitat selection in the Black ibis that might be influenced by constraints of foraging behaviour and availability of food.

Seasonal variation in food abundance often influences habitat use pattern. Seasonal rainfall pattern changes availability of food in birds (Fogden 1972). For most of the wading birds, critical seasonality is created by wet and dry cycles of weather (Kushlan 1978a). Many wading birds forage early in the morning and are more likely to forage in flocks. Although early morning feeding is explained in part by the preceding nightlong fast, early feeding may also be the result of a predictable and temporary increased availability of prey. Hafner *et al.* (1993) found that timing of flock feeding and temporal variation in foraging success of Little egrets in the Cambridge of France were explained by low dissolved oxygen levels in water during the morning, soon after sunrise, dissolved oxygen increased as a result of the diurnal portion of plant respiration, and capture rates decreased rapidly. Many ibises undertook regional movements with seasonal changes in prey availability (Carrick 1962, Urban 1974,

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Kushlan 1976a, Ogden *et al.* 1980), which allows utilizing productive habitats available in other areas. Some ibises altered habitat use to exploit sequential availability of food in different habitats (Kushlan 1979, Manry 1982, 1984). Seasonal variation in habitat use is also recorded in the Black ibis (Sheshukumar 1984, Chavda 1988). However, seasonal pattern of habitat selection and its relation to food availability could not be established by researchers. Therefore, it was studied during this study.

Feeding and breeding ecology of bird species could influence substantially by drought. Each species may differ in response to cope with the impacts of drought that usually exerted through scarcity of food. During drought reduced breeding performance were recorded in many ibises due to scarcity of food (Carrick 1962, Ryder 1967, Dusi and Dusi 1968, Robin 1973, Ogden *et al.* 1980, Manry 1985). Some species of ibises observed to undertake regional movements in response to reduced food supply (Carrick 1962, Urban 1974, Kushlan 1976a, Ogden *et al.* 1980, Hancock *et al.* 1992). Whereas in some birds, expansion of foraging niche or habitat use (Fischl and Caccamise 1985) and shift in diet (Ward 1969) occurred under shortage of food. Wading birds may forage on food left by humans. In Africa, Marabou storks frequently eat offal from slaughterhouse (Hancock *et al.* 1992), an easy extension of their natural habit of eating carcasses of large wild animals. Powell and Powell (1986) described routine consumption of bait fish from local human residents among Great blue herons in Florida Bay, and showed that some birds specialize in begging bait fish from residents. Reliance on human food source may become particularly important when other foraging choices become restricted.

Population of the Black ibis in arid zone of Rajasthan often experiences drought. Chavda (1988) has studied some aspects of ecology of the Black ibis at Junagadh during drought. He has recorded that habitat used by the Black ibis at Junagadh during drought found different from that of observed at Rajkot during normal season. However, he could not conclude whether the difference attributed to effect of drought or to different habitat available in the areas.

Materials and Methods

The study area was surveyed before starting actual research to classify various foraging grounds (microhabitats or microclimates) as per Seshukumar (1984). All the microhabitats were visited once a week during 2003-2006, and number of foraging birds counted to decide preference for habitats in summer, monsoon and winter seasons. Observations were made by using Olympus binoculars (10×50) to record number of Black ibis found in different microhabitats. The Black ibises observed in aquatic and terrestrial habitats were separately recorded to avoid confusion due to diurnal foraging rhythm. Chavda (1988) showed that the Black ibis exhibits striking diurnal rhythm in which it occupied terrestrial habitats during morning and evening time and gather at aquatic habitats during noon hours. Such diurnal foraging rhythm was studied at least, once a month and observations were made throughout the day at an hourly interval covering all feeding sites. Observations were intensified during critical time when it shifted habitat during morning between 8:30-12:00h and afternoon between 15:30-17:00h (Chavda 1988) to determine time allocated by the Black ibis at both types of habitats. The student's t-test was used to determine the statistical significance between any two seasons.

Focal sampling method (Altman 1974) was used to study various feeding and foraging behaviours of the Black ibis found in different microhabitats. Observations were taken in seven microhabitats viz. waste water body (WWB), municipal garbage dumping station(MGDS), animal dead body dumping station(ADBDS), agriculture field(AF), sand dune(SD), forest area(FA) and grazing field(GF). Actively feeding individual was selected as a focal bird and attempts were made to cover different individuals found in various feeding sites. Focal bird was constantly watched for 3 to 8 minutes from a distance of 10 to 30m. Observations on feeding behaviours such as, number of steps, probes, food items taken, scanning for predator (vigilance) and other activities (i.e. preening, hopping, encounters etc.) were recorded in audio cassette using recorder and data were analysed later in the laboratory. These events were also recorded in movie by using Sony handycam recorder and data were analysed in computer. Time allocated in various foraging activities including steps, probing, handling time of food items, vigilance and other behaviour were derived from the recorded data to formulate time budget of the Black ibis foraging in seven microhabitats. From the recorded data six variables; step/min, probes/min, steps, probe, probing success (%), food intake rate (No./min and g/min) were also calculated.

Nomenclature to describe various feeding behaviours of the Black ibis was followed as per Kushlan (1977b, 1978a):

Feeding behavior

(1) Probing: The placing of the slightly open bill into the substrate and closing the tip on encounter of the prey.

(a) Shallow probing- Less than quarter deep insertion of the bill into sediment.

(b) Deep probing- More than quarter deep insertion of the bill into the sediment.

(c) Step probing-The bird probes while stepping.

(d) Multiple probing-The birds probes at the same spot from shallow to deep.

(e) Stationary probing- Applying shallow, deep, or multiple probing around the body while standing at one location.

(2) Standing fly catching: Catches air born prey while standing.

(3) Pecking: Picks up the food material from the surface of the substrate.

(4) Bill dragging: The bird drags its bill through the loose substrate.

(5) Flipping: Turns over objects like dry cattle dung or stones to feed underneath.

(6) Foot raking: Bird racks the substratum with its foot to get out the hidden prey.

(7) Groping: The bird holds open bill into the water and lift it up.

(8) Hopping: Flies short distance and alight.

(9) Head swaying: Moves head from side to side out of water.

(10) Head swinging: Moves bill from side to side in water.

(11) Running: Moving quickly, or in this study, chasing a moving or flying insect.

Foraging behaviour

(1) Steps: Bird walks slowly to fast from one feeding spot to another.

(2) Neck shake: Bird shakes its neck to remove unwanted adhesive material, or to get rid of flying insects.

(3) Body shake: The bird fluffles feathers and shake itself.

(4) Vigilance: The bird's attention is drawn by someone in the neighbourhood. Its neck is been straighten and its bill is lifted a little upwards (Draulans et al. 1986).

(5) Preening: The bird arranges its feathers on the feeding ground.

(6) Resting: The bird stops feeding. It stands on its one foot or sits on the substratum.

Results

Feeding behaviour

The ibis exhibited 10 kinds of feeding behaviours in the 7 microhabitats (Table: 1). Probing behaviour was found as the chief technique with more than 90.00% time applied in the 6 microhabitats. Probing was very common in MGDS and WWB. ADBDS was the only ground where probing was exercised as low as 36.16% time in relation to the other applied behaviours. However, probing was found to be employed more or less with its subtle in all the 7 microhabitats. Except step probing, all the probing behaviours were considered as a stationary application. Standing fly-catching was uncommon and applied in a microhabitat which had a considerable amount of flies. It was mainly used in the FA and GF but success rate was more in MGDS and ADBDS with 85.63% and 50% respectively. Packing a visual feeding technique was applied in all the microhabitats with relatively less in FA and SD. Bill dragging, flipping, and foot raking were used rarely; depending upon the situation and type of prey.

Table:1. Application of various feeding behaviours of the ibis observed in the seven microhabitats * =Occurs, + = Occasionally occurs, — =Does not occur

Microhabitat Behaviour	WWB	MGDS	ADBDS	AFH	SD	FA	GF
Shallow probing	*	*	*	*	*	*	*
Deep probing	*	*	+	*	*	*	+
Step probing	*	+	*	*	*	*	*
Multiple probing	*	*	*	*	*	*	*
Standing flycatching	—	+	+	—	+	+	+
Packing	+	+	*	+	*	*	+
Bill dragging	+	+	—	—	+	+	—
Flipping	+	—	—	+	*	*	+
Foot racking	+	+	+	+	+	+	+
Groping	—	—	—	—	—	—	—

WWB= Waste Water Bodies, MGDS=Municipal Garbage Dumping Station, ADBDS=Animal Dead Bodies Dumping Station, AFH= Agriculture Farm House, SD=Sand Dunes, FA=Forest Area, GF=Grazing Field

Whereas groping was totally absent in all microhabitats. In sand dunes (SD), the ibis used stepping and probing to dig out the beetles. The Black ibis showed catching and probing in GF. Probing behaviour was also seen in the GF where the ibis was feeding on dung maggots.

Shallow probing was applied in all microhabitats but success rate was greater in MGDS and ADBDS, whereas deep probing was mainly applied in all the microhabitats while it occasionally occurs in the ADBDS, SD and GF. Step probing was also found to be used commonly with a little preference in MGDS. Another frequently exercised subtle was multiple probing.

It was most commonly applied in all the microhabitats with least preference to GF. Below is a five minute excerpt from my field observation recorded in tape recorder.

Foraging- Prey density recorded in all the classified microhabitats has been highlighted in the Table: 2. Highest average of the prey in one square meter quadrate was 52.4 insects recorded in the MGDS. Whereas lowest prey density was recorded in the grazing field with 1.7 preys items/square meter.

Food density and number of feeding attempts by the ibis were noticed relatively higher in the WWB, MGDS, and ADBDS. Feeding attempts in the SD, and the AFH were higher than the FA and GF even though density of food was recorded more or less equal. Highest average of the feeding attempts with 9.74 per minute was recorded in the ADBDS. And minimum average attempts per minute were 3.04 in the FA. These variations in the feeding attempts were also obtained by applying analysis of variance.

Analysis of variance

Source of Variation	df	SS	MS	F	P	Variance	F.critical
Between Sample	1	160.07	160.07	0.9358	0.3524	335.5	4.742
Within Sample	12	2052.6	171.05			6.57	

Table: 2. show the higher success of feeding was associated with the rate of attempts. Highest foraging success was in the ADBDS with 87.87% positive attempts. But actual average feeding period recorded in 30 minute interval was highest in the MGDS with 31.2 followed by WWB with 24.6 and ADBDS with 24.2.

Table:2. Feeding rate, success, foraging, and food density recorded in the microhabitats. Data are presented as the mean value. Percent successful feeding attempts in parenthesis

Habitat	Observations att/min	Success att/ min.	Steps/min	Feeding (min) / 30 min.	Food density/ m2 with 15cm depth
WWB	3.33	0.42 (12.71)	7.2	24.6	9.4
MGDS	7.89	6.03 (76.48)	2.6	31.2	52.4
ADBDS	9.74	8.56 (87.87)	4.4	24.2	13.8
AFH	5.36	0.64 (12.01)	34.6	17.0	2.8
SD	5.11	0.37 (7.41)	36.8	16.0	2.6
FA	3.04	0.28 (9.43)	32.2	12.4	2.4
GF	3.29	0.24 (7.47)	23.4	12.8	1.7

Att = Feeding attempts, Success = Successful attempts, Food density is given as a number of prey items.

Table 2 also exhibits the number of steps taken in 3 successfully exploited grounds viz. WWB, MGDS, and ADBDS were relatively lower than the steps taken in the other 4 microhabitats. Minimum average 2.6 steps/min were recorded in the MGDS and maximum average 36.8 steps/min were recorded in the SD. These variations in the steps/min were also obtained by applying analysis of variance.

Analaysis of variance

Source of Variation	df	SS	MS	F	P	Variance	F.critical
Between Sample	1	224.80	224.80	0.7983	0.389142	335.5	4.7472
Within Sample	12	3378.2	281.56			227.59	

Time budget

Various activity of a forager recorded to analyse the time consumed in each activity. It reveals that the relatively little percent of time has been spent in a body maintenance behaviour in the WWB, MGDS and ADBDS (Table: 3).Whereas highest percent time with 18.47% was spent in resting in the GF by the ibis. But resting in the WWB and AFH was not seen. Mainly the ibis was noticed to feed extensively in the WWB, MGDS and ADBDS where it spent more then 80.00% time in feeding and noticed to minimize walking time to less than 10%.The lowest time devoted in feeding was found in FA i.e. 41.43% and maximum time devoted in walking was also found in FA i.e. 42.18%. Vigilance was a frequent behaviour performed on all the defined microhabitats with the maximum 8.42% times in the AFH and minimum 00.47% in the ADBDS. Interactions took place while foraging in a flock in all microhabitats except GF. Maximum interactions were observed in ADBDS with 02.40% time and minimum in GF with 00.00%.

Table: 3. Time budget of foraging behaviour of the ibis recorded in the 7 microhabitats. Data are presented as the percent time. N= Sample size with 1 sample = 30 min

Habitat Foraging activity	WWB N=7	MGDS N=204	ADBDS N=7	AFH N=15	SD N=16	FA N=16	GF N=20
Preening	00. 38	00.68	00.00	01.44	01.16	01.64	01.42
Neck shake	00.19	00.26	00.06	00.16	00.46	00.32	00.04
Body shake	00.14	00.04	00.00	00.07	00.11	00.06	00.11
Resting	00.00	05.24	08.46	00.00	06.12	06.75	18.47
Vigilance	05.16	05.70	00.47	08.42	07.70	07.46	04.46
Interaction	00.52	01.74	02.40	00.09	00.06	00.16	00.00
Walk(steps)	08.12	05.34	07.24	34.26	35.18	42.18	24.96
Feeding	85.49	81.33	81.37	55.56	49.21	41.43	50.54

WWB= Waste Water Bodies, MGDS=Municipal Garbage Dumping Station, ADBDS=Animal Dead Bodies Dumping Station, AFH= Agriculture Farm House, SD=Sand Dunes, FA=Forest Area, GF=Grazing Field

Discussion

A non-visual tactile forager was characterised by the primary feeding techniques to capture its prey present underneath the any type of substratum. Its selection for the particular seven microhabitats and ten feeding techniques were apparently inherited from the generations living in the arid zone of Rajasthan, which were exploiting the available seven microhabitats. Because there is no evidence of any single general theory which explains habitat selection. The Black ibis used various feeding behaviours in different microhabitats. However, it is primarily non-visual tactile forager, feeds mainly by walking slowly and probing into substrate. Almost all Ibises, use probing as a principal technique to capture prey (Hancock *et al*. 1992). Walking slowly is very common feeding behaviour used by most wading bird species (Kushlan 1978a). In the Black ibis it was mainly associated with probing. The ibis applies various probing techniques which depend upon the type of prey, type of hard or soft substratum, depth at prey was available, and mobility and density of prey. But abundant density of prey on the surface of the substratum in the ADBDS results visual feeding niche, which could play a beneficiary role in adapting various foraging grounds (Kahl 1964, Kushlan and Kushlan 1975). This statement rationalizes by essence for its pursuant towards exploiting various terrestrial microhabitats successfully, though it is secondarily a water-bird species. It exhibits several feeding behaviours demonstrates its flexibility in its activity level with response to the nature of the habitat, morphological and physiological features of prey and availability of prey, such as feeding ground with relatively higher prey density allow the ibis to apply universal techniques; stand and feed (Kushlan 1978a).Given a repertoire of potential feeding behaviour, the Black ibis probably chooses any behaviour based on success rate or net energy return to fit its current need Though feeding repertoire of the Black ibis was restricted mainly to probing and walking slowly, subtle variations were recorded in frequency occurrence of behaviour in different foraging habitats. The variations were probably attributed to different degree of food dispersion in various habitats. The Black ibis use walking slowly less often and probing more frequently in habitats such as WWB, MGDS where success rate was relatively higher due to abundant food in discrete patches. The reverse phenomenon was observed in habitats like AFH, FA, GF and SD where food items were found widely dispersed in low density. Such variation in frequency, use of feeding behaviours allows the Black ibis to explore various microhabitats energetically in efficient way.

Feeding techniques such as aerial fly-catching and groping were restricted to some microhabitats and used in any one situation. Aerial fly-catching seems to be a passive feeding technique in which the bird wants to avoid the disturbance of an airborne prey. Looking at an over all applications of grabbing air born, it is considered a secondary behaviour of feeding. Whereas application of groping is seen rare in the water due to its niche selection preference, and may be because the bird is not dependent on water such as White ibis (Ali and Ripley 1983).

A special use of feet in foraging is sighted as common among waders (McLlhenny 1936, White 1947, Haverschmidt 1948, Rand 1956, Hobbs 1957, Meyerriecks 1959, 1962, 1966, 1971, Recher and Recher 1972, Kushlan 1978*a*, Baird *et al*. 1984). However, foot racking is employed in a particular situation by the ibis to capture moving prey like spiders, hidden underneath the loose substratum. Further, habit of feeding on slow ground dwelling insects may dissuade to run after relatively fast moving insects. According to Kushlan (1978a), bird is more likely to choose behaviour based on its success rate or on the time between successes. Application of packing instead principally used non-visual tactile method by the Ibis in the ADBDS showed relevancy towards successful attempts due to abundance of the prey items around the carcasses rather underneath the substratum. Whereas well scattered prey underneath the soft mud in the WWB reinforces the chances of escaping one shallow or deep probing. Hence, multiple probing is employed cardinally adapting to that ecosystem. In other microhabitats with the relatively lower prey density, the bird takes more steps in search of a better feeding spot by declining its feeding rate on the cost of a higher searching time. Likewise, depending upon the situation, foraging tactics may change from habitat to habitat and minute to minute.

Among body maintenance behaviours, preening is performed moderately to devote major time in feeding. Moreover preening is mainly practiced during the pre-roosting and roosting time at the end of the day. Application of head shake and bill shake applied when it is necessary to release unwanted wet and soft soil attached to the bill. Body shake following fluffing up feathers is practicable in removing flying ectoparasites settled on the body.

Ornithologists assumed that, in addition to looking for mates, birds flock to reduce the risk of predation or to increase their foraging success. Flocking reduces the risk of predation in at least two ways. First, a flock has more eyes to detect predators than does a single bird (Pulliam 1973). Second, flocking offers safety in numbers because individuals crowding near the centre of the flock are shielded from predation by those on its periphery. Flocking makes singling out a target more difficult for attacking predators (Hamilton 1971, Page and Whitacre 1975, Kenward 1978, Caraco 1979). Likewise, flocking can enhance foraging success either by increasing the probability of searching and exploring food resources. In flocking unknowing individuals can follow the knowledgeable ones to the best feeding sites (Ward and Zahavi 1973) or they may learn or copy the successful foraging techniques of their flock mates (Krebs *et al*. 1972).Thus flocking reduces the risk of predation and enhances one's feeding rate (Abramson 1979). Function of social gathering in birds is often emphasized as anti-predation behaviour (Lack 1968, Pulliam 1973, Weatherhead 1983). In large aggregation, a predator could be detected more easily by mutual awareness of flock members than by an individual bird (Pulliam 1973, Elgar and Catteral 1981). Therefore single individual is more likely to become target of predators (Page and Whitacre 1975, Kenward 1978). If adult Black ibises are feeding in flocks to reduce their risk of predation; such behaviour would have two effects on their foraging behaviour. First, birds in large groups exhibit significantly fewer scanning efforts than would those feeding in small flocks or as singletons. Birds in large groups should look up less often and for briefer periods because other flock members would be, in effect, sharing this responsibility. Second, birds feeding in large groups forage more efficiently (i.e., capture prey more frequently and with fewer steps and probes) because they would be spending more time looking for prey and less time looking up for predators. Precaution on fear being expressed in scanning while foraging is seen directly responsive to the disturbance. As other wading birds, the Black ibis also rest during the brightest hours of the day when predation risk may be high at feeding ground. Therefore they gather at well exposed aquatic habitat and muddy shore for resting. An inattentive foraging flock seek highest period in vigilance than anywhere else. Vigilance act is seen when anything suspicious is approaching near to the flock; such as motor vehicle in the MGDS, street dogs in the ADBDS and human interference in the sewage and other microhabitats. It is least required in the carrion where flock size is large so alertness among individuals is moderate, feeding success is high.

Bird species that face seasonal fluctuation in availability of food have two alternatives, (1) they may shift to feeding on other food resources, or (2) may move to other area where original food resource is available (Karr 1976).The Black ibis seems to follow former pattern. Rainfall pattern and environmental changes associated with it has shown to influence seasonality in many bird species (Beals 1970, Fogden 1972, Karr 1976).Rainfall pattern affects phenological conditions of grazing land, seasonal crops and thus food availability. Hence seasonal changes in availability of food play a dominant role in habitat use pattern in the Black ibis. Seasonal variation in the number of Ibis in various microhabitats is appeared largely attributed to seasonal condition of the feeding grounds and its impact on the availability of food. Kushlan (1978a) recorded similar observations on wading birds feeding in aggregation due to patchily distribution of food. In MGDS, food is available to the Ibis throughout the year which allow them to forage in different seasons. Feeding in a group on the restricted resources may render benefit to individuals (Turner 1964). Kushlan (1976a) has also recorded the positive relationship between higher food density with the larger flock size has been reported in Great-blue heron (*Ardea heroidias*).Sewage is also exploited regularly by the ibis except during the rich rainy days, which drain the settled water with the bounty of insects. Whereas microhabitat such as AFH in rainy season flourishes with several insects and allow the Ibis to feed upon insects. The GF is lush-full during the monsoon and allow the Ibis to prey upon its meso-fauna, but the same ecosystem use to remain arid during winters and summers. Moreover, during the regular precipitation time, unlimited food supplies do not restrict the ibis to feed at any particular site.

Seasonal variation in resource availability plays dominating role in evolution of species and communities (Fogden 1972, Leck 1972, Beals 1970). Apparently this could be correlated to the Ibis, which is secondarily a waterfowl species but for-mostly found to forage in the man made terrestrial microhabitats.

According to Krebs (1974a, b) and Quinney and Smith (1980), external parameters like flocking affect the foraging success. Draulans and Van Vessem (1985) noticed that the Grey heron (*Ardea cinerea*) in their study area do not forage longer due to larger flocks. But according to Kushlan (1978b), foraging in aggregation is advantageous as it decreases searching time between the food patches. Moreover, in aggregation, because of mutual awareness, scanning time effectively gets reduced. Solitary forager must remain more alert against potential predators, and hence waste time and energy which affect the foraging efficiency. Aggregation may not necessarily cause the feeding interference as reported by Goss-Custard (1970) on the foraging flocks of Pectoral sandpiper (*Calidris melanotus*).Our observations in the Black ibis feeding on MGDS agree with them. Increased conflicts among feeding ibises during the winter is relevant due to higher aggregation and higher food density in MGDS, but do not influence the flock to leave the site. Young (1988) has reported same behaviour in flock mates of Pectoral sandpiper. Tolerance of aggression is compromised with the flocking advantages such as in Bald ibis foraging in burnt grassland (Manry 1984).

Foraging bouts of any predator can be divided into pursuit time, searching time and handling time (Kushlan 1979). For non-visual tactile forager, pursuit time is zero because first contact with the prey is the moment of capture (Kushlan 1979). Since the Black ibis is non-visual tactile forager, searching for food is most important because it determines the foraging efficiency. Abundance and distribution of food items differ in various habitats which have profound influence on searching time. The Black ibis expends the highest time in walking while searching food in terrestrial habitats where food items are found dispersed in wide area in relatively low density. Availability of plentiful food in discrete patches decreases searching time as in WWB, MGDS and ADBDS.

Even though there is a seasonal variation in the flock foraging strategy and the food availability in the MGDS, the exploitation of the MGDS remain regular with the relevant variation in flock size. This may be because even the lowest densities of food in the garbage do not result in increase of searching time potentially. Albeit it is recorded that the ibis makes less attempts in the garbage when density increases during the winter. Normally it shows a positive correlation between the density of prey and feeding attempts due to short searching time. Whereas types of prey in the garbage are small and slow dwelling. Hence, with the higher density of prey, more items are caught per attempt. As the Black ibis is a tactile forager to which density of food profoundly influences searching time. Hence, there is a differential preference of different microhabitats and even differential preference of any one microhabitat seasonally. The number of foraging microhabitats used by the Black ibis is substantially influenced by the drought. In the years with normal rain, habitat use pattern is quite stereotypic, during which

Black ibis occupies usually less microhabitats, but when rainfall is less, the Black ibis utilizes all seven microhabitats due to scarcity of food.

Recher and Recher(1969) reports say that foraging efficiency depends on increase in handling time and the prey escape. Kushlan(1978a),says that the White Ibis responds to robbing pressure by selectively releasing most preys. The Black ibis selects slow moving small size prey to maintain handling time zero and avoid kleptoparasitism in a flock (Schoener 1971). Kleptoparasitism is not observed in Black ibis. However, surprisingly for unknown reason the Black ibis some time releases large vegetative material without eating even after attempting to handle it. Such a common behaviour can not be accounted for any specific reason. Increased handling time can not explain this behaviour as handling time is significantly less when it is left than it is successfully consumed and perhaps it may be due to rotten character of food items.

Black ibis derives its all nutritional requirements from the small size insects like fly maggots and cocoons, which also provide it facility to come to the same resource patches like some other wading birds (Owen 1955, Bateman 1970, Coock 1978).Like other wading birds, the Black ibis also reserves the right to fight with other partners as it maintains feeding space and keep itself at a distance. Similar behaviour is reported in some wading birds (Kushlan 1981).Every species requires comfortable space among them while foraging, and therefore when crowding increases, interactions likely to increase. In some vertebrates, number of aggressive encounters per individual increases with the group size regardless to space (Myers *et al.*1971, Sale 1972).The majority of encounters among the Ibis are recorded in MGDS and ADBDS where crowding is denser in a smaller area. In birds, the group size influences the rate of aggression by increasing both the number of encounters and interactions per individual (Wilson 1975). Beside tactile prey searching techniques, an aggregated mixed flock foraging tendency of the Ibis also bring a close proximity with other species and increases social conspecific and heterospecific interactions (Grubb 1976, Woolfenden *et al.*1976, Kushlan 1978b).

Major occurrence of heterospecific interactions in AFH, GF, and WWB is apparently relevant to lower food density and of course presence of different avifauna. Because of lower food density, covering relatively larger area in search of a prey would certainly increase the chance of any forager to come in a close contact with other foraging birds. But the Ibis do not lose any heterospecific interaction against smaller species which can anyway win seldomly over larger opponents (Kushlan 1978b).

Occurrences of passive interactions among the ibis are foremost neglected by not responding like many other flocks feeding avian species (Morse 1970, Poysa 1986). The majority of the passive interactions are recorded as a losing incidence in wading birds (Erwin 1983).They may not guard the feeding spot. Further, heterospecific interactions of the ibis in MGDS are recorded chiefly with Cattle egret (*Bubulcus ibis*), which feed on flying insects. As Cattle egrets run to catch the airborne prey, they are likely to conflict with the birds standing and feeding in the same area as they do.

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