Symbiotic relationship of cattle and cattle egret (*Bubulcus ibis*)

THESIS

BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
LUCKNOW
प्रज्ञा शील करूणा
ESTABLISHED 1996

SUBMITTED IN FULFILMENT FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy

IN

APPLIED ANIMAL SCIENCES

SUPERVISOR
Dr. V. ELANGOVAN
(PROFESSOR)

SUBMITTED BY
MANISHA
ENROLLMENT NO.- 584/15

DEPARTMENT OF APPLIED ANIMAL SCIENCES
SCHOOL FOR BIOSCIENCES AND BIOTECHNOLOGY
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY
(A CENTRAL UNIVERSITY)
VIDYA VIHAR, RAEBARELI ROAD
LUCKNOW-226025

2021

This thesis is dedicated to my family and teachers

CANDIDATE'S DECLARATION

I hereby declare that the thesis entitled **"Symbiotic relationship of cattle and cattle egret (*Bubulcus ibis*)"** submitted by me for the degree of **Doctor of philosophy in Applied Animal Science** is the result of my original work carried under the supervision of **Dr. V. Elangovan**, Department of Applied Animal Sciences, Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow and it has not been submitted for the award of any degree, diploma, associateship of any university or institution. I also declare that this thesis is essentially free from all kinds of plagiarism.

Manisha

Signature of candidate

(Manisha)

Date: 02/11/21

Place: Lucknow

CERTIFICATE

This is certify that the thesis entitled **"Symbiotic relationship of cattle and cattle egret (*Bubulcus ibis*)"** submitted by **Ms. Manisha** is an original work and has not been submitted for the award of any degree, diploma, associateship of any university or institution.

The thesis submitted to Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, satisfied the all requirements as stipulated in the *Doctor of philosophy regulation- 1999 as amended in 2013* and it is fit for submission and evaluation for the award of the degree Doctor of Philosophy of the University.

Date: 02/11/2021

Place: Lucknow

Supervisor

(V. Elangovan)

10/11/2021

(Head)
Department of Zoology

ACKNOWLEDGEMENTS

I owe my heartfelt gratitude to my guide, ***Prof. V. Elangovan,*** *Department of Zoology, Babasaheb Bhimrao Ambedkar University, Lucknow, for believing me and giving me an opportunity to carry out this research work and for his impeccable ideas, scholastic guidance, valuable suggestions, meticulous supervision, wholehearted cooperation, support and freedom to work throughout the period of work. I have been honoured in having* ***Prof. V. Elangovan****, as my supervisor.*

I would like to thank the Head of the department of zoology and Dean Prof. ***Kamal Jaiswal*** *School for Life science, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow, for all lab facilities carried out during the research work.*

I profess my heartfelt gratefulness and sincere regard to ***Prof. Kamal Jaiswal, Dr. Venkatesh Kumar R****,* ***Dr. Suman Mishra, Dr. Abha Mishra****,* ***Dr. Sandhya*** *and* ***Neeshma Jaiswal*** *and all department research committee members, Department of zoology, School for Life science, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar, Raebareli Road, Lucknow, for their cordial co-operation, constructive criticism, suggestions and encouragement given at various stages for the improvement of this study.*

I would like to give my special thanks Hon'ble Vice-Chancellor ***Prof. Sanjay Singh*** *for providing sufficient time to accomplish this research work.*

My research is entirely based on the field work so it was almost impossible for me to carry my research work without supports of friends, local peoples and relatives. So I would like thanks ***to Dr. Anjali Verma, Dr. Subhas Kumar Yadav, Mr. Arun Pachauri, Mr. Deepak Verma, Mr. Syed Ahmad*** *and many local peoples who provides*

information about the study sites and also helps at various places during the research work.

I wish to give my cordial thanks to my seniors ***Dr. Mukesh Kumar, Mr. Ram Kumar, Mr. Deep Narayan Prasad****, and friends* ***Mrs. Akanksha Dwivedi, Shani kumar Bhartiy, Savita Gautam****. And who helped and cooperated in all situation of the research period. Just because of their cordial support, this journey became memorable which will be sustained for long time in my life.*

I am also thankful to non-teaching staff of the Department of Applied Animal Sciences ***Mrs. Dipti Singh, Mrs. Kavita, Mr. Abhishek Prakash Tiwari and Mr. Deepak Singh*** *for their official help and support during research work.*

Lastly, I feel a deep sense of gratitude for all my family members. No words of gratitude will be able to express my feeling towards my loving parents, my father ***Mr. Jiya Lal Verma*** *and my late mother Smt.* ***Meena Kumari*** *and my elder brother* ***Mr. Deepak Verma and Abhijeet Verma*** *for supporting me in all possible ways.*

(Manisha)

CONTENTS

LIST OF FIGURES

List of Tables

ABBREVIATIONS

Cm	:	Centimeter
Gm	:	Gram
°C	:	Degree Celsius
dbh	:	Diameter at breast height
IUCN	:	International Union for Conservation of Nature
e.g.	:	Example
%	:	Percentage
hrs	:	Hours
Km	:	Kilometer
M^2	:	Square meters.
Cm^3	:	Cubic centimeters
Mid	:	Middle
No.	:	Number
N	:	Number of sample
Mm^3	:	Cubic millimeter
SD	:	Standard deviation
AIC	:	Akaike information criterion
Ha	:	Hectare

GENERAL INTRODUCTION

General Introduction

Around 9000 avian species are distributed throughout the world, out of them, about 23% of the avian species are found in Indian subcontinents (Manakadan and Pittie, 2001). They are known to be depending on wetlands (Kumar *et al*., 2005). The population of bird is reducing persistently from last decades. About hundred species of birds are either endemic or endangered (Shukla and Lone, 2010). However, Asia is a very important for water birds because of many wetlands and ecological condition. Birds have been also used in environmental studies to assess the impact of anthropogenic activity on the ecological health of ecosystems. Uttar Pradesh state is an essential route for migratory birds, hence it is important to monitor the wetlands ecological and physical condition, anthropogenic load and species composition. Birds are the basic part of ecosystem (Prasad *et al*., 2012) in providing ecological services and functions such as seed dispersal, pollination. These birds are the good indicators of water quality (Aynalem and Bekele, 2008). In the ecosystem, they are also valuable to humans in providing a pleasure, inspiration from watching and listening to birds sound (European Commission, 2004). Urbanisation and development activities including the promotion of tourism for socio-economic improvements are degrading the natural ecosystems, where the adequate attention has not been given to environmental conservation (Maharana *et al*., 2000). Urbanization and recreational activities are the two major causes in declining the species population. (Czech *et al.,* 2000). The determination of distribution and abundance of bird species could be made by knowing the composition of vegetation**.** Seasonality and consequent variations in the availability of food resources also results in seasonal changes of the species richness and abundance of birds (Williams and Middleton, 2007; Nirmala, 2016).

During last century in Asia, Australasia, Europe and America (Maddock and Geering, 1993;Pajero *et al*., 2010) the range of this bird spread extremely and now it is found in all continents excluding the Antarctica (Martinez and Motis, 1992).

The cattle egret is a medium sized bird, with a 'hunched' posture, even when it is standing erect. In comparison to other egrets, having short legged with thick necked. Cattle egrets generally attain a body length of 46-56 cm, a wing span of 88-96 cm, and body a weight of around 360 g (Scott and Rose, 1989). The plumage generally is white in both adult sexes, with a dull orange or yellow bill, and dull orange legs, for a brief period of time during the breeding season. However, the plumage of the breeding adults is dark orange at the head, neck, back, and the eyes. Legs and bill are a bright red. Because of this coloration, it is sometimes called the Buff backed Heron. (Telfair, 1994)

Classification

Common Name – Cattle egret

Local Name – Bagula, Heron

Zoological Name – *Bubulcus ibis*

Kingdom – Animalia

Phylum – Chordata

Class – Aves

Order – Pelecaniformes

Family – Ardeidae

Genus – *Bubulcus*

Distribution & Status: It is well known that the cattle egret has expanded its breeding range worldwide since the beginning of the 20th century (Cramp 1980; Bull and Farrand, 2000). Its breeding population has progressively increased in Italy too (Brichetti and Grussu, 1992). In Tuscany the first breeding was recorded in 1997 (Scoccianti and Tinarelli, 1999) and for Grosseto province it was reported in 1999 (Giovacchini *et al*., 2001). Cattle egret population in Tuscany increased to 361 breeding pairs (Centro Ornitologico Toscano, 2005). Despite its expansion of breeding range and increase in number, the data about the breeding biology and reproductive success are quite scarce for Europe, if compared with those outside Western Palearctic. Even few data is available for the birds nesting in Italy, although cattle egret is the species listed as Vulnerable under IUCN criteria (BirdLife International, 2014).

Symbiotic relationship of cattle and cattle egret

Foraging theory predicts that animals make decisions i.e. behavioural manipulation and foraging association about foraging, which maximize the foraging efficiency (Krebs *et al*., 1981, Stephen and Krebs 1986). The currencies of optimal foraging models usually suggest that energy and nutrient or gains, although they may be qualitatively different (food intake, predation risk, habitat suitability). Optimal foraging should result in maximum fitness, although this is often difficult to measure. Symbiotic relationship is a long term close association relationship between two or more species and provide a unique opportunity to examine the factors involved in decision-making, as because of their foraging, depends not only on prey behaviour and abundance, but also on another animal. Animals that forage with other species have to decide whether or not to seek a host or "beater", and which host species are to be selected. Further, they have to contend competitively for the best hosts. Cattle egret is

one of the best-known bird species to use such foraging strategies, usually forage in association with large mammals. (Heatwole, 1965; Siegfried, 1971; Thompson *et al*., 1982). Cattle egrets regularly forage in association with large mammalian herbivores in fields and Pastures, where they catch insects which are flushed by grazing mammals (Heatwole, 1965; Jenni, 1969). Which feed near the grazing cattle, requires fewer steps and take less time to catch prey in comparison with those which forage away from cattle in the same habitat (Heatwole 1965; Dinsmore 1973; Grubb 1976) and single egrets foraging with cattle obtains the prey at a maximum rate than those forage in groups and with cattle (Grubb, 1976). In symbiotic relationship of cattle egret with cattle, is beneficial to the host. For instance, cattle egrets remove the ecto-parasites such as ticks, mites from the host, these parasitic feed blood of host (Skead, 1963). In many associations with cattle egrets, it was observed that the hosts are especially large herbivores. Although sometime, the egret disturbs the resting cattle by beating their wings purposely to change behaviour of the cattle in order to gain food flushed by the upset cattle (Dawn, 1959). The foraging behaviour is widely defined as collection and absorption of food by individual (Breed, 2001).

Diet selection and food composition of cattle egret

Documenting the diet selection and composition yields important knowledge about patterns of resources used by birds. Because food is an essential resource, in term of survivorship and reproduction (Yu-Seong *et al*., 2008). As their feeding on variety of habitat, show the dietary flexibility. Feeding on large variety of prey in a given ecosystem (McKilligan, 2005). Previous studies has described about the change in the diet selection by the cattle egret according to the season, prey abundance and availability of symbiotic gains as well as impacts of anthropogenic disturbance (Ducommun et al., 2008). Cattle egret were seen feeding in large flocks on insects from ploughed fields

(Patankar *et al*., 2007). They are having an ability to use human reserved habitats. And play a vital role for its success, due to their scavenger habit (Subramanya, 1996). The importance of this bird in insect management at different agro ecosystems has also been reported (Yadav, 2000). It is a sociable bird, noticed in small flocks nearby grazing livestock, following energetically the grazers, riding upon their backs, running in and out between their legs, and attacks the prey.

It is an essential aspect of avian species in which food resources are obtained and consumed by using variety of tactics. Therefore, foraging behaviour is one of the most important activity for avian species in term of foraging ecology (Yu-Seong *et al*., 2008). Most birds spend majority of their time in foraging related activity, either to feed or in search of food. (Mayntz, 2012). Approximately 41 foraging behaviours based on the movements, body and head posture and use of wing or feet have been reported in family Ardeidae that include egrets, herons and bitterns (Mckilligan, 2005; Kushlan and Hancock, 2005).

The foraging ecology is often characterized by food selection, habitat preferences and prey capturing tactic or behaviour displayed by avian species in particular habitat (Dunchin *et al*., 2008). In foraging behaviour cattle egret shows mainly these kind of feeding techniques, stand and wait feeding, disturb and chase feeding, aerial and deep water feeding. As they feeds on various habitats such as rice fields, freshwater marshes, salt marshes, river and estuaries (Custer *et al*., 2004; Trocki and Paton, 2006; Taylor and Schultz, 2008). And consume large variety of easily identified insects such as grasshopper, cricket, beetles, fishes, amphibians etc.

Effect of food on reproductive behaviour of *Bubulcus ibis*

Habitat selection and its use by birds is the main aspect to understand their

biology and management (Hilden, 1965 and Cody, 1985). Consequently, it has also been one of the most well studied aspects of avian biology, particularly as habitats are altered by human activities (Pain and Pienkowski, 1996). Continued process of degradation in natural environment, loss of aquatic ecosystem, has created worldwide concern for water bird population. In Colonial tree-nesting, water birds depends on an aquatic habitats for both nesting and foraging. Cattle egret are of most adaptive nature, possibly due to their versatile feeding behaviour and non-specificity of the nesting environment. Cattle egret usually build their nest at aquatic ecosystem in rural as well as in urban environment depending on safe nesting places, free from anthropogenic disturbance and presence of grazer animals to obtain a benefits of symbiotic relationship. This enhances the egrets foraging as well as reproductive growth.

Easy accessibility of food and suitable environment does effect (Mathew and Gadvi, 2004; Rao, 2004) a good nesting site, and protect from predators. Required support to construct the nest within foraging areas (Hafner and Fasola, 1992). The nesting sites also support the hatching success and positive rearing of chicks, that is essential for species survival (Ludwig *et al*., 1994). Water bird can serve as bio indicators, that they reflect the health of the landscape and wetland (Kushlan, 1993). The source of breeding population of herons, egrets and other associate aquatic bird species, play an important role in conservation of water birds in general and threatened species in particular. Successful conservation of water bird species depends on an improved understanding of ecological requirements (Fellowes *et al.,* 2001).

Breeding ecology, especially the phenology of birds is related to the climatic conditions (Jakubas, 2011). Knowledge of the arrival dates and breeding dates of bird

is an important for studying long term trends of changes in timing of breeding in the on-going climate changes (Parmesan & Yohe, 2003). Therefore, such information could be used as an indicator tool for assessing the adverse impact on the ecological system. The worldwide surviving success of cattle egrets is credited to high habitat versatility due to capability of associating with anthropogenic habitats and feed on diversity of prey (Subramanya, 1996). Cattle egret appears to be the most adaptive by nature, possibly due to its versatile feeding behaviour and non-specificity of the nesting environment. This bird have been described to nest in agro-ecosystems, in rural as well as urban environment, which depends upon safe nesting places, food availability, and other environmental factors as presence of host animal and free from anthropogenic activities (Mathew and Gadvi, 2004; Rao, 2004).

Cattle egret foraging habit makes them important biological control agents because they are insectivorous birds. Cattle egrets consume some insects of public health importance as well as agriculture pest. In India especially in Uttar Pradesh, there are very less published literature is found i.e. Hillauddin (2003), Kushlendra (2012) and Rajneesh (2015) particularly on the behavioural ecology of cattle egret i.e. Symbiotic relation of cattle egret with host organism, effect of host on diet selection and reproductive behaviour. Therefore, the present study was planned to investigate the behavioural ecology of cattle egret.

REVIEW OF LITERATURE

Chaskda *et al.* (2018) studied the foraging success of the cattle egret (*Bubulcus ibis*) relating to insect abundance, herd and flocks size. They compared the cattle egret foraging success between foraging with cattle and foraging without cattle, during rainy season. Through focal observation method, 100 cattle egrets were observed. Presence in abundance of insects at each site was recorded using sweep net and direct counts. Cattle egrets foraging with cattle, significantly capture more prey and spent less time than those feeding alone However, there was no significant relationship found between foraging rates with flock size ($p > 0.05$) and insect abundance ($p>0.05$ for solitary feeding birds. They have suggested that the close benefits in terms of enhanced foraging success could be the reason for the strong association between the two organisms.

Sahi *et al.* (2017) have studied on clutch characteristics and egg diametrics of Indian Pond heron (*Ardeola grayii*) in Jammu region (J&K). The study was conducted for three consecutive years i.e., 2013, 2014 and 2015 in five different stations viz., site- I (Haripur), site- II (Mansar), site- III (Gharana), site- IV (Kalyana) and site- V (Gho Manhasa). The observations were carried out during the breeding season which commenced from May up to September. The overall mean clutch size was recorded to be 3.71 ± 1.06 varying from 1 to 5. The clutch size was found varied among different site viz., 3.73 ± 0.76 (n=41) at site- I, 4.07± 0.73 (n=14) at site- II, 3.68± 0.88 (n=38) at site - III, 3.71± 0.85 (n= 32) at site - IV and 3.64± 1.02 (n=17) at site - V. The eggs were recorded were oval with greenish blue colour and without any markings. Overall mean values of egg dimensions were recorded to be egg length (3.90±0.16cm), egg breadth (2.78±0.19cm), egg volume (15.57±2.41cm^3) and egg shape index

(71.45±4.95) and egg weight (17.93±2.71gm). A statistically significant correlation was registered between egg length and egg volume (r= 0.4852) as well as between egg breadth and egg volume (r= 0.8274).

Fernandez *et al.* (2016) examined the foraging ecology and intra specific host selection of cattle egrets, in association with Pere David's deer (*Elaphurus davidianus*) at the Dafeng National Nature Reserve, China in summer. The study suggests that the cattle egrets prefer female deer more than the male deer to feed with. In their observations, none of behavioural differences were found in feeding between juveniles and adults.

Kioko *et al*. (2016) studied on cattle egret interaction with large mammals in the Northern Tanzania. They investigated the effect of host type, host behaviour and type of habitat, on the distribution of cattle egret. Results describe as the cattle egrets are more associated with grazer animals than with mixed-feeders or browsers and select large-bodied animals than the small-bodied ones. Wetlands and grasslands are preferred more as feeding sites. Study focused on the wetlands managements and the grasslands, for the better survival and secures the future of cattle egrets.

Abdullah *et al*. (2016) have examined the breeding performance of cattle egret (*Bubulcus ibis*) in Faisalabad, Pakistan from 2012 to 2013 at three different sites. At three selected sites, 30 nests from each sites were marked and regularly monitored to collect data on nesting behaviour (nest height and diameter), birds plumage variations, courtship behaviour, eggs measurements (clutch size, eggs length, breadth and weight), incubation and hatching. Results revealed that cattle egrets are colonial breeders and colonies were monospecific with no other ardeidae members nesting in the neighbourhood. They usually make nest at the sites, having

water resource in near surrounding. And also indicated that the breeding season starts from April to August and *Acacia nilotica* was seen as the most preferred tree for nesting and followed by *Syzygium cuminii*. Besides, hatching of the chicks was observed to be an asynchronous one i.e., chicks did not hatch at the same time but at an interval of a day (20-25 h). Role of parents during weaning period i.e. feeding and parental care of nestlings was performed by the both partners.

Nefla *et al.* (2015) have studied that habitat use and breeding biology of herons in the Ramsar wetlands of Northern Tunisia. They studied about the breeding patterns and use of habitat by Herons at Lebna, Chikli and Ichkeul wetlands in Northern Tunisia during 2009 and 2010. They collected the data of maximum herons at Ichkeul after breeding season. The result revealed that the cattle egrets preferred restricted marshy area and farmlands for foraging. While other species i.e. Grey herons, Great White Herons, Little Egrets and Squacco Herons were found dependent on marshes and also on rivers. Their distribution varies according to the seasons among habitats. These Variations of reproductive behaviours were found between the sites, biotopes and years. The nesting sites at Ichkeul were suitable for cattle egrets. The study at Chikli site regarding breeding behaviour was found catastrophic. The nests built on ground were usually found destructed. The egrets clutch size differs in diameter of nests at Lebna. Their observation suggested that, at Chikli, the nest situated at height did effects on brood size of Little egrets.

Mohammedi *et al*. (2015) evaluated the impact of predation of cattle egret on pest in different agriculture fields i.e. Cereal, potato, citrus orchard and uncultivated field etc. comparing between the prey availability in the study area. It was found that the availability of prey differed habitat to habitat. The opportunistic behaviour of cattle egret was observed in using the area depending on the availability of prey.

This effects the predation on wildlife particularly on the insects at different agriculture habitat.

Kour *et al.* (2014) examined the selection of diet and feeding behaviour of cattle egret (*Bubulcus ibis*) in Jammu, India. Results revealed that the cattle egrets is highly insectivorous bird, due to the diet comprising grasshopper, flies, crickets, beetles, molluscs and orthroptrea etc. moreover, the feeding behaviour i.e. walking slowly in shallow waters, running with stabs on land, stand and wait position and standing flying catching were noticed. These main feeding methods were used by cattle egret during the study.

Fazili (2014) has studied the reproductive parameters of Little egret Egretta garzetta during breeding season of 2012 in Hokersar wetland, North-Kashmir arts emporium park Srinagar. Breeding parameters i.e. nest site, egg laying period, clutch and brood size, egg biometry and breeding success were studied. They observed that the nest were of bowl shape. Mean egg dimensions were 45.05 ± 1.78mm Mean egg weight was 27.44 ± 0.93g and clutch size averaged to 3.85 ± 0.59.the major role of females in incubation were noticed. The incubation period was averaged to 23.15 ± 1.21 days. Hatching, fledgling and nesting success calculated were 62.38%, 57.35% and 58.62% respectively. Mean causes of low nesting success were predation, nest abandonment and faulty incubation.

Cristina *et al.* (2013) studied the long term population trends of colonial wading birds breeding in Donana in relation to environmental and anthropogenic factors. They observed the nests of particularly nine species i.e. (Nycticorax nycticorax, Ardeola ralloides, Cattle egret, Egretta garzetta, Ardea cinerea, Ardea purpurea, Ciconia, Plegadis falcinellus and Platalea leucorodia) in breeding season.

Trim programme was used to assess the long term trends and Generalised Additive Models were used to study the effects of rainfall. From 1996, all species had a positive population trends. The number of active colonies was found increased. The precipitation found was less than 500 mm during autumn and winter season, it also relates to the reduction in breeders. Reduction was due to the rain fall and flood in marshes. Rice field areas near by Donana influenced positively on the breeding number of five species. Four of these species are considered to be growing in Europe and get increased in Donana coincide with control changes which have improved nesting and feeding habitat along with reduced human disturbance.

Kour and Sahi (2013) have been investigated the aspects of breeding biology of cattle egret, *Bubulcus Ibis* in Jammu, India. Breeding aspects such as courtship behaviour, location and selection of nesting site, egg laying, egg characteristics, clutch size, incubation period, hatching, nesting success, hatching success and parental care etc. were surveyed. Breeding behaviour observed on *Acacia nilotica* and *Mangifera indica* nesting tree during March to July. The average clutch size was recorded to be 3.70 ± 0.56 incubation period ranging from 21-23 days (n=250). The mean length of egg, breadth, weight and volume was observed to be 46.24 ± 2.94
mm, 34.02 ± 2.11 mm, 20.84 ±1.71 gms and 27457.41 ± 4321.99 mm^3 respectively. Furthermore, mean hatching success (%) was found to be 58.65 ± 35.60 and mean chick survival or breeding success was to be 39.99 ± 33.68. The incubation period was followed by a weaning period of 21-23 days. The parents were noticed feeding to their hatchlings, firstly by indirect feeding and then switching to direct feeding i.e. Beak Grab Feeding. Good parental care was discerned in cattle egrets.

Aboushiba *et al.* (2013) studied on the foraging behaviour of five egret species in Pome pond area of Carey Island, Peninsular Malaysia. Their observations indicates

about the probing activities, the highest probing activity was recorded 9 hrs to 10 hrs in Little egret which was 52 probes/minute. Followed by cattle egret (*Coromondus*) was 42 probes/minute, intermediate egrets i.e. 20 probes/minute, Chinese egret 19 probes/minute, and of Great egrets was 5 probes/minute. The lowest probing activity of cattle egret was observed (0.4 probe/minute) as comparing with Chinese egret i.e. Probe/minute. In this study it was recorded that common feeding behaviour was of walking slowly about Great egret and walking quickly for Little egret. The slow movement was of intermediate egret along with Chinese egret respectively. Here the cattle egret was found only species used the gleaning behaviour in capturing the hidden prey. Simultaneously under the mud a Little egret species was using foot shuffling techniques. Therefore the study resulted in about the feeding behaviour used by five egret species. They have concluded that site selection and prey capture was different.

Karanchie (2013) has examined the diet and food composition of cattle egret in three different habitats in Metropolitan area, Ghana. And used the technique of dietary analysis of gut content food of cattle egret. Result concluded that cattle egrets feed mainly insects, particularly such as dipteran larvae, and predominantly house flies larvae.

Kour and Sahi (2012) investigated the community ecology of egrets, *Bubulcus ibis* in Jammu, India. Their study threw the light on different foraging parameters of cattle egret association with herbivorous. They concluded that, the cattle egrets are obtaining more food when feeds with herbivorous and seems as commensalism association. The study resulted in showing about the parameter i.e. time spent by cattle egret with herbivorous host, rate of egrets steps per minute and attempt success rate per minute. And number of strike rate i.e. 10 to 13, average range of cattle steps

was 8 to 9. Consequently prey capturing rate was 4 to 6.

Bachir *et al*. (2011) have studied the recent expansion of an avian invasive species the cattle egret Ardea ibis in Algeria. They obtained the data on distribution of breeding in winter period during 1999 and 2007. The colonies were found increased from 51 to 87 and most were situated in the northern part of the country. The breeding distribution area, confined to the coastal areas in the 1970s, further it has shifted to south, and reached the northern part of the Sahara since the 2000s. They noticed that, most colonies were established during 1980 to 1995. The oldest colonies were larger than the current ones. The number of colonies was found increased by 83 % between 1999 and 2007. The number of breeding pairs found enhanced from 7765 to 28544 in 1999 to 2007 and the annual population growth rate observed was of 17.7 %. The changes in distribution and population were noticed.

Seedikkoya *et al.* (2011) have examined the breeding biology of little egret and cattle egret in Kerala. Variables used were the nest, egg characteristics, incubation and hatching. Their observations indicate that, the material used by birds was ranging between 19.18 to the 36.64 cm in length, from 35 plant species. Clutch size was found varied from 2 to 6 and 4 were being the most common clutch size. Hatching success was found about 74 %. As in adult birds, the food of the nestlings was mainly fish. Both the parents took part in feeding the young.

Xinlu (2010) has studied the aspects of reproductive ecology of three Tibetan water bird species, with special reference to life-history alterations along elevational gradients. With their hypothesis, it was suggested, that the birds nesting at higher elevations are having low reproduction, due to ecological limitation. They require more energy and attention in reproduction of individual offspring. For better survival in the rough environments. To examine their hypothesis, they collected the Data on 3

aquatic birds i.e. Mallard *Anas platyrhynchos*, Common Moorhen *Gallinula chlorpus* and Eurasian Coot *Fulicaatra*, at Lhalu wetland in Tibetan Plateau. It was investigated that, above said birds were the regular nesters of this high situated Plateau. The high-elevation mallards and moorhens primarily used reeds *Phragmites australis* for nesting. In the wetland researchers recorded the breeding period of Mallards, Moorhen and Coots. Mallards laid eggs from mid-April to mid-June, moorhens from early May to mid-June and coots from mid-May to late June. It was found that the clutch size and the size of egg laid by these high-elevation water birds were lesser than in birds of lowland. This supports partially to prediction. Predation by mammals and flooding effects harm to the nests.

Choi *et al.* (2010) studied the feeding activity of cattle egret and intermediate egrets at rice field in Korea. This observation focuses on the activities of egrets at all stages of rice cultivation. It was found that egrets catches mainly small invertebrates prey i.e. insect and spider 98.4 % during all stages in rice field. Result obtained that a higher prey capture rate of the bird i.e. 14.98 % per /minute at the ploughing stage than in other stage was 2.82-3.51 prey /minute. They have suggested that quantity of intake was highest in ploughing stage.

Ducommuna *et al*. (2009) have focused on estimating the diet of cattle egrets (*Bubulcus ibis*) in the food valley of the Parana River, Argentina. They analyzed the feeding ecology of cattle egrets (*Bubulcus ibis*) on the basis of 30 captured individuals to determine the size of prey feeding efficiency, dietary selection, size of the tropic niche, circadian pattern of feeding activity and habitat preference. They found 17 taxonomic set up, mainly insects, among those the orthropetrans were in abundant. The large percentage of prey size was found at the interval of 21-30 mm. size of the tropic niche ranged between 1.98 and 3.45 and the feeding efficiency was

between 89 and 92%. They have suggested that dietary selection, the correlation between availability of prey in stomach and availability of prey in the study area yielded no significant.

Youa *et al.* (2009) examined the variation in egg size and nestling growth rate in relation to clutch size and laying sequence in great tits Parus major. With the hypotheses, optimal clutch size in great tits (*Parusmajor*) nesting in nest boxes and variation in egg morphology and nestling growth rate with position in the laying sequence and hatching asynchrony and nestling survival as determined by infrared nest camera during 2005 and 2006. Results revealed that egg size and growth rate was found increased. Data from infrared cameras showed that early laid eggs tended to hatch before than the later laid eggs, leading to hatching asynchrony. They have suggested that the females were investing more time with last laid eggs and nestlings.

Ashoori (2009) has observed the breeding biology and success of the Little egret *Egretta garzetta* in Karfestan Ab-bandan Roudsar, Gilan Province and Northern Iran. This study focused on the breeding parameters, i.e. egg laying, clutch and brood size, egg measurements, nest-site characteristics and breeding. The results revealed that the clutch size in (total of 98 eggs) 4.26±0.81, among those, 82.6 % were hatched and 80.6 % were brood. On average, 3.43 eggs per nest reached brooding stage at this colony. And also found in chick‟s dietary survey that the chicks followed prey species i.e. Mole Cricket *Gryllotalpa gryllotalpa,* Walker *Chilo suppressalis,* Steppe Cricket *Gryllus desertus,* Asiatic Locust *Locusta migratoria,* Prussian Carp *Carassius gibelio,* Caspian Spined Loach *Sabanejewia caspia,* Riffle Minnow *Albumoides bipunctatus elchwaldi,* Carp *Cyprus* spp, European Catfish *Silurus glanis,* Common Grass Snake *Natrix natrix natrix* and Marsh Frog *Rana ridibunda.*

Dragonetti and Giovacchini (2009) had a surveyed on aspects of breeding biology of cattle egret. *B. ibis* in a Grosseto province colony (Tuscany, central Italy) during 2004, 2005 and 2006. The colony was almost mono specific (*Bubulcus ibis* 94.9%, *Egretta garzetta* 3.1%, *Ardea cinerea* 1.2%, *Ardeolaralloides* 0.8%) and was settled in a flooded area inside a thick willow wood, they adopted a non-invasive method in order to avoid the disturbance to the nesting pairs. The results revealed that the nesting pairs of cattle egret were found increased from 106 in 2004 to 240 in 2006. A similar increase was also recorded for the other three species. The whole population of the colony (nesting and non-nesting birds) grew from a total of 390 herons in July 2004 to 860 in July 2006. In spite of this increase of colony population, the wood area occupied by nesting birds did not get increased: it was 0.90 ha in 2004, 2005 and 0.87 ha in 2006, while the number of trees with nests increased from 54 in 2004 to 86 in 2006. Moreover the mean number of nests per occupied tree increased from 2.06 ± 1.69 (range = 1-9) in 2004 to 2.94 ± 2.85 (range = 1-20) in 2006. This trend show a tendency to an increasing crowd. The total wood area of observation for the colony was about 8 ha. Cattle egrets started nest building at the beginning of April. 21 sample nest were marked in mid of April for the study. In observation 80 % of pairs were found incubating their eggs between 7 and 25 May. Hatching also started between 7 and 25 May. On 9th June 68 % of broods were already hatched. No sample nests were noticed of bird incubating after 15 June. At the end of July all new born cattle egrets were fledged. They suggest the incubation period was almost same i.e. 23.8 days. The mean number of hatched cattle egrets per nest was 2.5 ± 0.95 (range = 1-5; N = 34) the average fledging success was 2.2 fledglings/nest, a value relatively high on comparing with bibliographic data.

Choi *et al.* (2007) have studied about the foraging habitat preferences of herons

and egrets. It was found that the feeding habitat preferences differ among species. Grey heron, great egrets and black-crowned night herons, used reservoirs and ditches. However, Intermediate egrets and cattle egret (*Bubulcus ibis*) were dependent on rice fields. The little egrets (*Egretta garzetta*) use all types of habitats. The two largest species i.e. the great egret and grey herons, feeds in deepest water bodies. All species were having seasonal changes in foraging habitat used.

Seedikkoya *et al.* (2007) suggested that the cattle egret is a bio-control agent. They found that the cattle egret, *Bubulcus ibis*, is one of the most common wetland birds in a variety of habitats. It was seen widely in solid waste dumps rich in maggots which are disease spreading, house flies and blue bottle flies etc. Maggots were found in extraordinarily high density during southwest monsoon season, when egrets migrate out of Kerala state to breed. It was found that a single egret removes about 100-150gm of live maggots per day acting as an important bio- control agent.

Liordos and Goutner (2007) have studied the diet of the Great cormorant (*Phalacrocorax carbo* L. 1758) were studied at two colonies in Greek: i.e. the Axios Delta and the lake Mikri Prespa, through analysing the regurgitated pellets. The varieties of fish taxa were found in the samples, but only one or two types of fish were found in the great cormorant diet. Prussian carp (*Carassius gibelio*) were noticed in the Axios Delta. Whereas, pumpkin seed (*Lepomis gibbosus*) and Prussian carp were the mostly found in the lake Mikri Prespa. Pumpkin seeds were in diet of cormorant is noticed first time in this study.

Patankar *et al.* (2007) have studied about the ecology and breeding biology of the cattle egret (*Bubulcus ibis)* in an industrial area at Vadodara, Gujarat. This bird has been breeding in an industrial area for the past many years. The campus of a multinational company (Asian Brown Boveri-ABB) having huge production plant

located in an industrial area at Maneja village, towards southwest part of Vadodara city was chosen for the study. The campus of the company is spread over an area of 105 acres and has good amount of cultivated vegetation or green belt. The study was carried out for two years (2004 and 2005) in the month of April to July, i.e., during the breeding season of cattle egrets. They observed 13 nests for their study. They examined various parameters i.e. nest size, nest thickness, its distance from the main trunk and distance from the ground were measured. The egg length, egg breadth, fresh egg weight, egg volume and the species specific egg weight constant were noted down. Role of pellets during weaning period was observed. Dropped food pellets were analysed and predation pressure was noted down.

Minciy (2006) studied the foraging behaviour of herons and egrets in natural and artificial wetlands. They observed that the wading birds would show similar foraging behaviour and success in artificial and natural wetlands. And these birds use artificial wetlands without a shift in behaviour and with similar success (capture/strike) in comparison to natural habitat. All species exhibited about a 70 % strike success rate at overall habitats. The only exception was about the Great egret, which foraged with lower success but captured larger prey in artificial wetlands. Their results show that artificial wetlands are feasible foraging habitats for herons and egrets.

Torres and Mangeaud *et al.* (2006) evaluated the impact of physical factors on the breeding success of cattle egret in Central Argentina. They marked all nests in ten plots (10 x 10 m) located at 20 m intervals along two randomly selected transects, in each colony and breeding seasons. They estimated the number of breeding pairs in each colony by averaging nest densities in other 25 randomly selected 10 x 10 m plots by extrapolating that mean density to the total colony area, which was determined

using hand-held Global Positioning System (GPS) units. Their observation revealed that the brood size was influenced mostly by egg losses caused by heavy wind stroms. Nesting success rate was directly influenced by rainfall during the breeding season. Death of nestlings due to the starvation or sibling aggression effect, while other variables such as nest abandonment, predation and vegetation structure etc. had no effect on the final productivity. Rainfall influences the faster pasture growth, which increased the abundance of orthoptera, the main food item of cattle egrets in the study area. Nest survival was generally higher in the chick-stage than in the egg-stage, as winds caused the higher losses of eggs than of nestlings suggests a relatively small influence of other limiting factors such as predation and the wind factor was the main cause of egg losses.

S**alazar *et al.* (2005)** have studied on the comparative study about the diet of cattle egrets and Little egrets. Examined through their pellets at the nest in a mixed heronery. Food niche overlaps were calculated by analysing the prey size and prey type. Both the species significantly differs in their preferences of prey type and size. cattle egrets preferred smaller prey i.e. coleoptera, ododnata, little egret prefer orthropetra and fish. Both variables were considered important in resource separating in these species.

Seedikkoya *et al*. (2005) studied that the cattle egret, *Bubulcus ibis* habitat use and association with cattle. It was observed that the cattle egrets were mixed with Indian Pond heron (*Ardeola grayii*), Intermediate egret (*Mesophoyx intermedia*) and little egret (*Egretta garzetta*) in their study areas. At the time of cattle egrets feeding in association with cattle, it usually feeds near the front legs of the animals. In associated feeding of egret, the prey capture rate was significantly higher (1.3 ± 0.86) as compare to non-associated feeding (0.9 ± 0.75) items per minute. They spent less

energy to achieve the higher foraging rate, as it takes fewer steps between successful captures (19.8±2.1) steps per minute in compare to non-associated foraging of egret (29.1 ± 2.5). Cattle egrets also had a higher rate of strikes (4.8 ± 1.8) versus (3.6 ± 1.3) strikes per minute. There was no significant difference found in the strike success between associated and non-associated birds, the mean strike was 27.2 % and 27.6 % respectively. Seasonal local migration was observed in an egret during monsoon, from June to September. During this period they moved towards north direction in Kerala. The variation was also observed in habitat used i.e. Grassland was used throughout the season. While in October, paddy fields were used heavily and plantation areas were used least frequently.

Kazantzidis and Goutner (2005)[12] the diet of nestlings of three Ardeidae species (Aves, Ciconiiformes) in the Axios Delta, Greece. This work was focused on the diets of the little egret (*Egretta garzetta*), the night heron (*Nycticorax nycticorax*) and the squacco heron (*Ardeola ralloides) Axios Delta (Nortern Greece)* they analysed the nestling regurgitations during five breeding seasons (1988-1990 and 1994-1995). At least 58 different prey taxa were identified among 5,108 items found in little egret[24] regurgitations, at least 45 taxa among 2,373 items regurgitated by night herons and 12 taxa among 277 items from squacco herons regurgitations. Differences were detected between the three ardeid species in the proportion of each prey category. Little egret nestlings were mainly fed fish (39.6% by number) and insects (32.0%), but amphibians and fish were found the most important groups by biomass (44.9% and 32.9% respectively). The proportions of prey categories varied significantly between years ($x^2 = 922.91$, $p < 0.001$). The night heron nestlings were mainly fed insects and the crustacean, although the dry mass of the latter contributed little to the consumed biomass (4.0% compared to the 37.9% of insects). Small mammals and

reptiles were included in the diet of the young night herons, while the fish they ate, were much bigger than those consumed by little egret nestlings. The proportions of the night herons main prey categories varied significantly between years ($x^2 = 598.67$, $p < 0.001$). Squacco heron chicks were fed mainly insects (50.9%) and amphibians (31.8%). The diet of the squacco heron was similar to that of the little egret when prey type frequencies were considered, but closer to the night herons by dry mass. The dry mass differed significantly between the species ($x^2 = 87.39$, $p < 0.001$, Kruskal-Wallis test). This dietary segregation may be a mechanism that reduces competition among these species, especially when prey is limited.

Kopij (2003) has described about the diet of cattle egret in managed farmland in South Africa. Their result shows that the presence of small frogs (*Pyxicephalus adspersus*) sand grasshopper (cricket and locusts) were present due to the low rainfall at different habitat. Larger proportion of flies in the diet of cattle egrets plays an important role in pest control.

Adam et *al.* (2003) have proved that the rice field was an adequate substitute for natural wetlands as foraging areas for egrets. Their study reveals about the declination in abundance of wading birds. Due to diversion in river streams and irrigation do effects on the declination and loss of natural wetlands. Because of this, the egret use rice fields as a substitute. The presence of egret and Great egret increased maximum after sowing of the rice thereafter it decreased. The declination phase correlates with decreasing of prey capture rate and also their shifting from vertebrate prey to invertebrate prey.

Samraoui *et al.* (2003) have studied the breeding behaviour of the cattle egret (*Bubulcus ibis*) at Sidi Achour, north-eastern Algeria. The breeding behaviour of the cattle egret (*Bubulcus ibis*) in a monospecific colony was observed in 2003. The

result revealed that a seasonal decline in Clutch size was found and correlates with nest diameter. Hatching success was (83.0%) and an average of 2.29 ± 0.18 chicks per nest survived two weeks. Mean clutch size was 3.10 ± 0.13 eggs per nest. The result suggested that clutch size did not vary significantly.

Hilaluddin *et al.* (2003) studied the breeding success on the basis of nest site selection of cattle egret and Little egret in Amroha, Uttar Pradesh, India. Nesting trees characteristics were measured such as canopy diameter, canopy height and girth at breast height etc. They estimated total population size of nesting pairs was 882 (Cattle egret=550) and (Little egret= 332). Nest abundance of cattle egret was 0.045 ± 0.041 (95 % CI) nests, canopy volume was m^{-3} and 0.026 ± 0.019 (95% CI) $nests^{-1}volume^{3}$ of canopy volume of Little egret. Their result suggested that both the species construct nest above the middle height of the trees and cattle egret selects higher trees for nesting than Little egret.

Lombardini *et al.* (2001) have examined the foraging success and foraging habitat use by cattle egrets and little egrets in the Camargue, France. This study is focused on the habitats used by little egrets (*Egretta garzetta*) and cattle egrets (*Bubulcus ibis*), they nest in mixed-species colonies in the Camargue of southern France. The birds use different type of habitat, their presence and the selection of habitat in respect to foraging success. They observed that increase in use of habitats co-relates with higher foraging success in both species.

Bachir *et al.* (2001) have studied the diet of adult cattle egrets (*Bubulcus ibis*) in Africa. They observed 100 pellets of regurgitated food. Sample was collected monthly, in one year study 11000 fragments was analysed and 3493 individual of prey items were identified, in which 73 species, 12 orders and 35 families observed. Biomass of prey per pellet was of an average (fresh weight 62.25gm) corresponding to the mean of daily

consumption. Insects were found in common food items (99.0% in number and 73.3% in biomass). Orthoptera were the main insects prey (63.2% in number and 53.6% in biomass). In vertebrates (Muridea, Rodentia) found 0.8% and 26.2% of the total biomass. The prey diversity was inversely related to its biomass. The species showed a high adaptability yearly in the diet and having ecological flexibility in a study area.

Mukherjee (2000) reported about the addictiveness of cattle egrets (*Bubulcus ibis*) foraging, this study indicates about the feeding of cattle egrets in close association with cattle. The cattle egret consumes the prey more without spending much energy per attempt in comparison to that forage alone. The observation showed that cattle egret also shifts from grazing cattle to the tractors especially in agriculture field. Comparing between cattle and tractor, the capture success rate is more with tractor because the tractor disturbs the prey more.

Bennetts *et al*. (2000) have evaluated the influence of environmental and density-dependent factors (intraspecific and interspecific) on the clutch size, brood size and nesting success of Little egrets (Egretta garzetta) in the Camargue in south France. The observation record was collected and studied about the reproductive parameters from 1970 to 1998. General modelling method (model selection based on AIC) was used to examine all parameters. The result revealed that clutch size was found positively associated with rainfall and negatively associated with the number of nests in the Camargue. Brood size was negatively associated with the number of nests; however the rainfall was also significant in effecting along with these two effects. It was noticed that the nesting success was negatively correlates with the number of tree nesting herons. And also negatively correlates with the number of little egret nests. They have suggested that cattle egrets displaced the little egrets at some centrally located nest sites which had a better protection from strong winds.

Kopij (1999) has studied the breeding success of cattle egret in relation to clutch size of egg in South Africa. Total number of examined nest was 258. Results found that the hatching and breeding success was highest in the clutch size of three eggs and lowest in the five eggs clutch size.

Gonzalez *et al.* (1997) have studied about the seasonal variation in the foraging ecology of the Wood stork in the Southern llanos of Venezuela and analysed the seasonal variation in using the habitat, foraging behaviour and diet of the Wood stork (*Mycteria Americana*) in the changing environmental conditions. With the beginning of the rainy season, streams and lagoons and extensive marshes becomes the preferred foraging sites for storks. Amphibians and aquatic invertebrates are mostly found in these flooded areas. 50% of egrets diet is composed of these amphibians and aquatic invertebrates and remaining 50% was composed of fish. The Wood stork population was dispersed widely in flooded area. Individuals were observed foraging solitarily or in small groups. Foot stirring and Groping were mostly used foraging behaviours. These patterns were found changing gradually with the end of rainy season. Dried shallow marshes become inadequate feeding sites. They recorded that 99% of fish were in the diet of Wood storks during the dry season.

Burger (1993) focused on the foraging decisions of host selection by cattle egret (*Bubulcus ibis*) in Kenya. The study was about the foraging of cattle egret in association with ungulates. Result shows that the cattle egret does not forage with all species of ungulates, as they are selective in preferring the host. They also discussed on the average speed of moving host, i.e. 5 to 15 steps per minute. The egrets avoidance of host was according to the speed of host, faster or slower. It shows the correlation between the steps of egrets and host. Subsequently the attempt success rate also depends on speed of host. This activity shows about prey availability and host

suitability.

Cezilly *et al.* (1990) have studied the group foraging in Little egrets (*Egretta garzetta*) from field evidence to experimental investigation. Prey density and foraging efficiency was studied in group foraging of Little egrets. The two parameters i.e. striking efficiency (percentage of successful pecks) and the number of captures per minute found improved in large groups. The reduced striking efficiency was observed in a small group as compared to solitary birds. During the experiments, the number of captures per minute was higher in a pool with high prey density than in the situation with low prey density, while differences were not significant in comparing the medium with low or high prey density. Group size had no effect on capture rate. Striking efficiency, searching effort and prey selectivity were not affected by flocking or prey density. The possible benefits of flock feeding are discussed.

Burger and Gochfeld (1989) differentiated the age related foraging behaviour of cattle egrets (*Bubulcus ibis*) with wild ungulates in Kenya. The egrets fed on insects disturbed by the Buffalo, Zebra, Wilde beest and Hartebeest. Adults had higher capture success rates than that of the juveniles, although the number of steps taken per minute was equal. Choice of host species and foraging location (host head, front or hind legs) differed between adults and juveniles. A higher proportion of adult cattle egrets fed with Buffalo compared to young.

Burger and Gochfeld (1982) studied about the host selection along with an adaptation to host-dependent foraging success in the cattle egret (*Bubulcus ibis*). The investigations were made regarding the age different in foraging of cattle egret with wild animals in Kenya. They observed the feeding behaviour of adult and juvenile cattle egret at Nairobi Park. And also observed that the egrets feeding on insects flushed by the foraging grazing animals. The adult egrets obtained more prey in

comparison to juvenile egrets. The adults and Juvenile were foraging in different positions i.e. Feed on host head, front or hind legs, in comparing between adults and juvenile it was observed that the adult egret feed more with buffalo than the young egrets.

Kushlan (1978) studied examined the tactics of little blue heron commensalism with white Ibis. Besides, feeding behaviour of little blue herons and white ibis in association and alone. Little blue herons feed in association with white ibis by following the ibis's movements to increase foraging effectiveness. When blue heron feeds near a white ibis, a heron increases the number of prey caught without increasing its energy use for foraging. The strike rate of a bird was higher when feeding commensally than it feeds alone, but its success rate did not found increased because of the commensalism association. They have suggested that no obvious commensalism relationship has been suggested in previous reports about the association of water birds commensalism.

Michael *et al.* (1973) studied the summer food of cattle egrets in Florida. They Identified and quantified the summer food from 841 cattle egrets from four roosts site during summer season. Invertebrates comprised 93.3% of the food by volume. Orthropoda were found in 96.8% of the stomachs contents and accounted for 80.5% of the total volume. The fish or the young nesting birds were not found in any of the stomachs.

Siegfried (1971) has studied the feeding ecology of cattle egrets (*Ardeola Ibis*) in South Africa. The paper signifies about the average prey size (body-length) and the number of food items eaten by adult, juvenile and nestling cattle egrets in the south-Western Cape Province of South Africa. Adult birds consumed on average larger food items than the young ones. A juvenile takes a slightly larger variety of food items. The

average food item eaten was smallest at the end of the local dry season, when Cattle egrets experiences a period of food scarcity. The average size of food items consumed by nestlings increases with their age simultaneously. Juveniles use to include more vertebrates in their diet in comparing to the younger nestlings.

Chapter-I

To study the symbiotic relationship of Cattle and Cattle egret.

CHAPTER-I To study the symbiotic relationship of cattle and cattle egret

INTRODUCTION

Cattle egret (*Bubulcus ibis*) has a worldwide distribution in the tropics, sub-tropics and warm temperate regions. In Indian subcontinents, it is very common in varieties of habitat especially grassland, marshy land and in some wetlands such as paddy fields, marshes and mangroves etc. They are the part of the environment and nature belongs to the family Ardeideae, which are small white herons of approx. 50 cm tall at standing position. They plays an important role in the food chain in the ecosystem. Cattle egrets is a diurnal feeder commonly foraging around grazing animals in the wild or domesticated livestock (Del Hoyo *et al*., 1992; Kushlan and Hancock, 2005). In the late 19^{th} century, such species became established in South America (Turner, 2011) and the present century has established itself in Australia, Asia, New Zealand, North America and Europe. It plays a significant role in a variety of ecosystems with their foraging habits and makes them efficient as an important biological control agent. Such insectivorous birds consume insects like grasshopper, cricket, flies, moths, spiders and some insects of public health as well as agricultural pest (Doumandji *et al*., 1992; Telfair and Raymond, 2006). Cattle egrets is an opportunistic predator feeding on an abundant and accessible prey (Kushlan and Hafner, 2000). And the best-known bird that feeds in close association with cattles (Dinsmore, 1973; Thompson *et al*., 1982; Wahungu *et al*., 2003; Kamler *et al*., 2008) such as, cow, buffalo, horse, bull etc. And also with some other domestic and wild host. Cattle egrets support symbiotic relationship through foraging association with cattles in gaining more benefits of feedings (Rand, 1954 and Siegfried, 1978). At inter

specific levels, host selection of egrets are most effective with the host species such as cow, buffalo, horse, bull, wildebeest, zebra, hippopotamus and other ungulates in various habitats with having less human disturbance, this helps birds to feed for long time (Burger and Gochfeld, 1993; Kour and Sahi, 2012; Ogutu *et al*., 2014). Cattle egrets feeds with cattle, captures more food than those are feeding alone. The birds appear to exploit their beating effect whereby insects and other prey disturbed by the cattle and hence are easier to detect or capture (Heatwole, 1965). However, the strategy implemented by egrets for improving the success rate was examined (Grubb, 1976; Burger and Gochfeld, 1999).

The cattle egret, *B. ibis* follow animals specifically because they move and flush prey items. This method is effective for the egrets that they must follow the animals closely (Burger and Gochfeld, 1981). Kour and Sahi, 2012; Seedikkoya *et al*. 2005 have reported about the factors influencing preferences of the host by cattle egrets and the characteristics of certain cattle, as "suitable host". The term attempt success rate is the number of food items obtained and swallowed by the *B. ibis* per five minutes (Burger and Gochfeld, 1981). *B. ibis* keeps feed near the cattles until the cattle ignore its presence otherwise it starts tail wagging and shakes the head to remove the *B. ibis* (Burger and Gochfeld, 1993). The activity of switching counts of *B. ibis* means the time duration of association and disassociation counts with the host (Burger and Gochfeld, 1981). Egret are selective in host preference. with its suitability. They selects the host species by deciding when and which host species is to be choose and when shall be switched to a new host. These influencing factors are left to be considered in previous studies in Uttar Pradesh, India. The present study was aimed to investigate the relationship between speed, capture success rate and different aspects of host preference i.e. attempt success rate and switches of host. Both concepts have been referred to as success rates,

time of association i.e. "time spent by the egrets in foraging with cattle".

MATERIALS AND METHODS

Study area

The study was carried out in Lucknow district and its associated areas up to 40km i.e. Vrindavan, Kallipaschim and Kusheri.

Vrindavan grassland is located at latitude of 26°45'2"N and a longitude of 80°57'46"E. Consisting of 10 hactares in area. It is an uncultivated open land dominated by grass, shrubs. During monsoon water logging was observed.

Kallipaschim marshyland is located near kalli village at 26°44'15"N latitude and 80°57'23"E longitude. It is an approximately of 4 hactares in area. On this study area there is a lake surrounded by swampy area and get flooded in monsoon season. Scanty vegetation present around the lake during monsoon season.

Kusheri agricultural land situated between the latitude and longitude of 26°62'49"N and 80°71'13"E respectively. This is about 15 hectares. The post cultivated empty paddy fields are having overgrown grass during February to April. Irrigation canals are also present there as a water source.

The geographic coordinates of Lucknow are 26°51'0.0000"N and 80°56'59.9892"E (Seedikkoya *et al*., 2005; Kannaujiya *et al*., 2013). The temperature ranges are between 25-45°C in summer, 2-20°C in winter. According to India metrological department, 2018 mean annual rainfall is approx. 35.28inch.The study was assessed through periodical field visits at Grassland (an area which included ecosystem where grasses and forbs were dominant) Marshy land (wetland associated with lakes, swampy) and agriculture land (including intensively managed or grazed wet meadow or pastures) Grobicki, 2016.

Data collection

Conducted weekly between 2018 to 2019.The collection of the data lasted between 0600 hrs - 1800 hrs through visual observations, digital video camera and binocular Celestron up close G2, 6.8°/35FT/118M (10x50X). *Bubulcus ibis* feeding behaviour was studied with the cattle i.e. cow, buffalo, horse, bull, mule on the basis of number of host steps, cattle egrets steps, number of attempt success and the number of time cattle egrets switching, which was recorded for five minutes and in some cases it was for one or two minutes due to the fast foraging movements by most individuals at different locations and habitats. Host species availability was determined teach present within 200 – 300 meters by counting to avoid distracting avian behaviour at all feeding habitat up to 30 individuals of each species at each habitat was observed to determine the host suitability. Association foraging was considered when cattle egrets forage near the host within two to three meters to avoid ,the pseudo-replication method with slight modification, while Chaskda *et al*.,(2018) considered up to 5 meters. Swallowing behaviour was counted after capturing the prey, as the capture success rate of egrets is identified. Host preference and foraging success were analyzed by the previous studies, Grubb (1976) and Scott (1984) i.e. the numbers of steps per minute were recorded. An information on average attempts/minute and items obtained per minute by cattle egrets in association with cattle and alone. This methodology is used with slight modification in this study.

Statistical analysis

The relationship between the speed of both hosts and cattle egrets with the attempt success rate was analyzed by Spearman Rank correlation test (SPSS version 21). The

switches count per hour calculated by Average number of switches/Average time of observation x1/60.

Figure 1.1. The feeding activity of cattle egrets with buffalo in Vrindavan, grassland**.**

Figure 1.2. The feeding activity of cattle egrets with mule and horse in Kallipaschim, marshyland.

Figure 1.3. The feeding activity of cattle egrets with cow in Kusheri, agriculture land.

RESULTS

In the present study, the foraging association of the cattles was observed with the total no. of 634 hosts consisting of cow, buffalo, bull, horse and mule in grassland, marshy land and agriculture land. In association with cattle, the percentage was highest in grassland (36.10%) followed by marshy land (32.10%) agriculture land (30.68%). At agriculture land anthropogenic activities such as human disturbance and use of agriculture implements, tractors, cultivators, power trillers and diesel pumps sets etc. these makes negative effect on the foraging of egret and associated cattle. Also none of nomadic grazers found in agriculture land due to guarding by farmers or land owners. It is observed that in agriculture land, the human disturbance was comparatively higher than that in marshy and grassland.

The percentage of egrets associated with cattle showed the little seasonal variations in agriculture land. In afternoon the correlation rate is significant at the ($P<$ 0.01) level. Based on such study the increasing order of the suitability of the host are as follows, buffalo<cow<bull<mule<horse.

Table 1.1 (A): Monthly variation in steps count between cow and cattle egret in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Steps of cow Mean ± SD	steps of cattle egret Mean ± SD	Steps of cow Mean ± SD	Steps of cattle egret Mean ± SD	Steps of cow Mean ± SD	Steps of cattle egret Mean ± SD
January	44.04±10.49	54.31±10.52	45.86±10.01	54.81±12.61	42.72±8.71	61.63±10.15
February	31.08±16.31	42.29±15.45	34.58±15.53	49.54±15.91	40.75±12.99	54.12±14.71
March	32.87±17.90	27.95±18.56	37.08±18.00	46.79±16.86	34.12±14.31	58.29±16.13
April	45.12±13.40	32.4±16.41	43.52±15.67	63.6±18.87	38.56±14.93	52.48±19.18
May	31.87±19.46	39.95±19.94	42.04±11.21	52.95±12.94	45.95±11.46	65.87±15.22
June	32.04±19.94	52.08±14.17	36.62±16.94	59.54±16.10	37.5±11.25	42.37±14.09
July	27.83±20.39	45.45±15.92	32.62±15.84	49.79±12.42	42.45±8.48	43.58±21.49
August	29.83±23.97	44.20±13.95	43.79±13.18	51±14.60	44.62±9.39	53.25±16.23
September	46.95±21.64	59.16±12.04	35.58±15.87	46±13.25	41.16±13.28	58.41±11.74
October	40.91±18.31	54.375±15.19	39.58±15.54	42.62±12.03	40.5±13.91	45.29±14.83
November	38.41±19.00	52.83±18.04	42.70±19.75	53.95±18.08	39.91±16.25	60.33±15.03
December	32.6±16.86	56.4±15.88	40.08±12.91	59.72±12.29	30.4±14.46	51.16±12.66

Table 1.1 (B): Monthly variation in foraging success of cattle egret with cow in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD
January	13.95±7.33	2.91±2.37	23.09±7.09	11.36±5.19	20.45±5.49	8.59±3.17
February	18.86±9.41	8.95±5.85	20.66±6.89	9.75±6.13	32.04±9.88	15.83±10.04
March	30.04±12.62	17.12±7.08	21.12±6.56	5.75±4.61	28±13.39	16±9.49
April	18.56±9.24	7.88±6.11	20.01±5.70	6.6±4.83	14.96±5.60	7.64±4.21
May	19.08±9.28	10.04±6.06	18.91±8.00	8.60±6.29	15.83±6.30	7.37±3.22
June	17.79±8.11	8.25±6.20	20.79±5.85	6.83±5.44	24.45±7.19	12±5.69
July	15.83±8.04	10.33±6.75	20.58±6.70	7.33±5.34	18.79±8.32	9.37±5.62
August	18.58±5.02	9.83±5.88	19.5±6.56	8.5±4.03	22.29±6.73	12.79±6.33
September	18.66±6.72	10.83±5.38	20.79±11.47	8.20±7.93	21.54±6.27	7.08±4.50
October	15.16±7.16	8.41±5.17	20.5±6.37	9.70±6.23	20.20±8.76	8.08±7.07
November	21.95±6.72	14.25±6.31	18.20±6.53	10.54±5.09	18.95±5.23	10.66±3.81
December	14.66±7.55	3.20±2.53	21.16±6.18	7.4±5.14	22.36±5.42	10.88±5.37

Table 1.1 (C): Monthly variation in steps count between buffalo and cattle egret in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Step of buffalo Mean ± SD	Step of cattle egret Mean ± SD	Step of buffalo Mean ± SD	Step of cattle egret Mean ± SD	Step of buffalo Mean ± SD	Step of cattle egret Mean ± SD
January	41.90±9.56	55.77±9.04	43.77±10.62	55.72±12.29	42.68±8.41	56.31±8.52
February	46.66±6.22	62.79±8.21	36.66±13.88	50.25±15.05	47.04±6.39	62.66±8.14
March	42.20±8.63	61.91±9.81	37.12±17.68	49.73±12.07	42.16±8.72	61.45±9.77
April	42.6±14.75	54.88±14.53	45.44±14.4	62.64±18.01	42.12±15.16	56±11.64
May	43.41±11.84	53.58±11.16	32.92±18.04	55.58±15.93	43.04±11.70	52.83±11.07
June	35.04±10.96	50.16±11.30	43.70±12.25	52.83±12.42	34.54±11.32	49.70±11.35
July	40.37±10.95	56.16±12.28	45.45±10.27	55.01±18.53	39.16±12.75	55.16±10.97
August	41.12±13.91	55.58±12.62	40.62±10.23	56.66±14.05	40.08±13.60	54.41±11.65
September	43.20±12.00	47.87±13.08	36.29±16.04	58.91±17.39	46.37±9.61	50.58±14.21
October	45.83±17.74	47.45±13.42	37.87±12.14	47.54±15.19	40.12±10.15	49.62±8.41
November	41.41±20.56	57.08±19.50	42.29±11.81	52.58±11.68	45.62±14.15	56.75±14.20
December	35.87±11.46	44.19±22.50	44.30±12.67	43.04±19.58	44.03±12.33	59.38±9.52

Table 1.1 (D): Monthly variation in foraging success of cattle egret with buffalo in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD
January	15.81±7.50	8.86±6.06	15.77±7.00	10.04±5.58	15.95±7.56	8.95±5.67
February	20.87±6.66	11.95±5.48	17.45±6.08	10.20±6.24	20.33±6.70	12.08±5.68
March	15.66±7.43	11.69±5.04	18.66±5.32	9.75±5.74	15.91±7.25	6.04±4.50
April	16.04±8.05	6.88±5.60	18.24±6.51	11.84±6.20	12.44±6.48	6.88±5.60
May	13.45±8.25	6.54±5.57	12.44±6.48	9.12±6.09	14.12±8.40	7.04±5.61
June	19.25±7.25	8.75±5.23	19.58±6.12	12.12±4.90	18.87±7.80	8.62±5.29
July	14.04±9.33	7.25±5.77	19.37±7.09	11.95±5.52	14.01±8.70	7.12±5.65
August	20.58±8.29	9.95±5.25	18.02±5.94	9.58±5.57	20.41±6.96	9.25±4.34
September	17.87±9.34	8.66±6.64	18.54±5.93	9.75±4.08	16.33±9.97	8.03±6.89
October	23.29±5.55	11.95±7.01	18.33±4.66	10.54±5.14	17.5±6.90	9.01±5.55
November	16.20±7.02	7.41±4.78	19.41±7.59	10.79±5.59	12.29±6.59	6.41±4.86
December	17.07±6.72	8.23±4.25	21.65±7.41	5.75±4.61	14.42±6.67	7.30±4.92

Table 1.1 (E): Monthly variation in steps count between bull and cattle egret in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Step of bull Mean ± SD	Step of cattle egret Mean ± SD	Step of bull Mean ± SD	Step of cattle egret Mean ± SD	Step of bull Mean ± SD	Step of cattle egret Mean ± SD
January	42.72±8.71	61.63±10.15	39.90±12.75	61.63±10.15	40.54±7.48	52.31±16.56
February	40.75±12.99	54.12±14.71	38.5±15.73	55.62±14.22	48.16±16.25	54.75±14.39
March	34.12±14.31	58.29±16.13	36.95±12.68	60.54±14.42	37.62±11.34	55.58±17.73
April	38.56±14.93	55±16.52	41.64±16.39	53.04±11.54	41.08±11.04	49.32±10.15
May	45.95±11.46	49.54±14.49	39.79±9.46	65.87±15.22	34.70±11.10	52.75±10.79
June	37.5±11.25	43.91±13.82	27.66±11.70	64.04±18.19	46.37±11.34	59.32±14.21
July	39.16±14.72	46.25±13.43	39.58±13.05	47.87±13.63	35.25±12.35	45.91±13.98
August	42.02±8.07	54.08±15.65	36.91±15.09	65.5±16.22	34.08±12.73	50.41±9.25
September	45.62±9.56	56.95±12.49	29.54±12.67	52.12±12.01	34.91±8.16	47.91±7.58
October	41.45±14.50	58.91±12.24	42.87±14.25	64.79±16.93	38.12±13.32	56.79±13.25
November	46.16±8.40	62.16±8.44	42±12.27	55.58±10.84	39.58±12.68	56.95±14.48
December	42.8±11.18	55.2±10.40	40.68±9.75	55.04±10.99	36.44±12.73	43.95±13.79

Table1.1 (F): Monthly variation in foraging success of cattle egret with bull in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD
January	20.45±5.49	9.09±3.11	19.13±5.54	8.59±2.98	20.09±5.26	3.33±3.11
February	22.25±5.55	9.12±5.26	22.5±5.81	4.25±6.30	20.79±6.04	3.54±3.25
March	19.25±5.03	17.25±9.13	17.5±5.39	7.45±4.30	18.66±6.35	4.70±4.88
Apirl	14.8±5.45	7.2±3.57	14.2±9.18	7.36±5.10	17.88±7.31	12.01±7.10
May	16.20±6.08	7.37±3.22	10.62±5.20	5.01±4.12	22.16±9.98	9.12±3.12
June	18.29±7.27	11.87±5.51	20.95±9.87	5.12±2.92	21.62±6.54	13.91±6.0
July	24.37±7.25	4.83±3.87	19.20±10.10	9.66±4.96	22.20±7.46	14.5±6.40
August	17.70±9.77	4.63±3.93	23.5±8.46	9.79±6.00	20.12±7.46	11.79±5.57
September	18.54±9.70	4.20±3.30	17.91±5.86	7.02±3.70	22.16±6.25	14.87±7.02
October	13.66±6.34	7.16±5.53	25.45±5.97	7.91±5.41	18.75±6.71	8.20±3.64
November	18.29±7.37	9.62±5.44	19.91±8.04	9.16±5.70	22.54±5.80	4.16±6.32
December	12.96±7.30	6.76±5.33	15.44±8.85	7.8±5.97	16.96±5.45	7.8±4.11

Table 1.1 (G): Monthly variation in steps count between horse and cattle egret in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Step of horse Mean ± SD	Step of cattle egret Mean ± SD	Step of horse Mean ± SD	Step of cattle egret Mean ± SD	Step of horse Mean ± SD	Step of cattle egret Mean ± SD
January	51.27±10.99	54.77±12.77	39.31±12.41	61.63±10.15	61.40±24.93	45.22±14.12
February	44.75±13.13	50.75±13.75	38.5±15.73	55.62±14.22	47.70±28.15	47.87±13.05
March	45.45±10.27	55.01±18.53	36.95±12.68	60.54±14.42	53.33±23.74	42.83±12.35
April	36.2±11.34	56.84±13.78	41.64±16.39	51.76±13.89	37±27.90	54.84±17.58
May	36.37±16.08	58.62±17.41	39.79±9.46	33.04±23.07	71.02±11.09	44.08±9.93
June	43.25±12.75	57.41±19.31	46.37±11.34	45.62±12.51	71.70±14.81	64.04±18.19
July	43.04±9.90	51.95±18.48	39.58±13.05	47.87±13.63	54.29±16.21	35.04±16.04
August	34.58±11.41	43.8±14.20	36.91±15.09	62.5±20.75	46.79±15.23	52.12±12.01
September	38.5±11.21	44.12±13.17	29.54±12.67	46.45±18.30	54.04±17.42	40.54±18.97
October	37.41±11.91	44.91±16.76	42.87±14.25	62.5±20.75	49.75±17.02	33.58±16.31
November	43.83±10.39	60.62±12.72	42.20±13.75	57.12±17.62	61.70±13.03	44.25±12.01
December	47.08±10.63	62.96±22.00	46±10.89	63.28±20.78	63.28±20.17	49.76±10.89

Table 1.1 (H): Monthly variation in foraging success of cattle egret with horse in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD
January	15.86±7.86	9.77±7.32	18.36±9.69	7.63±5.26	18.54±6.01	8.27±3.29
February	14.12±7.82	9.20±7.63	16.12±7.23	5.45±3.16	21.79±6.68	4.62±6.30
March	14.04±8.95	6.87±5.38	15.04±7.95	4.91±3.93	17.25±5.31	6.41±4.43
April	16.24±5.36	7.24±4.42	17.48±6.42	4.92±3.27	13.72±8.53	8.16±5.05
May	18.5±7.45	7.70±4.98	16.5±9.57	3.16±2.68	11.37±5.05	6.54±5.75
June	14.83±7.91	7.83±5.45	20.33±9.44	4.33±2.92	20.37±10.05	5.58±2.53
July	22.29±8.34	10.33±6.26	17.62±10.53	6.83±5.66	16.62±10.87	9.83±4.88
August	17.16±7.49	8.45±4.67	16.45±8.54	8.83±5.80	19.91±10.67	10.04±6.43
September	16.79±8.55	7.58±4.64	17.62±8.76	6.58±5.99	17.79±5.86	7.33±3.33
October	15±9.20	5.62±5.49	15.91±8.22	5.5±4.69	25.37±6.04	7.20±4.82
November	17.37±6.93	6.12±5.10	17.54±8.51	7.37±4.22	21.91±9.09	7.62±4.83
December	14.52±7.83	4.16±3.06	21.64±6.8	6.56±5.09	18.64±8.48	3.01±3.74

Table 1.1 (I): Monthly variation in steps count between mule and cattle egret in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Step of Mule Mean ± SD	Step of egret Mean ± SD	Step of Mule Mean ± SD	Step of egret Mean ± SD	Step of Mule Mean ± SD	Step of egret Mean ± SD
January	35.08±23.44	45.04±10.84	21.22±8.04	42.77±8.11	41.72±7.05	53.04±16.89
February	52.27±24.52	33.04±15.45	33.62±11.89	48.04±6.83	42.25±8.16	54.5±14.03
March	31.66±23.31	35.37±13.39	33.16±14.79	43.25±9.18	38.08±11.83	55.12±17.86
April	21.2±18.48	35.6±14.27	43.88±18.71	43.04±13.54	39.64±11.22	49.04±10.37
May	19.54±13.04	40.25±16.32	20.04±9.02	41.08±9.71	35.12±10.81	53.37±10.32
June	42.2±8.69	30.12±20.95	39.91±13.41	37.5±11.98	27.20±12.85	42.58±14.29
July	17.04±11.58	38.95±15.34	36.29±12.97	39.95±13.57	35.33±12.36	45.33±14.19
August	42.62±24.15	28.16±11.80	27.20±13.69	41.16±12.26	34.33±12.87	50.91±9.04
September	17.04±11.58	38.95±15.34	36.29±12.97	39.95±13.57	35.33±12.36	45.33±14.19
October	35.79±15.26	33.37±20.53	44.12±13.56	51.04±17.66	33.41±13.16	55.29±17.16
November	32.54±8.37	49.25±10.19	45.20±9.38	54.33±14.77	46.08±11.98	59.79±17.72
December	27.88±14.68	43.2±13.44	34.08±12.63	59.24±13.44	15.5±8.65	52.08±17.89

Table 1.1 (J): Monthly variation in foraging success of cattle egret with mule in different feeding habitats.

Months	**Grassland**		**Marshy land**		**Agriculture land**	
	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD	Attempt Mean ± SD	Success Mean ± SD
January	19.13±5.54	8.72±2.89	18.63±5.58	8.59±2.98	19.81±8.73	4.31±3.15
February	22.5±5.81	4.41±6.26	22.08±5.80	4.25±6.30	19.70±6.23	9.5±5.25
Mach	14.68±4.90	4.68±4.48	11.32±7.74	4.28±4.60	20.54±13.99	5.75±3.98
April	11.16±6.85	3.76±3.74	11.92±7.47	3.48±3.48	17.04±7.99	5.48±3.26
May	12.75±6.08	5.37±4.52	12.83±5.97	5.62±4.35	18.08±5.31	6.41±4.10
June	18.41±8.64	5.04±3.02	18.79±9.10	4.75±2.77	16.83±4.13	5.70±2.94
July	18.29±9.55	7.29±4.44	17.62±8.71	7.16±4.22	22.16±9.67	9.87±5.53
August	23.41±8.50	9.83±6.60	23.20±8.67	8.95±5.00	25.45±5.97	7.95±4.78
September	18.45±5.69	7.04±3.65	18.33±5.80	6.87±3.65	16.83±4.13	5.70±2.94
October	25.45±5.86	7.91±5.41	24.95±5.75	6.87±4.29	15.25±7.50	6.41±5.12
November	21.04±7.98	5.37±3.85	20.41±8.16	5.54±3.85	15.16±8.81	4.29±3.58
December	15.88±8.54	3.24±3.38	17.88±8.63	4.8±4.22	10.96±7.37	5.24±3.01

Table 1.2. Foraging behaviour of cattle egret with different host.

Habitats	Host	Step rate of host	Step rate of cattle egrets	R-Value
Grassland	Cow	36.09±19.2	46.71±18.11	0.451**
	Buffalo	41.1±14.06	53.71±14.59	0.546**
	Bull	41.90±13.02	55.98±14.55	0.411**
	Horse	41.74±12.54	53.52±17.23	0.283**
	Mule	29.64±20.20	37.94±17.31	0.099
Marshyland	Cow	39.51±15.57	52.69±15.88	0.379**
	Buffalo	40.80±13.26	53.36±15.95	0.297**
	Bull	39.57±13.46	57.05±14.78	0.272**
	Horse	40.00±13.74	57.09±17.39	0.220**
	Mule	35.23±15.10	46.17±13.98	0.233**
Agriculture land	Cow	39.83±13.17	53.83±16.72	0.434**
	Buffalo	37.23±13.38	49.94±16.84	0.559**
	Bull	36.82±11.66	52.18±13.82	0.212**
	Horse	55.92±21.89	43.10±16.20	0.169**
	Mule	40.20±11.92	51.69±15.11	0.219**

R-value: Spearmean Rank correlation value between steps of host and steps of cattle egrets Steps was recorded at per five minute. **. Correlation is significant at the 0.01 level (2-tailed).

Table 1.3. Foraging success of cattle egret with different host.

Habitats	Host	Attempts	Success	R-Value
Grassland	Cow	18.63±9.15	9.35±6.74	r=0.774**
	Buffalo	17.10±8.05	8.50±5.79	r=0.761**
	Bull	18.02±7.63	7.461±4.87	r=0.503**
	Horse	16.18±8.05	7.28±5.67	r=0.548**
	Mule	18.92±8.19	6.29±4.81	r=0.363**
Marshy land	Cow	20.47±7.12	8.39±5.76	r=0.481**
	Buffalo	18.46±6.60	10.63±5.49	r=0.678**
	Bull	18.83±8.45	7.42±5.15	r=0.334**
	Horse	17.55±8.56	6.01±4.69	r=0.409**
	Mule	19.02±8.14	6.35±4.80	r=0.346**
Agriculture land	Cow	21.64±8.88	10.5±6.70	r=0.619**
	Buffalo	15.94±7.90	7.98±5.57	r=0.811**
	Bull	20.31±6.95	9.81±7.39	r=0.488**
	Horse	18.79±8.49	7.30±5.02	r=0.131*
	Mule	18.77±8.67	6.51±4.51	r=0.419**

R-value: Spearman Rank correlation value of attempt success rate of cattle egret

Attempt success was recorded at per five minute.

**. Correlation is significant at the 0.01 level (2-tailed).

*.Correlation is significant at the 0.05 level (1-tailed).

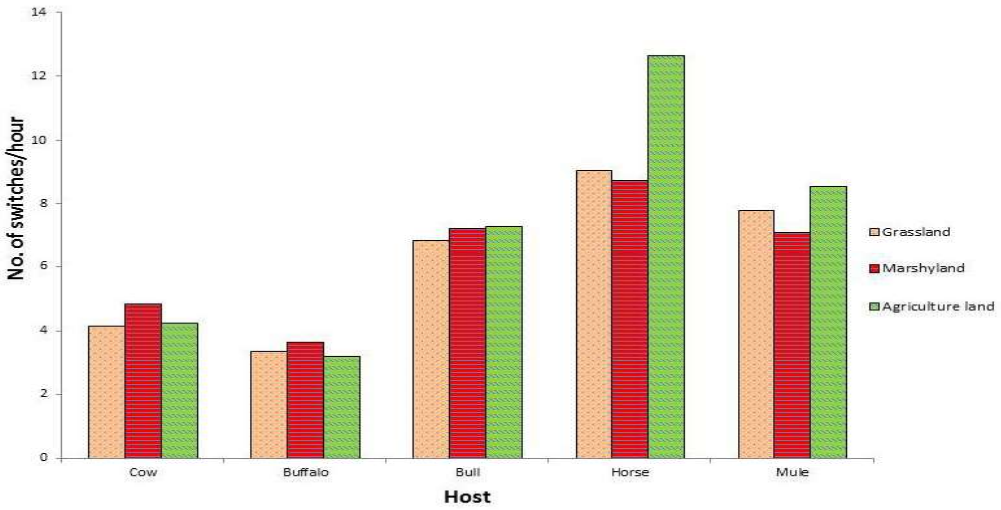

Figure 1.4. Number of Switches of cattle egrets with different hosts in grassland, marshy land and agriculture land.

Table 1.4. The Percentage of feeding success rate of attempt and success of cattle egrets with reference of Mean ± SD shown in two mode of feeding behaviour.

Mode of feeding	**No. of observation**	**Attempt(Mean ± SD)**	**Success(Mean ± SD)**	**Success rate(%)**
Foraging without cattle	118	48.03 ± 10.32	22.27 ± 8.89	46.36
Foraging with cattle	153	50.91 ± 10.07	31.9 ± 7.47	62.65

* Observation was recorded at 15 minute duration.

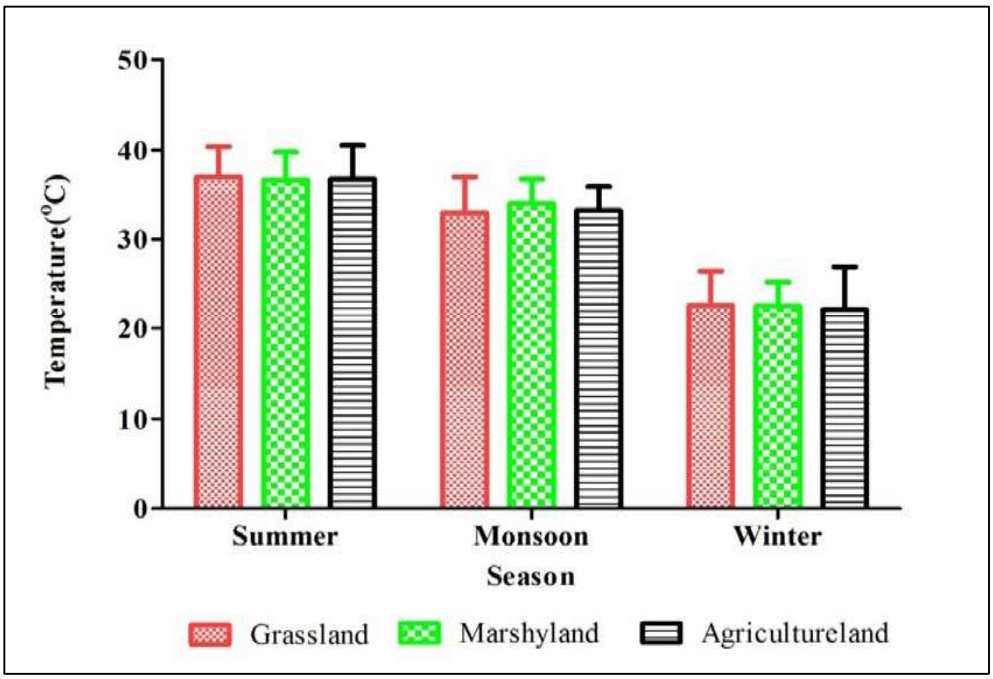

Figure.1.5. Ambient temperature recorded in Grassland, Marshy land and Agriculture land during summer, monsoon and winter.

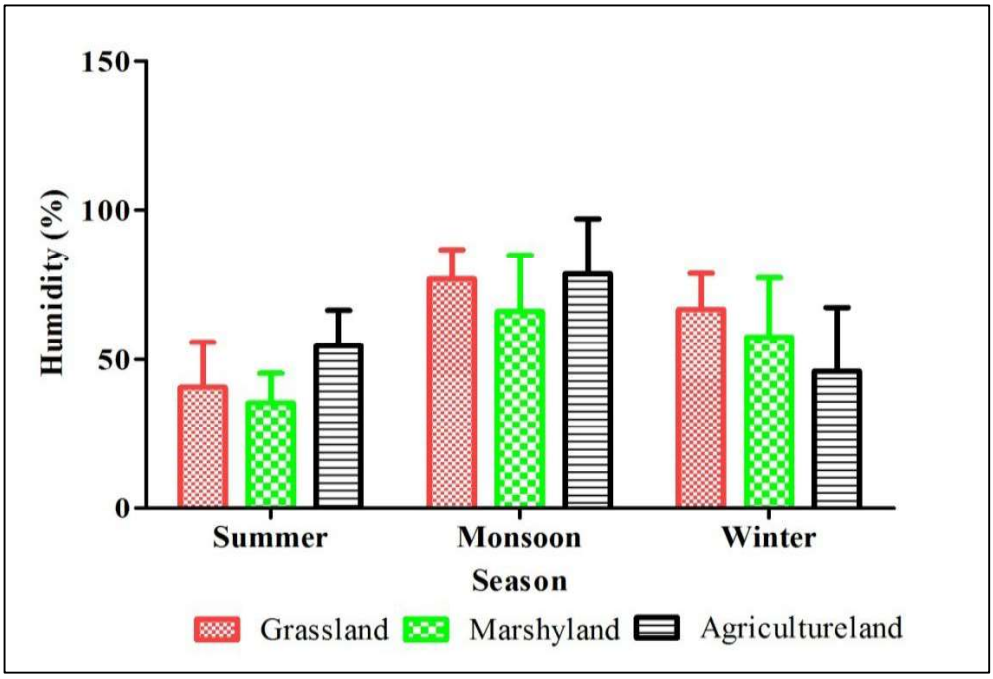

Figure 1.6. Ambient humidity recorded in Grassland, Marshy land and Agriculture land during summer, monsoon and winter.

The constant ambient temperature was recorded throughout the year in all the habitats i.e. (36.68 ± 015) in summer and in monsoon partial fluctuated (32.3 ± 3.95), (33.09 ± 2.77) and (33.15 ± 2.66) in grass land, marshy land and agriculture land respectively (Fig 1.5). Moreover, humidity was highly fluctuated in all habitats which was lowest on marshy land (35.3±9.98) in summer and maximum on agriculture land (78.5 ± 18.52) in monsoon (Fig. 1.6). As it concludes the humidity and temperature shows non-significant effect in the host selection of cattle egrets.

In the study on monthly basis the variations was observed in the steps of cow, i.e. The maximum steps count at agriculture land in the month of May was (45.95±11.46). And in July it was minimum at grassland (27.83±20.39). Simultaneously the steps of egret were also found maximum in the month of May (65.87±15.22) at agriculture land and it was the minimum in grassland (27.95±18.56).

Simultaneously, it was observed that the maximum attempts of egret with cow at agriculture land in the month of February (32.04±9.88) and it was minimum at grassland (13.95±7.33) in January. The success rate of egret shows the maximum in the month of March (17.12±7.08) at grassland and in January it was minimum (2.91±2.37) (Table 1.1 A and B).

Buffalo shows the maximum steps count (47.04±6.39) at agriculture land in February. The minimum was observed in May at marshy land (32.92±18.04). The step counts of egret were the maximum (62.79±8.21) in the month of February at agriculture land and were minimum in December (43.04±19.58) at marshy land.

The attempts were found maximum at grassland in the month of October (23.29±5.55) and minimum attempts were at marshyland (12.44±6.48). The success rate was the maximum in the month of February (12.08±5.68) at agriculture and it was minimum at

marshyland (5.75±4.61) in December (Table 1.1 C and D).

Bull shows the maximum steps count at agriculture land in the month of February (48.16±16.25) and minimum was at marshy land (27.66±11.70) in June. Simultaneously the steps count of egret was the maximum (65.87±15.22) in the month of May at marshy land and minimum was in December (43.91±13.82) at agriculture land.

The attempts of egret were the maximum in grassland in the month of July (25.45±5.97) and minimum was at marshyland (10.62±5.20) in May. The success rate found was maximum in the month of March (17.25±9.13) in grassland and minimum was in agriculture land (3.33±3.11) in the month of January according to monthly observation (Table 1.1 E and F).

Monthly observation of steps count of horse shows the maximum at agriculture land in the month of June (71.70±14.81) and minimum was in marshy (29.54±12.67) in September. And the step counts of egret were the maximum (64.04±18.19) in the month of June at agriculture land and were minimum in June (33.04±23.07) at marshy land.

The attempts of egret were the maximum at grassland in the month of July (22.29±8.34) and were minimum at agriculture land (11.37±5.05) in May. The success rate was the maximum in the month of July (10.33±6.26) in grass land and minimum was at agriculture land (3±3.74) in the month of December (Table 1.1 G and H)

The monthly variations in the Steps count of Mule was the maximum at grassland in the month of February (52.27±24.52) and was found minimum at agriculture land (15.5±8.65) in December. Similarly the variation in the step count of egret was found maximum i.e. (59.79±17.72) in the month of November at agriculture land and was minimum in August (27.20±13.69) at marshyland.

The maximum attempt rate was observed at marshyland (25.95±5.75) in the month of October and was minimum at agriculture land (10.96±7.37) in the month of December. The maximum success rate was observed in the month of July (9.87±5.53) at agriculture land and minimum was in grass land (3.24±3.38) in December (Table 1.1 I and J).

Foraging behaviour with cow

Cattle egrets showed significant positive correlation in steps of cow. Cattle egrets switches per hour was about (r= 0.451**, 4.1) in grassland, (r=0.379**, 4.8) in marshy land and it was (r=0.434**, 4.2) in agricultural land. The attempt success resultant showed the cow was a satisfying host to cattle egrets with the significant positive correlation i.e. in grassland (r=0.774**), (r=0.481**) in marshy land and (r=0.619**) in agriculture l and (Table 1.2 1.3 and fig1.4).

Foraging behaviour with buffalo:

The feeding association relationship of cattle egrets with buffalo, steps showed significant positive correlation and switches per hour was very low in grassland (r=0.546**, 3.3), marshy land (r=0.297**, 3.6) and in agriculture land it was (r=0.559**, 3.2)(Table1.2 and fig.1.4), hence the resultant attempt success showed highly significant positive correlation and reaches maximum range of feeding success i.e. (r=0.761**), (r=0.678**) and (r=0.811**) (Table 1.3).Therefore, it is concluded that buffalo was the best suitable host to cattle egrets.

Foraging behaviour with bull:

The foraging behaviour with bull in grassland and agriculture land, the steps were having a significant positive correlation and switches per hour were as (r=0.411**, 6.8)

and (r= 0.212**, 7.2) (Table1.2 and Fig. 1.4) therefore, cattle egrets attained attempt success rate (r=0.503**, r=0.488**) (Table1.3) it also has the significant positive correlation, which was approximately fifty percent feeding success in grassland and agriculture land. While in marshy land this feeding association showed less steps correlation rate and high number of switches per hour (r=0.272**, 7.3) (Table1.2 and Fig.1.4). Therefore, in marshy land, cattle egrets achieved less attempt success rate (r=0.334**) (Table1.3), accordingly it is concluded that feeding association relationships of cattle egrets with bull was the less satisfying association.

Foraging behaviour with horse:

The foraging behaviour with horse in agriculture land, steps shows the significant positive correlation (r=0.169**, P<0.01) (Table 1.2) and the switches per hour was high (12.6) (Fig.1.4) hence, cattle egrets attained (r=0.131*, P<0.05) (Table 1.3) attempt success rate. Therefore as per the observed data, the lowest attempt success rate was achieved by cattle egrets with horse in comparison with other hosts. The attempt success and switches per hour in grassland were higher with horse in comparing to the other hosts such as (r=0.283**, P<0.01, 9.0) and in marshy land it was (r=0.220**, P<0.01, 8.7) (Table 1.2, Fig.1.4). Therefore, it's attained attempt success rate was (r=0.548**and r=0.409**) (Table 1.3). Based on the step correlation, switches and the attempt success rate in this relationship was less than satisfying.

Foraging behaviour with mule:

In foraging behaviour with a mule in grassland, showed non-significant correlation in steps, while in attempt success it was significant positive correlation i.e. (r=0.099), (r=

0.363**). In marshy land and agriculture land, steps and attempt success both showed the significant positive correlation i.e. (r= 0.233**), (r=0.219**) and (r=0.346**), (r=0.419**) and the switches per hour were (7.7) in grassland, (7.1) in marshy land and (8.5) in agriculture land (Table 1.2, 1.3 and Fig.1.4). Based on the steps correlation, switches and attempt success, this relationship was less than satisfying.

Switches:

In Fig.1.4 Cattle egrets showed the lowest switches per hour with buffalo at all the three feeding habitats in comparison to all other hosts i.e. grassland it was (3.3/hour) (3.6/hour) in marshy land and (3.2 / per hour) in agriculture land. In respect with horse, it shows the highest switches per hour at all the three lands such as (9.0/hour, 8.7/hour and 12.6/ hour).

Foraging success:

The foraging success of cattle egrets in two different feeding mode i.e. Cattle egrets forage with cattles and forage without cattles. Egrets attained more feeding success when its feed with cattles or alongside cattle (62.65) as compared to feed alone or without cattles (46.36) (Table 1.4).

DISCUSSION

The host preferences by cattle egrets are more effective in gaining their opportunity to capture more prey. They prefer to select the host species which moves neither too much fast nor too much slow. If the host moves very slow or rapidly the egrets switch their hosts. The steps of hosts affect the steps of egrets simultaneously **(**Itzkowit and Makie, 1986). The capture rate depends on the optimal speed of the host steps as

well as egrets steps (Burger and Gochfeld, 1993). When cattle egrets associated with large bodied cattle over small bodied as the large bodied cattle disturbs more prey (Mikula et al., 2018) so, they caught prey items at a faster rate and spent less energy to achieve more, it has been also noted in other studies on this species (Heatwole, 1965; Grubb, 1976).Cattle egrets showed the highest frequency of association with cattle at noon time. It was and low association in early morning and late in the evening (Aboushiba *et al*., 2015). In such association, they usually fed near the front leg or back leg or middle (Kour and Sahi, 2012). They left roost in small groups to disperse in the different areas. In evening, small groups return from foraging areas often congregated in flocks of hundreds of individuals. The buffalo was the best suitable host for cattle egrets in the attempt success correlation rate in comparison with the others and horse was the unsuitable host as compare to another host.

In this study, it was observed that cattle egrets usually showed feeding association relationships with cattle on grassland, marshy land and agriculture land (Anastasios *et al*., 1997). According to an analysis of all the variables, buffalo seems profitable and best suitable host to cattle egrets. *B. ibis* showed highest attempt success relationship with buffalo, lowest with horse. The buffalo was grazing with slow speed as compare to horse at per five minute, as a result steps of egrets with buffalo and with horse was differed. Cattle egrets taken less switches with buffalo in compare to other hosts as well as horse i.e. Due to its ignorance behaviour towards cattle egrets. Overall switches count with horse was very high than other hosts, as it starts tail wagging and shakes the head to remove the cattle egrets (Kour and Sahi, 2012). And when its moves too fast, cattle egrets usually makes switches or ignore them, or takes stand and wait position. Based on increasing order, the switches counts hosts are as follows,

buffalo<cow<bull<mule<horse. Cattle egrets forage in single, pairs and flocks by searching, running and flying after catching the prey. Egrets occasionally feed with donkey or goat but do not spend so much time to forage with them.

Effects of type of cattle on foraging behaviour of egret, as their size, coat colour and group size

Mode of feeding of cattle egrets is influenced by the type and size of the cattle. When the cattle egrets associates with large bodied cattle i.e. buffalo, cow and bull, over small bodied "mule". It was observed that, the large bodied cattle are more suitable for egrets as they disturbs more prey (Mikula *et al.,* 2018) so, they catches prey items at a faster rate and spend less energy to achieve more. This has been noted in other studies (Heatwole, 1965;Grubb,1976).

However the time spent in successive prey captures for this category of birds, was determined neither by coat colour nor by the group size of cattle. It was observed that during the feeding with different colour of cattle i.e. black and brown buffalos, white and spotted cows or bull have no impact on egrets feeding rate. Simultaneously feeding with large group of cattle, the egret loses its concentration on prey capturing, because insects are disturbed in abundance. It is also noticed by (Seedikkoya *et al.*2005).

During the study period,egrets was present regularly in grassland as the prey was present there throughout the observation period and due to the less human disturbance seen at the grazing time of cattle. Therefore, present study shows the high percentage of birds association in grassland. Marshy habitat was followed by few numbers of vegetation. Grass was present only at the edge of habitat with a number of pits were present. In summers, as the temperature increases the marshy land get dried out and it

converted into the dry land (Bauder, 1989) hence, cattle were not preferring much grazing in such habitat because of low vegetation. But in monsoon season, the marshy habitat converted into wetland due to the water logging, rushes and grasses grows over the whole land. Hence, the cattle starts grazing in marshy land during monsoon season, as it shows the less percentage of association of birds comparatively than in grassland. Buffalo prefers such area of low wetland and grazes comfortably for the long time than other grazers, such as cow, horse and bull. Therefore the egret obtained more feeding success with buffalo than the others. In agriculture land. At the time of none cultivation, we observed a good percentage of association and the number of birds. In cultivation period, from middle of December - February last we observed very less association feeding of cattle egrets. The availability of bird populations in habitat varies depending on the requirements of the bird species and effective conditions offered by the habitat. However, the trapping way in habitat studies revealed the uncultivated fields offers more prey to predatory birds, especially cattle egrets (Mohammedi *et al*., 2015). Egrets regularly forage in agriculture land. During the study, all host cattle reflects a good correlation in steps and attempt success rate with egrets, except with horse and mule (Rao, 2004). Horse and mule prefers grassland for grazing (Sheehy and Martin, 1996) and other cattles such as buffalo, cow and bull grazes so comfortably as the grasses were less in compare to the crops. Horse and mule need to move faster in searching of more green grass, this results in the percentage of switches, goes high and the time of association becomes less (Burger and Gochfeld, 1981). Cattle egrets can forage without cattles, when hosts are not available or are in resting phase (Siegfried, 1971). It was observed that the egrets get more food items with host at per five minutes than, those of feeding alone. Switching and association time is a basic factor of

cattle egrets foraging with cattles, i.e. allowing birds to repeatedly in preferring the host with more suitable movement. The high number of switches and less time of association indicates the low foraging success. We found that about 90% of the egrets switched the hosts, which is an important factor that influences the foraging success of egrets. In foraging success, our result revealed that of cattle egrets does not select hosts randomly, but they prefer the host which seems to be tolerant along with easy and long association. It was observed that in all sites the cattle egrets feeds mainly orthopterans insects (Siegfried, 1972).

Cow is the most selected host by egrets (Burger and Gochfeld, 1981).While this study showed that the buffalo is the most appropriate and selected host due to the widespread distribution than other hosts in the study areas. The walking steps of the cow as well as buffalo, were in an optimal feeding range of egrets.

CONCLUSION

Above results shows that, cattle egrets shift hosts when the hosts movements are not within their optimal foraging range, they do not randomly select hosts. Egrets could avoid or leave hosts that moved too fast by losing its accuracy of capturing the prey with increasing host speed. In case of high feeding success rate, foraging with cattles showed a number of steps of cattle egrets, which was about (49.94±16.84) at per five minutes and for cattle it was (37.23±13.38). The high number of switches and less time of association indicates the low foraging success. Thus, the buffalo is a suitable host for egrets. Based on decreasing order, the suitability of hosts are as follows, buffalo>cow>bull>mule>horse. The high number of switches and less time of association indicates the low foraging success. Feeding habitat preferred according to the seasonal changes, egrets feed at all types of habitat in all season whether it was

grassland, marshy land or agricultural land. The number of population of birds will decrease or increase accordingly. Grassland proved to be more profitable than marshy land and agriculture land, this plays a complementary role for egrets foraging.

Chapter-II

Diet selection and diet composition of *Bubulcus ibis.*

CHAPTER-II To study the diet selection and diet composition of Bubulcus ibis.

INTRODUCTION

Cattle egrets (*Bubulcus ibis*), belonging to the family Ardeideae, this is cosmopolitan bird of heron species. It occupies a big geographic area (Zaccagnini and Beltzer, 1982). In India it is commonly found in various habitats like wetlands, fresh water sources, marshylands ponds, grassland, roadsides, dumps, parks, sport lawns and agricultural farms etc. (Meyerricks ,1962 and Seedikkoya, 2004). They are terrestrial foragers as they pick the disturbed insects alongside grazing animals, without causing any inconveniences or disturbances to them (Wittenberger and Hunt, 1985). Egrets are gregarious birds feeding in flocks, breeds colonially and form large ‘‘roosting places’’ in permanent and temporary swamps or trees (de laPen a, 1992). Several studies have been reported regarding the habitat and diet selection of egrets, that the both habitat and diet selection get changed with the change in seasons and presence of grazers helps in making a quality symbiotic relationship. The habitat selection is also depends on prey availability and absence of anthropogenic disturbance. (Fogarty and Hetrick, 1973; Ducommun *et al*, 2008). Their prey quality and quantity also changes in different habitats with the time of foraging. (Kour *et al*, 2014). They described about cattle egrets diet, that it feed primarily grasshoppers, crickets, flies, moths, spiders, frogs, crayfish and earthworms (Mckilligan, 2005). Rarely, they also consume fish and snake. At garbage dumps they feed like scavengers.

A wide range of food taken by the egret shows that it consumes whatever could be captured by its primary tactile foraging method (Siegfried, 1971). The good foraging habitat provides an easy availability and accessibility in selecting the prey at a reduced

predation risk (Wahungu *et al*., 2003). It plays significant roles in a variety of ecosystems, as their foraging habit contributes in controlling the agricultural pests and helpful to public health. Seasonal changes effects the insect prey population, many species of insects, prey disappear after the rain. This also effects the cattle egrets feeding and foraging behaviour (Elgood, 1979). Seasonal variation in habitat use was noticed in the cattle egret by (Thompson, 1977, Hafner and Fasola 1992). However, seasonal pattern in selecting of habitat and its relation with food availability is not established by researchers in Uttar Pradesh, India. Therefore, aim of this study includes: Analysis of seasonal diet of egrets through food consumed by egrets on the basis of habitat use. Foraging behaviour is observed on the basis of different posture and actions displayed by this bird at respective habitat used. Practically nothing has been revealed b e f o r e on these aspects of cattle egrets from study areas at Lucknow.

MATERIALS AND METHODS

Study area

The field surveys were carried out at the different sites in Lucknow district i.e. Jagat Kheda, Mawaiya and Kantha.

Jagat Kheda, grassland is positioned at a latitude of 26°44’30”N and longitude of 80°58’1”E with comprising of about 6 hactares in area. Main vegetation at this site was of grass and shrubs. During rainy season they receive enough water to grow tall grass and other scrubby plants.

Mawaiya, marshyland is situated between the latitude and longitude of 26°45’31”N and 80°56’32” E respectively. It is approximately an area of 11 hectares and surrounded with Mawaiya Lake and small water bodies. The water level rises during monsoon and in winter season it is covered by herbaceous aquatic plants andwhen the water level falls

down during summer, at the end of April till June water level gets decreased and the lake gets almost dried.

Kantha, agriculture land is situated between the 29°05'76"N latitudes and 78°59'57"E longitudes. It has 10 hactares in area. At this site the canal is used for irrigation the field; the major area of this site is under cultivation. Cropping pattern followed in vicinity of study sites consisting of wheat and rice. And the surrounding plains are having cultivation of vegetables and cereal crops.

The geographic coordinates of Lucknow are 26°51'0.0000"N and 80°56'59.9892" E (Kannaujiya, 2013) and the temperature ranges between 25-45°C in summers, 2-20°C in winters. The study was assessed through periodical field visits at Grassland (an area which was included of ecosystem where grasses and forbs were in dominant), Marshy land consisting of (wetland associated with pond, swampy) and agriculture land (includes intensively managed or grazed wet meadow or pastures) And wetlands(A deep-water body such as lake and pond surrounded by land), (Grobicki ,2016).

Data collection

The study was carried out weekly between 2016 to 2018. The sampling had been done between 0600 h - 1800 h, the observation carried out visually during the feeding time of cattle egrets with the help of digital video camera and binocular (Celestron up close G2, 6.8°/35FT/118M 10x50X). Non-invasive method was avoided. The whole study period was divided in to three seasons, summer (March to Jun), monsoon (July to October) and winter (November to February). The food consumed success was identified by the characteristic of i.e. Head-jerk, swallowing behaviour of cattle egret as described by Dinsmore, 1973 and Scott, 1984.

Statistical analysis

"Shapiro wilk test" method was used for Normality test of the data where level of significant at (P>0.05), therefore,prey items consumed and availability of prey items were analyzed through Krushkal Wallis-H analysis (SPSS version 21) level of significant at (P>0.05).

Availability of prey items was recorded by the help of two sweeps of a long handled net from the foraging area, with in $5m^2$ range. While fishes were collected with help of local fisherman, all was done by following the similar method as of (Fasola, 1986). Besides it, regurgitated food items were collected and preserved in a 70% ethanol for identification of taxa (Chapman, 2013). Food consumed and different foraging behaviour was recorded at every15 minute interval from dawn to dusk and was noted carefully from a distance of 30-40 meters with a help of binocular. The nomenclature of foraging behaviour was used as (Mayerricks, 1962 and Kushlan, 1978).

Table 2.1. Definition of different foraging behavior of cattle egrets.

Foraging behaviour	Definition	References
Leapfrog feeding	Egrets flies from the back of feeding flocks to the front	Siegfried, 1971
Search and Pecking	Pecking is the action of a bird using their beak search for food or otherwise investigate an object or area by trapping it.	Heatwole, 1956
Walk Slowly	Cattle egrets moves slowly, just before striking.	Recher, 1983

Stand and wait	The egrets stand motionless for some time to watch the prey item for capturing.	Kushlan, 2010
Walk Quickly	Egrets walks through shallow water or field catching prey disturb by its movement.	Recher and Holmes, 1982
Foot stirring	Egrets extends one leg and vibrates, especially the food, then stabs at any prey darts from the disturbance.	Sharma and Soni, 2014
Probing	Cattle egrets placed its bill half and more than half inside the water to pick up a prey items.	Sharma and Soni, 2014
Standing fly catching	This feeding behaviour involves catching of flying preys, while the birds are in standing posture.	Recher,1972
Neck swaying	Forward and backward movement of neck to obtain a precise estimate of distance and location of object.	Kushlan,1986
Canopy feeding	The large wading birds are bringing their both wings forward to form a canopy type structure, the shadow in front of their own body attracts the fish and insects.	Delacour,1946
Fly scanning	Cattle egrets scans the ground or wetland to search their food while flying from a distance between 5 to 10 meter.	
Resting	The bird stops feeding. It stands on its one foot or sits on the substratum	Sharma and Soni, 2014
Hopping	Herons follow the flying insects for short distance and often stabs the insects simultaneously with landing	Meyerriecks,1960

Figure 2.1. Cattle egrets feeding at marshyland, Mawaiya.

Figure 2.2. Cattle egrets feeding at grassland, Jagat kheda.

Figure 2.3. Agriculture land (Kantha) feeding site of cattle egrets in paddy field.

RESULTS

In the present study, the total number of 1,443 cattle egrets were observed at different foraging sites , the percentage in agriculture land (34.21%) followed by grassland (26.57%), marshy land (21.70%), and wetland (17.49%). Most of cattle egrets a little seasonal variations at foraging sites i.e. in rainy season they feeds in large number as compared to summer and winter. It was observed that the bird has a highest frequency of feeding in early morning and late in the evening (Aboushiba, 2015).

In monthly variation prey consumed by egrets in different habitats, showing the maximum prey items were present in Insect was Odonata (20.75±4.39) in the month of August and the minimum was of Diplopoda (0.37±0.51) in the month of January and in Pieces, the maximum prey items was Channa (10.87±5.43) in the month of

November and the minimum was of Channa (0.37±0.74) in the month of April. In case of Amphibia, the maximum prey items were showed in Anura (12.62±6.06) in the month of July and minimum was in the month of August (7.87±7.03). In Annelida, the maximum prey items were showed in Opisthopora (10.12±7.77) in the month of July and minimum was in the month of August (6.87±4.29). In Reptilia the maximum prey items were showed in Squamata (2.62±2.92) in the month of February and minimum was in the month of April (0.62±1.06) (Table 2.2).

Table 2.2: Monthly variation in prey consumed by cattle egrets in different habitats

	Month	January	February	March	April	May	June	July	August	September	October	November	December
A.	**INSECTS**												
1.	Hymenoptera	2.87±2.74	2.25±1.90	4.87±3.18	4.5±3.25	5.75±2.96	2.87±3.13	4.12±3.39	3.62±3.70	3.87±3.48	3.75±3.57	2.87±2.74	3.25±2.49
2.	Hemiptera	-	-	-	-	-	-	1.62±1.99	1.5±1.60	3.25±3.32	0.62±0.74		
3.	Odonata	5.12±3.60	3.25±4.30	9.75±7.28	9.25±6.04	10.12±6.01	8.87±7.07	16.25±5.31	20.75±4.39	12.25±9.09	16.75±4.02	4.87±3.18	4.87±3.35
4.	Lepidopetra	-	-	-	-	-	-	3.5±3.07	4.87±3.35	3.87±3.04	2.75±4.16		
5.	Orthropetra	2.12±2.10	4.12±2.23	4.25±2.60	4.62±4.13	3.87±2.94	4.62±2.87	11.62±4.53	11.37±4.24	10.62±7.99	8.75±4.20	2.87±2.29	1.12±1.35
6.	Diptera	1.25±1.75	4.25±3.05	6.5±4.56	5.25±4.23	3.12±1.55	2.12±2.64	9.75±6.11	9.12±5.19	9.25±7.40	2.87±2.23	3.12±1.95	2.37±2.26
7.	Dermapetra	-	-	-	-	-	-	2.37±2.26	3.25±3.01	2.5±2.39	1.87±2.10	-	-
8.	Areana	3.87±3.39	4.12±2.29	1.75±1.48	1.87±2.35	1.5±1.41	1.12±1.12	3.12±1.80	2.62±2.26	2.25±1.38	2.12±1.55	1.87±1.95	5.25±2.49
9.	Ixodida	1.87±1.95	2.37±1.99	1.62±1.59	1.87±1.72	3.12±2.47	2.12±2.47	2.5±2.67	3.37±2.19	2.12±1.95	2.25±1.83	2.62±2.61	3.12±1.80
10.	Coleopetra	2.62±2.44	4.25±1.90	11.5±5.12	8.75±5.77	7.87±6.12	6.87±5.24	16.37±4.59	18.37±5.57	15.75±6.56	6.37±5.26	3.87±3.04	4.25±2.65
11.	Diplopoda	0.37±0.51	2.12±1.88	-	-	-	-	14.87±4.85	16.12±5.13	12.87±4.61	6.87±2.03	1.37±1.50	1.25±1.28
12.	Chilopoda	1.25±1.38	4.12±2.47	-	-	-	-	15.12±8.47	14.5±7.57	15.87±5.81	8.62±5.15	3.75±3.53	1.87±1.80
B.	**PIECES**												
1.	Cypriniformres	5.75±4.20	7.75±3.41	2.12±1.95	0.5±0.75	0.87±1.12	1.37±1.50	2.12±1.95	3.75±3.32	5.37±3.62	7.75±2.37	5.87±3.79	11.5±4.37
2.	Siluridae	5.75±5.03	4.87±4.54	2.62±2.38	1.62±1.99	1.37±1.50	1.5±1.85	2.12±1.80	2.25±2.96	3.12±3.60	5.75±4.33	8.75±7.55	9.5±5.52
3.	Channa	4.62±3.99	8.62±5.37	1.37±1.06	0.37±0.74	0.5±0.75	0.75±0.88	3.12±2.69	2.87±3.64	4.25±3.99	4.87±3.13	10.87±5.43	8.75±8.10
C.	**AMPHIBIA**												
1.	Anura	-	-	-	-	-	-	12.62±6.06	7.87±7.03	8.12±7.75	8.37±7.46	-	-
D.	**ANNELIDA**												
1.	Opisthopora	-	-	-	-	-	-	10.12±7.77	6.87±4.29	8.37±6.80	9.62±6.18	-	-
E.	**REPTILIA**												
1.	Squamata	2.25±2.12	2.62±2.92	1.62±1.59	0.62±1.06	1.12±1.35	1.75±1.03	1.25±1.58	2.87±2.47	0.87±0.99	1.87±1.45	1.75±1.48	2.37±2.61

A total of 18 orders from five phyla of prey items consumed during the study period including twelve orders of Insects, three orders of Pisces, Anura of Amphibia, Opisthopora order of Annelida and Squamata order of Reptilia. We observed that the prey items of cattle egret were found varied according to the seasons. The maximum prey fed were insects among the phylum included twelve orders alone. Odonata was maximum fed by cattle egret in all the seasons, whereas the result was, a maximum fed in monsoon (16.5 ± 5.80) and minimum in winter (4.5 ± 3.69). Kruskal Wallis H test also showed significant difference in all season (H=6.031, P= 0.049) (Tabel 2.3). While secondly maximum consumed prey item were Coleoptera in every season i.e. in monsoon (14.25± 5.57) summer (8.75 ± 3.30) and in winter (3.75±3.30). Statistically a significant variation among the season was observed (H=6.89, P=0.032) (Table 2.3).It was seen that, when insect availability was limited, the Pisces was the main food item of cattle egrets. As in winter the channa (8.25±2.87) was maximum consumed by cattle egrets. While minimum in summer (0.75±0.95).Whereas Kruskal Wallis H test showed significant deference among the seasons (H=6.026, P= 0.049) (Tabel 2.3). Furthermore, other prey items including Amphibian, Annelids, and Reptilia were consumed in less quantity in all three seasons (Table 2.3).

Table 2.3. The seasonal variation in consumption of prey items by cattle egrets is given as mean ± SD of three distinct seasons. The Kruskal Wallis H test is Significant at the 0.05 level.

Taxa	Summer	Monsoon	Winter	Statically value	
	Mean ± SD	Mean ± SD	Mean ± SD	H	P
Insect					
Hymenoptera	4.5 ± 4.50	3.75 ± 4.11	2.5 ± 3.78	1.09	0.58
Hemiptera	-	1.75 ± 1.70	-	7.157	**0.028**
Odonata	9.5 ± 6.60	16.5 ± 5.80	4.5 ± 3.69	6.031	**0.049**
Lepidoptera	-	3.75 ± 3.30	-	7.031	**0.239**
Orthoptera	4.25 ± 3.5	10.5 ± 2.38	2.5 ± 2.64	6.934	**0.031**
Diptera	4.25 ± 2.06	7.75 ± 8.38	2.75 ± 3.09	1.012	0.603
Dermapetra	-	2.5 ± 1.91	-	10.507	**0.005**
Areanea	1.5 ± 1.29	2.5 ± 3	3.75 ± 0.95	0.792	0.673
Ixodida	2.2 ± 1.70	2.5 ± 1.91	2.1 ± 1.71	0.396	0.82
Coleoptera	8.75 ± 3.30	14.25 ± 5.56	3.75 ± 3.30	6.89	**0.032**
Diplopoda	-	12.75 ± 4.99	1.25 ± 1.5	9.116	**0.01**
Chilopoda	-	13.5 ± 4.43	2.75 ± 1.89	9.116	**0.009**
Pisces					
Cypriniformes	1.25 ± 0.95	4.75 ± 3.09	7.75 ± 3.30	7.372	**0.025**
Siluridae	1.75 ± 2.06	3.25 ± 1.5	7.25 ± 1.70	7.577	**0.023**
Channa – punctatus	0.75 ± 0.95	3.75 ± 3.86	8.25 ± 2.87	6.026	**0.049**
Amphibia					
Anura	-	9.25 ± 2.06	-	6.715	**0.035**
Annelida					
Opisthopora	-	8.75 ± 4.11	-	6.958	**0.031**
Reptilia					
Squamata	1.25 ± 1.25	1.75 ± 1.25	2.25 ± 1.5	1.131	0.568

A total prey items availability was observed among 18 orders of five phyla at foraging sites during the study period. In the whole study, the maximum orders of prey items were found i.e. Odonata, Coleoptera, and Opisthopora in monsoon, while presence of Coleoptera was also seen maximum in summer and Cypriniformes, Siluridea and Channa in monsoon and winter (Table 2.4).

Table 2.4. The availability of prey items of cattle egrets in three distinct seasons respectively summer, monsoon and winter. Whereas (-) absent, (+) 10 % (++) 20%, (+++) 30-35%, (++++) 40-50% observation.

Taxon		**Season**		
Vernacular name	**Order**	**Summer**	**Monsoon**	**Winter**
Wasp, Bees, Ants	Hymenoptera	+	++	+
Rice bug, True bug	Hemiptera	-	+	-
Damselfly, Dragonfly, Nymph	Odonata	+	++++	+
Caterpillar	Lepidoptera	-	+	-
Grasshopper, Cricket	Orthoptera	+	++	+
House fly	Diptera	+	+	-
Earwig	Dermaptera	-	+	-
Spider	Areanea	+	+	+
Ticks	Ixodida	+	+	+
Ladybird beetle, Ground beetle, Blister beetle	Coleoptera	++	+++	+
Millipedes	Diplopoda	-	++	-
Centipedes	Chilopoda	+	+	-
Labeo rohita, Catla	Cypriniformes	+	++	++
Mystus seenghala	Siluridae	+	++	++
Spotted snakehead	Channa punctatus	+	++	++
Frog, Tadpole	Anura	-	++	-
Earthworm	Opisthopora	-	+++	-
Lizard, snake	Squamata	+	+	+

Table 2.5. Different foraging behaviour displayed by cattle egrets at different habitats. Whereas (-) absent, (+) Present observation.

Foraging behaviour	Grassland	Marshy land	Agriculture land	Wetland
Leapfrog feeding	–	–	–	–
Search and pecking	+	+	+	–
Walk slowly	+	+	+	+
Stand and wait	+	+	+	+
Walk quickly	+	+	+	+
Foot stirring	–	–	–	+
Probing	–	–	–	+
Standing flying catching	+	+	+	+
Neck swaying	+	+	+	+
Canopy feeding	–	–	–	–
Fly scanning	+	+	+	+
Resting	+	+	+	+
Hopping	–	–	–	–

Table 2.6. Morphological measurement of collected prey items of cattle egrets.

Taxon		**Body length (cm)**	**Body weight (gm)**
Insecta	Hymnoptera	1.11±0.38	12.77±4.36
	Hemiptera	5.05±3.84	10.05±6.77
	Odonata	5.25±2.37	0.04±0.006
	Lepidoptera	6.97±5.10	2.41±0.76
	Orthroptera	2.05±0.28	0.41±0.17
	Diptera	0.8±0.21	0.01±0.003
	Dermaptera	1.96±0.39	3.75±1.35
	Areanea	1.47±0.50	0.15±0.10
	Ixodida	0.84±0.04	1.92±0.90
	Coleoptera	1.77±0.63	2.5±0.85
	Diplopoda	4.75±1.55	1.82±6.03
	Chilopoda	17.05±3.33	32.75±6.65
Pisces	Cypriniformes	5.82±1.04	12.00±14.28
	Silirudea	6.25±1.55	10.10±4.74
	Channa punctatus	5.65±0.73	17.91±10.51
Amphibia	Anura	5.62±2.52	30.67±11.02
Annelidia	Opisthopora	11.55±4.38	27.5±6.85
Reptilia	Squamata	16.75±3.30	65.12±54.11

In this study five types of prey items were identify and considerable variation was found among the prey species. Insects size was divided into four category (0.5-1cm, 2-5cm,5-10cm and 10-20cm). Cattle egrets choose 0.84-17.05cm insects, and body weight was measured 0.04±0.006 to 32.75 ±6.65. In this study mainly three types of Pisces were captured by egrets, their size varied from 5.65 – 6.25 and body weight of Pisces 10.10 – 17.91gm. In case of Amphibian, Annelida and Reptilia only one type of species was captured by it, their size were oberevd i.e. 5.6±2.52,

11.55±4.38 and 16.75±3.30, body weight was 30.67±11.02, 27±6.85 and 65.12±54.11 respectively (Table 2.6).

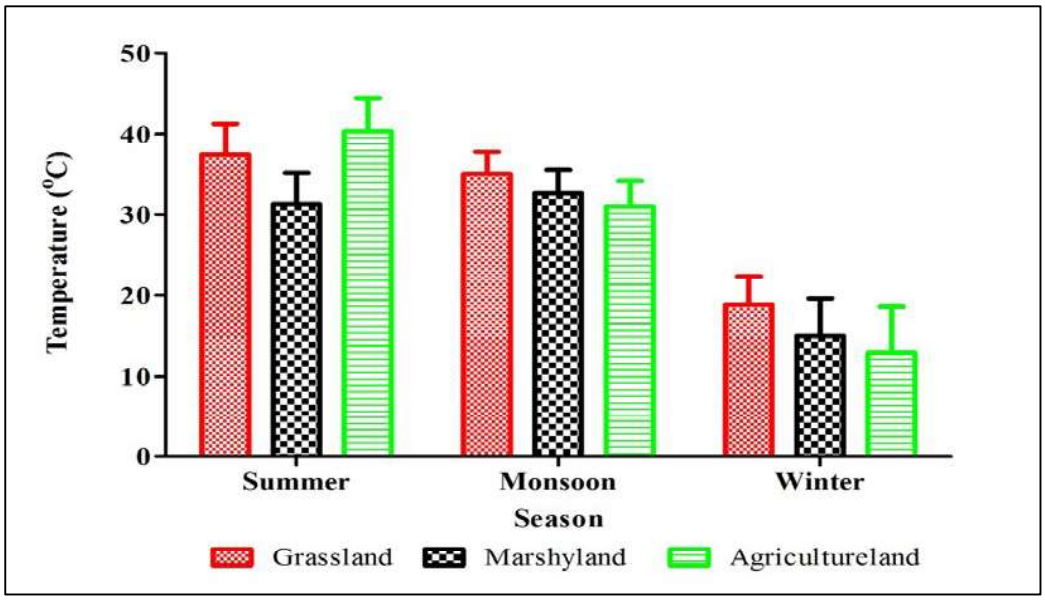

Figure 2.4. The ambient temperature preferred by cattle egrets on different habitats in summer, monsoon and winter.

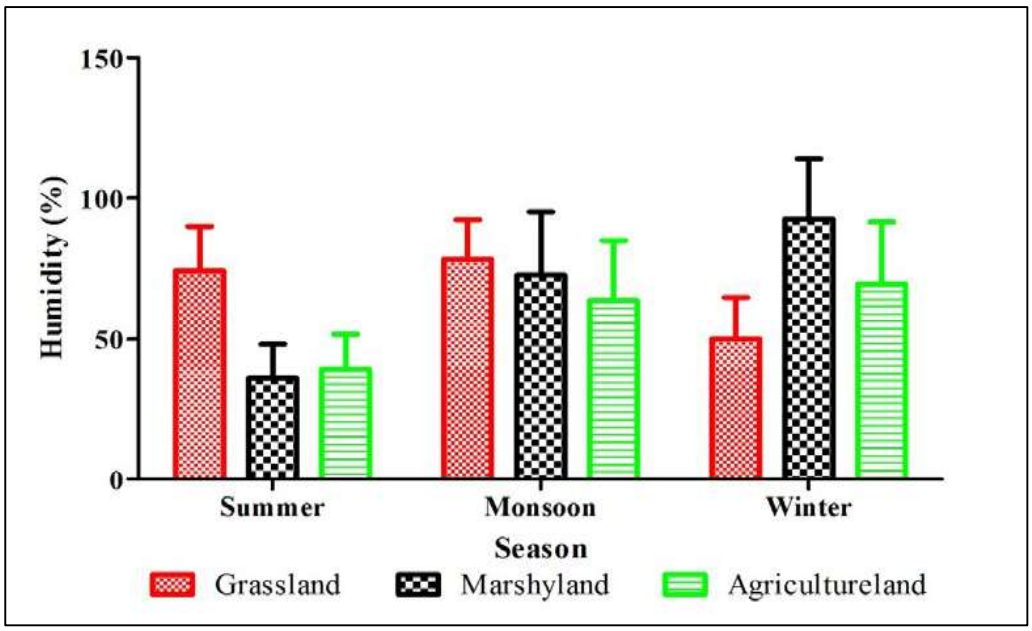

Figure 2.5. The ambient humidity preferred by cattle egrets on different habitats in summer, monsoon and winter.

Temperature and humidity

The maximum temperature was recorded on agriculture land during summer (40.35±4.09) in grass land (35±2.73) followed by marshy land in monsoon (33.32±2.87) (Fig 2.5). With temperature, the humidity was recorded in such a way to be maximum (92.75± 21.63) on marshy land in winter, followed by grass land (78.5±13.94) in monsoon and agriculture land in summer (69.6±22.01) (Fig 2.5). During the feeding of cattle egrets, the series of foraging behaviour were observed. Each behaviour had a different postures and actions. According to habitats some differences were also noticed in the number of displayed foraging behaviours. From 13 different common feeding behaviour of herons, 10 behaviour were seen in cattle egrets. From these only seven i.e. Walk slowly , stand and wait, walk quickly, standing fly catching, neck swaying, resting and fly scanning were seen at all habitats. While Foot stirring and probing were observed in only wetlands. Search and pecking behaviour was not found in wetlands. Leap frog feeding, hopping and canopy feeding behaviour were also not found in any habitats.

DISCUSSION

This study discusses about the diet selection, diet composition and foraging behaviour of cattle egret. Cattle egrets obtain their food items usually from the grasslands, marshylands, agriculture lands and wetlands. Terrestrial food items are present such as insects, damsel fly, beetles, grasshopper etc. Although aquatic organisms were also seen in their diet. Cattle egrets were found with less dependency on vertebrate prey items as Pisces and Reptilians in comparison to

invertebrates prey items, those belongs to Arthropoda, Annelida. However, the differences in the diet selection and composition were observed in cattle egrets. For example among insects, the egrets consumed more dominantly Odonata, Orthoptera, and Coleoptera (Table 2.1). (Weber, 1972 and Kaufman, 1996) also considered that the diet of egrets was mainly insectivorous, it can be assumed that, the cattle egrets is also having some impact on particular prey species and it shall be classified as a beneficial addition to the native fauna.

During the whole study period it was observed that, whenever egret forage with cattle, it usually apply the behaviour like walk slowly, walk quickly, search and Pecking, Neck Swaying etc. to maximize the food intake. While Leap frog feeding, Stand and wait, Foot stirring, Probing, Standing fly catching, Fly scanning, Resting and Hoping was not Observed.

Diet selection and composition was also influenced by symbiotic relationship i.e. Odonata (damselfly,dragonfly and nymph) Orthopetra (grasshopper and cricket) Coleopteran (ladybird beetle, ground and blister beetle) was mostly found in grassy area and agriculture area, where the symbiotic relationship of egret with cattle was also observed high. The insects are easily get disturbed by the movement of cattle, this makes increase in food intake of cattle egret during association with cattle. Although there was no impact of symbiotic relationship was noticed regarding annilidia, amphibian, fish and other aquatic insects.

The anthropogenic effects in agriculture land were observed i.e. the number of egret and association feeding of cattle egret was maximum. Simultaneously anthropogenic activity (human disturbance, as weeding activity by farmers) was high and consequently disturbs the association feeding of cattle and cattle egret.

This present study also reflects the variation in their food items according to seasonal changes. It reveals the egrets foraged more extensively in monsoon as compare to summer and winter. As the number of insects or aquatic organism increases in rainy season in all type of feeding habitats. The wide range of food items in the diet of cattle egrets indicates that it consume the suitable prey items, abundantly available at the foraging sites according to season. It is useful to study about the types of posture and actions, as they could be used in distinguishing of the sitting behaviour which were observed in all the habitats mentioned in Table 2.5. The series of foraging behaviour displayed by the egrets were found to be very immense (Table 2.5).

Searching of food items on feeding ground and in water bodies from short distance height (Fly scanning) was noticed as one kind of the foraging behaviour. Perhaps it is recorded for the first time in this study. The explanation and nomenclature of feeding behaviour along with total behaviour cataloguing were found to be the most important in foraging studies of the cattle egrets.

Leap frog feeding: A herons jumps into the air and flies a short distance to a potential prey item and often stabs simultaneously with landing. Siegfried (1971) suggested, that it helps birds to maintain contact in the long grass. In observation the cattle egrets was not found feeding in dense high grass, therefore this behaviour was not observed in egrets.

Search and pecking: Cattle egrets displayed this behaviour at all feeding habitats accept in wetland. There the cattle egrets easily picks up the food materials from the substrate or ground, with the help of their bills. It also reported by (Heatwole,1965; Sharma and Soni, 2014).

Walk slowly: In this behaviour walking becomes slower as the heron examines items or area of interest, just before striking, the heron may walk too slow (Recher *et al*, 1983). This kind of behaviour was observed at all types of feeding habitats. In this behaviour egret does not make extra effort to exhibit.

Stand and wait: Cattle egrets commonly execute this behaviour at feeding sites. The egrets stand for some time to watch the prey item for capturing (Kushlan, 1976). In this behaviour less energy is consumed.

Walk quickly: This kind of behaviour indicates about the chase disturb feeding. (Kushlan, 1976). They observed that, the running and quick walking activity was used by the birds for capturing the moving prey and spotting the prey in a better way. It was seen that in solitary mode of feeding, cattle egrets feeds in absence of cattle and other disturbing objects i.e. Moving vehicle and farmers etc. (Recher and Holmes, 1982)

Foot stirring: The special use of feet in this type of foraging seen in cattle egrets. It is also comes under category of disturb and chase feeding (Holt, 1961) a heron extends one leg forward and vibrates its leg and foot, or it vibrates its foot while wading forward normally. This motion disturbs the area around its foot, the disturbed prey get captured. Foot stirring can occur in mud, vegetation, mid-water. In present study it was observed only at wetlands.

Probing: This feeding movement noticed when cattle egrets placed its bill half and more than half inside the water to pick up a prey items. It was observed in stagnant water bodies and in the natural wetlands. (Meyerriecks, 1959).

Standing fly catching: This feeding behaviour involves catching of flying

preys, while the birds are in standing posture (Sharma and Soni, 2014). This behaviour however rarely used and was noticed only in few cattle egrets. During the study period this behaviour was seen in foraging lands and margins of wetlands.

Neck swaying : While the egrets is in standing or walking posture, it use to move the neck forward and backward, this keeps the egret to remain in parallel position for maintaining a precise estimated distance and location of the object (Kushlan,1986). Thus it catches the easily escapable prey in a single strike. Egrets used this behaviour at all type of feeding habitats.

Canopy feeding: The large wading birds bring their both wings forward to form a canopy type structure, the shadow in front of their own body attracts the fish and insects. (Delacour, 1946). This type of technique was not observed in cattle egrets, as the size of cattle egrets is smaller than other larger heron.

Fly scanning: Cattle egrets scan the ground or wetland to search their food while flying from a distance between 5-10 meter. After scanning the rich availability of food, they start feeding. This behaviour is used more at wetlands in compare to other habitats. Perhaps this behaviour is reported first time in this investigation.

Resting: This behaviour was observed at all type of feeding habitats. Cattle egrets displays this activity after the feeding. They usually stand on one leg (Sharma and Soni, 2014), and after 10-15 minute interval they change their leg position.

Hopping: The characteristic of this behaviour is that, the herons follow the flying insects for short distance and often stabs the insects simultaneously with landing (Meyerriecks, 1960). In present study this behaviour was absent in cattle

egrets. In place of hopping, it commonly uses the standing fly catching and neck swaying behaviour to capture the flying insects.

Foraging behaviour helps in understanding the ecology of herons. (Murton ,1972 and Kushlan ,1976) the beginning of their study on ecology of herons provides about the role of habitat in determining herons feeding behaviour. The observations suggest that the variation in availability of prey may also effects the feeding efficiency, diet and habitat selection along with other parameters of the feeding site, i.e. it differs from one location to the next. The Present study shows the variations in prey type and density, density of cattle egret, and other parameters of the feeding site differ from one location to the next. And the feeding efficiency also differs.

Figure 2.6. Sample collected from different feeding habitat of cattle egrets.

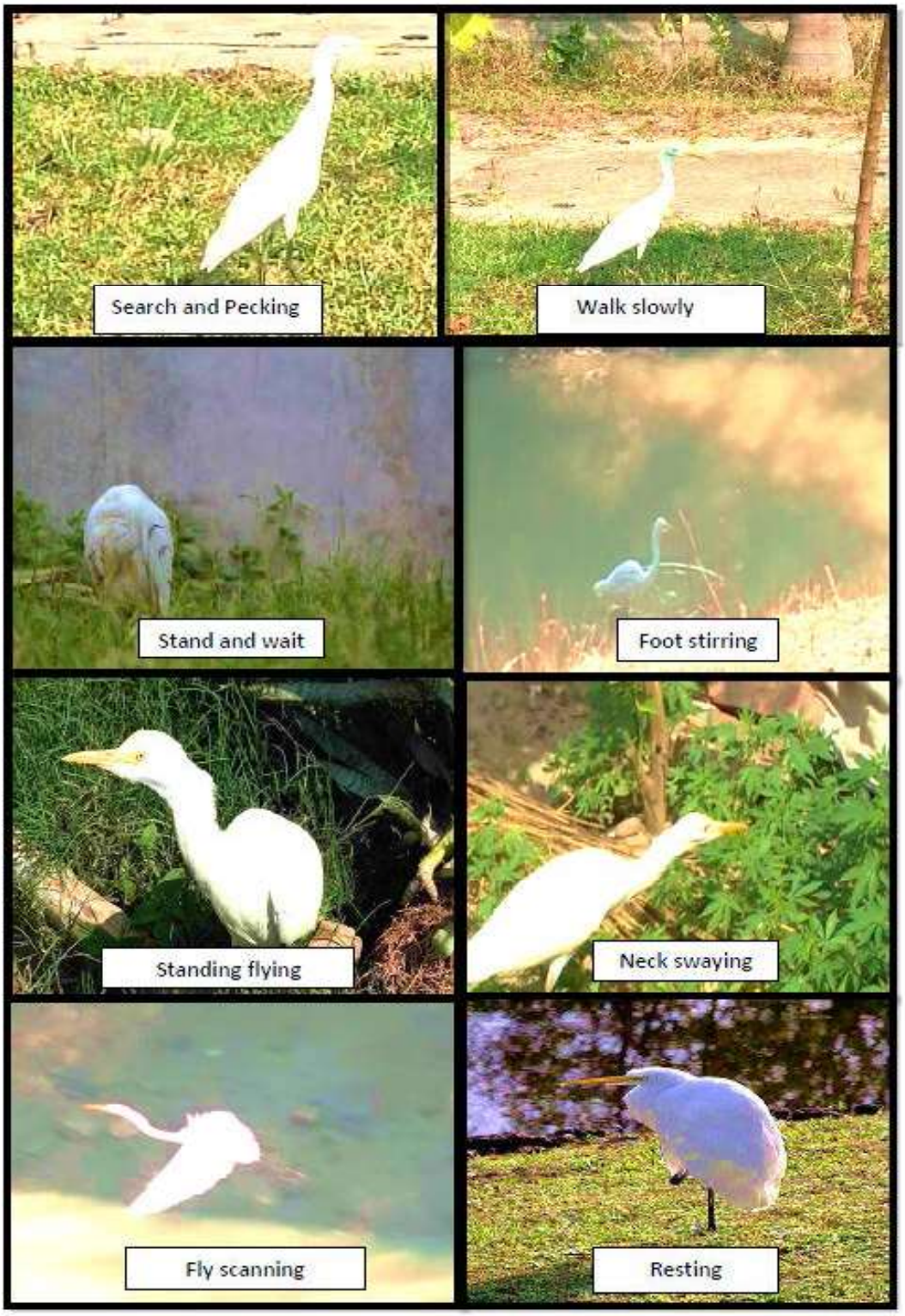

FIGURE 2.7. Different foraging behaviour displayed by cattle egret.

CONCLUSION

According to the study, it is concluded, that cattle egrets in Lucknow area are carnivorous. This study suggests that the diet of cattle egrets is influenced by the habitat where they feed, rather than on specialized food. Cattle egrets showed a dietary flexibility and habitat adaptability. The food of cattle egrets at the grasslands and agriculture site were mainly restricted to insects, as odonata, orthoptera and coleoptera however, at the aquatic habitat, the cattle egrets fed on a variety of prey including insects and amphibians. Regarding to the type and amount of prey consumed by egrets at grassland and agricultural land. The feeding priority shows that the egrets are playing major role in determining the ecological conditions of the habitats. Clear understanding of the descriptive aspects of each behaviour and knowledge of the occurrence of various behaviours in cattle egrets shall be beneficial to understand more about the foraging ecology of cattle egrets. This present study may provide a common background and may help in future studies.

Chapter-III

Effect of food on reproductive behaviour of *Bubulcus ibis.*

CHAPTER-III To study the effect of food on reproductive behaviour of Bubulcus ibis

INTRODUCTION

Heron are the aquatic birds, and are indicating species for wetland areas. Cattle egrets, *Bubulcus ibis* belongs to the order Ciconiformes and family Ardeidae (Ali, 1996). They are small, white and widely distributed herons, they usually nests in large colonies. Conservation of aquatic birds is an extensive understanding of their eco biological requirements (Fellowes *et al*., 2001; Li *et al.*, 2016). It Prefers habitat near water bodies and feeds in grassland, pastureland, freshwater marshes, salt marshes, rice fields, river and estuaries (Taylor and Schultz, 2008). Egrets are good subject for breeding study as they are large, abundant and consume easily identified prey. Availability of food, host animals, good symbiotic association along with other feeding environments i.e. free from anthropogenic activities influence on the selection of habitat by the birds (Samraoui *et al*., 2007). Many studies (Robert *et al*., 2000) shows that, the environmental changes does effects in motivating them in their distribution, habitat use, reproductive parameters and foraging behaviour. They are also the best indicators of pollution (Connell, 1967; Kazantzidis and Goutner, 1996; Kushlan and Hafner, 2000; Goutner *et al*., 2001) food is believed to be one of the main resources for the survival and reproduction of all living organisms. Cattle egrets show dietary elasticity and adaptability in feeding on varieties of prey in a suitable environment (Mckilligan, 2005). Numbers of studies have shown that the diet of cattle egrets keeps changing according to the seasons, time period of the day, prey availability and abundance (Ducommun *et al*., 2008). They also feed in flocks on insects at freshly ploughed fields (Patankar *et al*., 2007). As its insectivorous behaviour, cattle egrets is considered as a biological pest control agent in an agro-

ecosystem (Thomas *et al*., 2004). The cattle egrets is the best-known social bird creates symbiotic relationship with the hosts such as cow, buffalo, bull, horse etc. And also with some other domestic and wild host. This symbiotic relationship help in reproductive growth of egrets. In breeding ecology of this bird, especially the growth of birds, relates to climatic conditions (Jakubas, 2011). The climatic changes do effects on their arrival dates and the breeding time of birds (Parmesan and Yohe, 2003). Such information could be used as an indicating tool and impact assessment on the breeding ecology of the bird. This bird has been described to nest in agro-ecosystems, in both urban and rural environment, it depends upon safe nesting places, food availability, and other environmental factors (Abdullah, 2016). A good nesting site generally provides protection against predators, necessary support in making the nest, and access to feeding sites within foraging areas (Rao, 2004). Nesting sites also support in hatching success and positive rearing of chicks for species survival (Ludwig *et al*.,1994).Well known theory in ecology known as the "Food availability breeding time" hypothesis suggests, that for the effectual survival , it is very important that, birds breed at the most advantageous time of the year for upbringing their offspring. Favourable time of the year constitute the supportive environment factors like, optimal temperature, photoperiod, availability of nest sites. The selection of habitat and environmental requirements of cattle egret as well as breeding parameters i.e. egg laying, hatching success of this species were studied. An effect of urbanization and food factors on the reproductive growth is not focused in any study in Uttar Pradesh, India. Therefore the nesting success and survival rate factor of cattle egret in urban, semi urban and rural areas was observed on the basis of habitat use and the effects of urbanization on reproductive biology of cattle egrets.

MATERIALS AND METHODS

Study Area

The study was carried out in Lucknow and its associated areas, within in 40 km distance i.e. Khuajapur: Urban area , Deva: Semi urban area and Bichiya: Rural area.

The Site I, Khuajapur in Lucknow : Urban area (*Ficus virens*) nesting tree lies between the 26°45'55"N latitudes and 80°55'29"E longituds. At this study site only one nesting tree *Ficus virens* (22.94 m height, 7.5 m dbh) was observed. Source of water was not present with in the 500m range. Urban area have a population of at least 1500 person per sq. km, semi urban area, which have at least 300 person per sq. km and rural area, consists mostly low-density per sq. km according to (Chandramouli,2011).

Site II, Deva in Barabanki : Semi urban area (*Pithecellobium dulce*) nesting tree is positioned at a latitude and longitude of 27°01'48" N and 81°10'12"E respectively. In semi urban the observed nesting trees were *Pithecellobium dulce* (18.918m height, 6.7 m dbh). Source of water was the pond, present with in the 500m range in both sites

Site III, Bichiya in Unnao: Rural area (*Vachellia nilotica*) nesting tree lies between 26°47'15"N latitude and 80°81'28"E longitude. The observed nesting trees were *Vachellia nilotica* (9.52m height ,4.5m dbh). Apart from these nesting tree, some different species of trees were also found like, *Arecaceae, Vachellia nilotica,and Ficus racemosa.* Source of water was the pond, present with in the 500m range in both sites.

Data collection

In order to record various eco-biological aspects of cattle egrets periodic surveys were undertaken for one year 2018 from March to August. Some qualitative data was also collected by interviewing the local peoples around the breeding sites. Non-invasive methods were used in monitoring the colony; therefore all the investigations were carried out without disturbing the nesting pairs. Different breeding aspects of bird appearance, nesting behaviour, courtship display, egg laying, incubation, hatching success, breeding success and parental care period were based on the direct visual observation by digital video camera and binocular Celestron up close G2, 6.8°/35FT/118M (10x50X) (Joshi and Shrivastava, 2012;Kour and Sahi, 2013). The nests in colony were counted as per point count method used by Dodd (1995) i.e. counting and marking of selected egrets nests before commencing the study. Availability of prey items was recorded by the help of 2 sweep of a long handled net from the foraging area, with in 5x5 metre range, fishes were collected with help of fisherman. imilar method was used by (Chaskda *et al*.,2018).

Statistical analysis

Difference in prey consumed was analysed by Krushkal Wallis-H test analysis (SPSS version 21). Temperature and humidity was recorded by using hygrometer. Mean and standard deviation of prey items were also carried out by using (SPSS version 21). The ecology of breeding habitats was studied during field visit by observing the size of breeding territory, distance of water resources, prey availability. This makes the site attractive for breeding according to Patankar (2007). Nesting and hatching success were calculated by following Fazili (2002).

Nesting success was calculated as NS/ (NS+NU) X100, where NS is the number of successful nest (i.e. nest in which at least, one nestling survived beyond 10 days of age), NU is number of unsuccessful nests. Hatching success was calculated as: Number of egg hatched/ total number of eggs laid or clutch size X100. Breeding success was calculated by the formula (Number of fledglings survived) / (Number of eggs laid X 100) as per Vijayan (1980) and Jehle (2004). Food items consumed by a cattle egret were recorded on the basis of direct observation while feeding. The contents of regurgitated food from the nests was collected and preserved in a 70% ethanol for identification of taxa as referred by Chapman (2013).

Figure 3.1. Nest site selection by brooder of cattle egrets on *Ficus virens* - nesting tree in urban area

Figure 3.2. Nesting sites of cattle egrets on *Pithecellobium dulce*-nesting tree in semiurban area.

Figure 3.3. Nesting sites of cattle egrets on *Vachellia nilotica*- nesting tress in rural area

Figure 3.4. Adult brooder with yellow plumage and juvenile of cattle egrets

RESULTS

The total observed nest were 18 in urban area (Lucknow) 17 in semi urban area (Barabanki) and 12 in rural area (Unnao). In which total egg laying was observed is 52, 71, 47. Rate of egg destruction was found 12 number in urban, 10 egg damaged in semi urban and 5 egg were damaged in rural area. Chick destruction rate in urban was 6, in semi urban 3 and 2 were in rural site. The Percentage of breeding success was high in rural area (85.10%) compared to semi-urban (81.69%) and urban (66.66%) (Table 3.1). Courtship display was observed during the breeding season i.e. head flicks, wing preening and aggressive encounters between the nesting pair. Breeding biology of cattle egret was found varying in different habitats. The overall reproductive activity was observed from mid-June to the end of August in urban area, March to mid-May in semi urban and mid-April to end of June in rural area. Time of reproductive behaviour of cattle egrets vary according to the local environment of nesting habitat (Table 3.2).

Table 3.1. The reproductive event performance by cattle egrets during reproductive season at three distinct habitats such as urban, semi urban and rural in 2018. The number of sample and percentage were.

Nesting Variable	Urban (n=23)		Semi urban (n=19)		Rural (n=12)	
	No. sample	%	No. sample	%	No. sample	%
Abandoned nest	5	21.73	2	10.52	0	0
Successful nest	18	78.26	17	89.47	12	100
Total no. of eggs laying	52	-	71	-	47	-
No. of damaged eggs	12	21.56	10	10.34	5	8.51
Hatching success	40	78.43	61	85.91	42	89.36
No. of die fledglings	6	11.76	3	4.22	2	4.25
Breeding success	34	66.66	58	81.69	40	85.1

Table3.2. Reproductive behaviour performance by cattle egrets during breeding season in three distinct habitats i.e. urban, semi-urban and rural in 2018.

Reproductive events	Urban	Semi- urban	Rural
Plumage	26-May-18	13-Mar-18	3-Apr-18
Nest construction	17-June-18	28-Mar-18	20-Apr-18
Egg laying and incubation	23-Jul-18	13-Apr-18	16-May-18
Hatching	15-Aug-18	7-May-18	8-June-18
Parental care	18-Aug-18	13-May-18	17-June-18

Table 3.3. The mean and SD of prey item consumed by cattle egrets in three distinct habitats, urban, semi-urban and rural, whereas Kruskal Walish H test of statistical value at 0.05 level.

Habitat	Prey item	Month						Statistical value	
		March	April	May	June	July	August	H	P
Urban	Insects	10.75 ± 6.02	13.25 ± 7.84	5.75±4.57	7.75±6.29	14.25±3.40	22.5±5.97	11.908	0.036
	Annelidians	-	-	-	-	4.25±3.40	2.75±3.09	19.011	0.002
	Amphibians	-	-	-	-	1.75±1.70	2.25±1.70	14.992	0.01
	Reptilians	2.5 ± 1.91	4.5 ± 2.38	3.75±3.59	4.25±3.20	3.5±2.5	3.25±3.86	2.286	0.808
	Pisces	-	-	-	-	-	-	-	-
Semi urban	Insects	11.5 ± 3.69	13.5 ± 6.75	3.75±2.75	7.5±7.72	16.5±5.25	21.75±4.27	13.582	0.018
	Annelidians	3.75 ± 3.86	-	-	3.5±4.35	9.75±2.98	14.75±10.59	16.485	0.006
	Amphibians	0.75 ± 0.96	-	-	1.75±0.95	8.25±3.30	9.5±6.02	20.495	0.001
	Reptilians	1.5 ± 1.29	2.75 ± 2.5	0.25±0.5	0.75±0.95	2.75±3.09	1.75±2.36	5.094	0.404
	Pisces	3.25 ± 2.98	-	-	2.5±2.64	9.45±9.53	12.75±8.26	13.886	0.016
Rural	Insects	22.25 ± 3.5	16.5 ± 9.57	8.25±3.40	17.5±9.11	20.25±8.30	24.5±3.10	13.039	0.023
	Annelidians	5.75 ± 4.25	-	-	4.75±5.61	13.25±3.68	17.5±4.65	18.631	0.002
	Amphibians	3.75 ± 2.5	2.25 ± 2.87	-	-	10.25±5.73	11.25±5.56	18.555	0.002
	Reptilians	2.25 ± 2.06	1.25±0.95	2.25±0.95	3.5±2.38	4.25±2.36	2.75±3.09	4.072	0.539
	Pisces	4.5 ± 5.31	3.5 ± 2.88	-	2.75±2.75	10.5±4.04	13.25±4.27	16.238	0.006

Table 3.4. The prey taxon collected from foraging ground in three habitats i.e. urban, semi-urban and rural. Whereas (-) absent, (+) 10 % (++) 20%, (+++) 50% observation.

Habitat	Taxon	March	April	May	June	July	August
Urban	Insects	++	+	+	+	++	+++
	Annelidians	+	_	_	+	+	++
	Amphibian	_	_	_	+	++	++
	Reptilians	+	+	+	+	+	+
	Pisces	_	_	_	_	_	_
Semi-urban	insects	++	++	++	++	+++	+++
	Annelidians	+	_	_	_	++	+++
	Amphibians	+	_	_	+	++	++
	Reptilians	+	+	_	+	+	+
	Pisces	+	_	_	+	++	++
Rural	Insects	+++	++	++	++	+++	+++
	Annelidins	+	_	_	+	++	+++
	Amphibians	+	_	_	+	++	++
	Reptilians	+	+	+	+	+	+
	Pisces	+	+	+	+	+++	+++

Prey items

Breeding success is apparently depends on the quality of prey items in the diet, mainly during the peak of their development period (Kazantzidis *et al*., 1996).Growth of reproductive behaviour was highly influenced from the prey consumed by egret and availability of prey items at reproductive sites. As the high prey availability of insects increases in the prey consumed rate and high prey consumption provides the healthy reproductive growth in cattle egrets. In this study cattle egrets diet was observed, i.e. that Reptilians having no significant difference at different habitat and in different month. The availability of reptilians did not decrease or increase according to month or habitat,was recorded. Insects occupied 30 to 40% part in diet of egrets, as the availability was high as compare to Pisces, Amphibians, Annelidans and Reptilians (see Table 3.3 and 3.4). In urban area Pisces was absent in diet and availability too. While Amphibians, Annelidians and Pisces number was found increased, in both availability and in consumption during month of (rainy season) July and August (20 to 30%) (Table 3.3 and 3.4) at all three breeding habitats. Because of the monsoon season started from last week of June in Lucknow region. The Pisces, Amphibians, Insects and Annelidians were observed with having significant difference in availability and consumption throughout the breeding time at all breeding habitats. While overall prey items was highly available in semi urban area, of which the influence was recorded. The breeding activity in semi urban area started much earlier than in rural and urban area. The first juvenile was observed in the month of May, while in urban and rural area it was observed in the month of August and June.

Table 3.5. Number of regurgitated food items collected from different nesting of cattle egrets.

Regurgitated food items	Nesting trees			Total number and % of food items
	Ficus virens	***Pithecellobium Dulce***	***Vachellia nilotic***	
Hymnoptera	3	0	0	3(5.4)
Hemiptera	0	0	0	0
Odonata	2	3	5	10(18.18)
Lepidoptera	0	0	0	0
Orthroptera	2	7	5	14(25.45)
Diptera	0	0	0	
Dermapetra	0	3	2	5(9.0)
Areanea	0	1	0	1(1.8)
Ixodida	0	0	0	
Coleoptera	0	0	2	2(3.6)
Diplopoda	1	0	1	2(3.6)
Chilopoda	1	2	0	3(5.4)
Cypriniformes	0	3	0	3(5.4)
Silirudea	0	0	1	1(1.8))
Channa	0	0	0	
Anura	0	2	1	3(5.4)
Opisthopora	3	2	3	8(14.5)
Squamata	0	0	0	0
				Total = 55

Regurgiated food pellets of cattle egret was collected from three different nesting trees. These nesting trees are located at a distance of 30 to 50 km between each other. *Ficus virens* nesting tree were present on the road side in the urban area. *Pithecellobium dulce* nesting tree are present in semi urban area and *Vachellia nilotica* found at rural area. The diet of the egrets as revealed by regurgitated food pellets is given in (Table 3.5). Insecta: Odonata and

Orthroptera) were found to be the most observed prey items constituting 18 and 25% of the total prey. And other in Annelidia, the Opisthopora was found 14%.

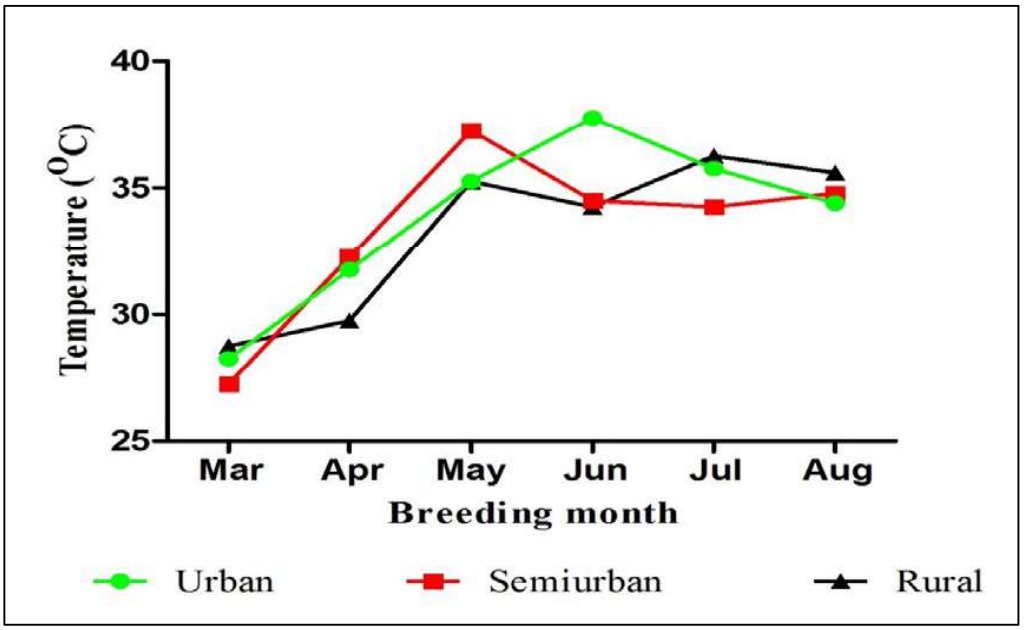

Figure 3.5. Ambient temperature of three distinct habitats including urban, semi-urban and rural.

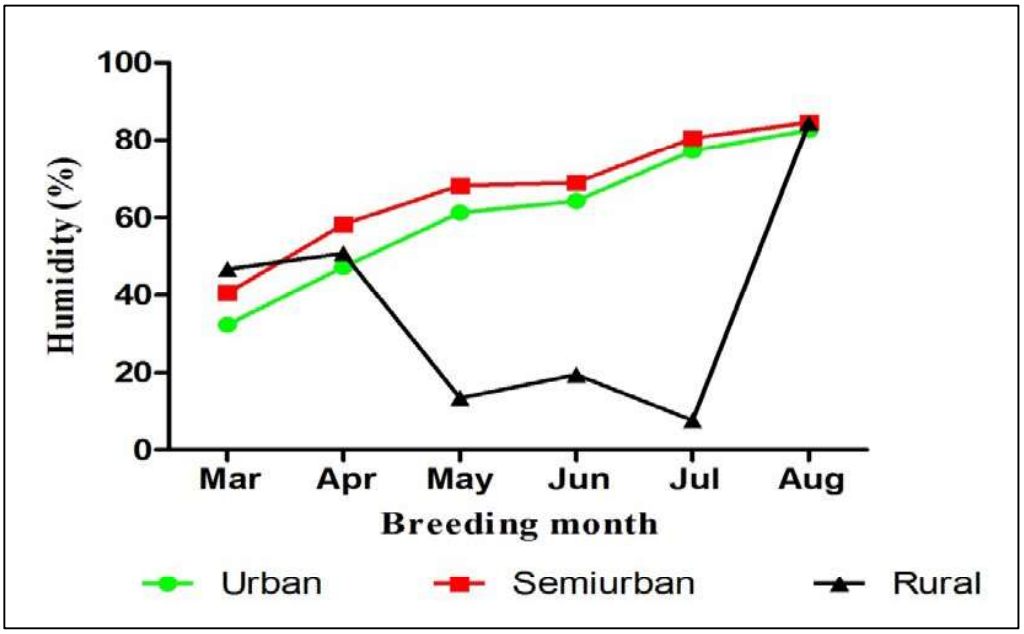

Figure 3.6. Ambient humidity of three distinct habitat including urban, semi-urban and rural area.

Temperature and humidity

Mean temperature of all breeding habitats was recoded between 32 °C to 37 °C. (Haftorn, 1988) has reported about mean temperature of 34°C for birds in general for breeding success. July to August was incubation time in urban area, temperature was (35.25°C to 34.4°C) and humidity was (77 to 82%). In April to May at semi urban area temperature was (32.25 to 37.25 °C) and humidity was found (80 to 84).At rural area in May to June temperature was 36.25°C to 35.27°C) and humidity was (82 to 84%) (Figure 3.5and 3.6).

DISCUSSION

Availability of food or environmental conditions may explain variance in the number of individuals breeding both within and among colonies (Brown *et al*., 1990). Anthropogenic changes do affect the breeding colonies in the study of bird species, as (Frederick and Collopy, 1989). The damage rate of eggs and chicks die was observed high in urban area. According to observation the breeding success rate, could be affected by the human disturbance. As the nesting tree is located on the side of road. And the residential area around the tree is increasing due to construction of more buildings day by day.

In urban area symbiotic relationship was also not observed for a long time, they associate for very few minutes. As we already discussed that in urban area nesting tree are situated near the road side. The breeding birds were noticed feeding within the area of 1km around. And whenever they start feeding in association with nomadic cattle, the breeding birds gets rapidly disturbed by the movements of human or vehicle and there sounds. therefore the breeding birds at this study site does not gain more feeding benefits from symbiotic relationship.in comparing with other sites, the birds get more benefited in rural and semi urban

area than that of in urban.

Anthropogenic effect on food:

The negative effects of anthropogenic activities was observed in urban area. Due to this , there was very less vegetation as well as the availability of prey items was very less. As the high vegetative area offers more insect to egret. While in other two areas the anthropogenenic activity was less, this results in high vegetation. Water bodies in urban area such as Pond, Lake and canal are less in number and whatever is present there, it was highly contaminated, due to this, even the fish and amphibian was lacking in the diet of the egret .In rural and semi urban area, there are numerous water bodies present, .these helps the egret to provide more food items as (Amphibain, annnelidian and picses). A modern solid waste treatment facility to manage the waste by municipal bodies is in the regular practice, so dumps are cleared regularly. The vegetable market waste, restaurant's and hospital waste dumps provide foods for the nomadic animals along with egrets i.e (diptera larvae,) in urban and semi urban area. Generally in rural area a good number of waste yards are present at edge of pond which remains for long time that's why it provides more garbage insect for a long Period of time, before its disposition at agriculture land as used in manure. Thus it effects on the availability of food.

Generally, cattle egrets is monogamous and their breeding activity starts when small groups of males and female establish territories. After this, they perform courtship displays to attract the groups of females and aggression increases. Immediately before pairing, a female attempt to subdue the displaying male by landing on his back. Eventually, the male allow one female to remain in his territory. The female then follows the male to another site where the nest

built. Copulation usually also takes place at the second site. The display involved with copulation. Some rape attempts have been documented. (Telfair, 1994).

Cattle egrets build nest in large colonies with the other herons. They usually reuse old nests or build new ones with dry sticks and vegetation. They build their nest in a place where they support the nest. Both male and female participates in nest building as the female usually builds with materials brought by the male. Throughout the incubation and hatching period, the material is continuously added to the bulky nests. The female does not become attentive to the nest until the last eggs are laid and the eggs laid in every 2 days. The eggs are oval in shape, light blue in colour and turns lighter as the time passes. Although the clutch size is of 2 to 7 eggs have been recorded and the incubation is carried out by both male and females and lasts for 24 days. During the week, nestlings are easily overheated, so the parents shade them from the sun beneath their wings. Both parents brood constantly for the first 10 days. The parents may accept chicks from other broods only if they are less than 14 days old. Begging for food becomes very aggressive in 48 days, and the nestlings are very competitive with one another. Mostly growth of the chicks are completed in the nest or branches of the nesting trees by 14 to 21 days, the chicks are capable of leaving the nest, climbing in vegetation and at this stage, they remain nearby and continue to beg for food. At 50 days, they can make short flights, at 45 days, they are independent and at around 60 days, they fly to the foraging areas. (Telfair, 1994).

Breeding season

In general the breeding season of cattle egrets was observed from March to August, while various studies in India supports that, breeding period of egrets

vary according to seasons and locations, as the (Patankar *et al*., 2007) in Vadodara, Gujarat reported that breeding month was April to July. And in Jammu, India (Kour and Sahi, 2013) reported from March to July was breeding month. And in present study the overall breeding month was considered from March to July. This study agreed with (Joshi and Shrivastava, 2012; Abdullah, 2016), that in non-breeding season Orange colour plumage was completely disappears. Whole body appears in white colour, bill becomes yellow; legs were black in both male and female birds. In breeding season, the orange colour plumage is appeared on head, neck and back of the bird, however bill and legs becomes yellow reddish in colour. The breeding plumage are used mainly in courtship behaviour and were absent in non-breeding season.

Nest construction

The process of nest construction was observed in the month of June in urban area, in March at semi urban area and in April at rural area. However, the practice of nest repairing was seen to be continued even after eggs laying, incubation and hatching. Although the activity of nest construction was slowly decreased, also reported by (Kour and Sahi, 2013). It was observed that cattle egrets formed their colonies where water sources are present nearby trees and at the edge of the village area, road side and human vicinity. It was observed at each study site I, II, III, both male and female birds build the breeding territory. Nest construction were typically started in second week of June in urban area, fourth week of March in semi urban area and in rural area third week of April.

Nest was made up of rough sticks, shrubs and twigs retained in wedge of branches in trees. Egrets started constructing the nest much earlier of their mating. They were observed to collect nesting materials from the nearby fields, from old nest and other branches from same nesting trees. Nests were found

completed in 8 to 10 days in all the three breeding habitats. Nesting colonies were observed in this study were polyspecific with pond heron, snowy egret (Ali and Ripley, 1968; Maccarane and Parsons, 1988).

Courtship behaviour

Courtship behaviour of egrets was observed after they had completed their nests in the fourth week of June in urban, second week of March in semi urban and in first week of May in rural site. In all sites egrets mating was observed near the nesting sites. All study was done from one to five meter range distance of the nest (Mackilligan, 2005; Kour and Sahi, 2013). In the present study mating was observed mostly in the morning and at the middle of day.

Egg laying

Egg laying behaviour were seen after mating activity in second week of July at urban, fourth week of March at semi urban and in first week of May at rural site. Female birds were seen sitting in nest or around the nest whole day. After egg laying, the male egrets takes care in maintaining nest. Eggs were medium in size, oval in shape and light blue in colour, (Kour and sahi, 2013) also reported similar characteristics of eggs.

Incubation period

The incubation periods started with the laying of first egg and during incubation, one of the two partners sat on the eggs, but mostly the female was noticed. The variation in incubation period was observed from 24-26 days in urban site. (Joshi and Shrivastava, 2012; Kour and Sahi, 2013) has also reported about incubation periods from 21-24, in both semi urban and rural sites.

Clutch size

The clutch size was observed at all breeding sites after 4 to 5 days of

egg laying. Results revealed, that the clutch size was (Mean ± SD) (4.17±1.38) in semi urban area, (3.91±1.37) in rural area and (3.27±1.17) in urban area. The range of the clutch size was observed as 02 to 06 eggs (n=), 03 eggs being the common and exceptionally 06.

Hatching

Hatching time of eggs differs according to the time of egg laying. At site (urban, semi urban) it was observed in third week of August and first week of May and in site (rural) it was observed in second week of June.

Parental care

Parental care was started just after hatching of eggs, it vary nest to nest. Cattle egrets searches food to their chicks from nearby areas after hatching, the parent birds starts to bring the regurgitated food to their chicks and teach to eat regurgitated food in their partly opened beak. The chicks grew their feeding method regularly to change from nest feeding to ground feeding. Over all parental care was observed for three to four week at each site respectively. During parental care chicks make an effort to fly within the branches of nesting trees or around the nests. After the age offour weeks, juveniles were found able to fly.

Availability of aquatic organisms in food is one of the main factors for breeding success of cattle egrets. In urban area the Pisces and Amphibian were absent in the diet of egrets. This may be the reason of reducing of clutch size. The food resources availability also an effect on the time of breeding season begins. As many of study reported that the fishes and aquatic organisms are the rich source of nutrition for the herons. According to (Si Bachir *et al.,* 2000) study indicates that the difference between the clutch sizes, nestling survivorship depends on the food availability at different sites.

Territory site	**Nest construction**
	
Courtship behaviour	**Egg laying**
	
Eggs damaged	**chicks died**
	

Figure 3.7. Different reproductive behaviour displayed by cattle egrets.

Conclusion

This study highlights the basic breeding ecology of cattle egrets. Availability of food resources and foraging environments influence the selection of habitat by the cattle egrets. The results of this study suggest that the mortality of eggs and fledglings probably varies according to the local environmental conditions, especially the temperature and humidity plays a major role in incubation period of eggs. Nest location is the major factor which affects the survival rate, as seen in egrets. The urbanization and anthropogenic effect at regular breeding habitats is the main threat to the local egrets.

SUMMARY

The study was planned to investigate the symbiotic relationships between cattle and cattle egret, their diet selection and diet composition with the effect of food on reproductive behaviour of *B. ibis*. The cattle egrets (*Bubulcus ibis*) is a species of African origin historically and traditionally called the white birds, which is now cosmopolitan living in multiform of natural habitats such as foraging in pastures, farmlands and grasslands alongside grazing livestock. It is recognized as an invasive bird species whose progression was considerably enhanced during the last 50 years through an increase of its distribution area as of its local populations across its global range. In the ecosystem different types of organisms grows together in close symbiotic relationships that indicates about the presence of animals, plants species or population occurs within the same geographical areas. Cattle egrets (*Bubulcus ibis coromandus*) belongs to the family Ardeideae, lives together in the same community which are commonly referred as terrestrial foragers for potential interaction as they pick, disturb insects like invertebrates, amphibians and reptiles alongside grazing livestock, without causing any inconveniences or disturbances to the livestock .

For avian species, term of survival and reproduction is one of the most important activity. In herons, especially the cattle egrets associates with grazing animals to support their symbiotic relationship for gaining the more feeding benefits and grazers gets slightly benefit from such relationship. The herons mostly feed themselves or take care of brooding mate or young hatchlings and spend their time in foraging related activity. In temperate zone seasonal changes generally affects the insect prey population such as appearing of many insect species in rainy

season and in summer makes the scarce that influence the diet composition of cattle egrets. In terrestrial habitat, the egrets consumes vegetative as well as animal diet. Cattle egrets found to feed mainly on larvae of insect in aquatic habitats.

A wide range of food utility suggests that it would consume whatever could be captured by its primary tactile foraging method .Therefore, foraging strategies adapted by birds are the major interesting fields of the study. Factors affecting distribution of cattle egrets and its breeding biology are discussed in previous studies. Studies done on breeding, distribution, status and conservation with the information on colonial nesting birds in India. However, in certain parts of Uttar Pradesh in India, the breeding biology of cattle egrets is less exposed excepting for information on some aspects.

Colonial tree-nesting water birds appears to be most adaptive of all, possibly due to its versatile feeding behaviour and non-specificity of the nesting environment and are dependent upon aquatic habitats for both nesting and foraging . In rural as well as urban environment, cattle egrets is known to build nest in aquatic ecosystems depend upon safe nesting places ,free from anthropogenic activities, food availability and other environmental factors. A good nesting site generally provides support to the nest and gives protection against predators and access to feeding sites within foraging areas. The nesting sites also support positive rearing of chicks and the hatching success that is imperative for species survival. Water birds can serve as bio indicators, as they reflect the health of the landscape and wetland. Investigations regarding eco-biology of herons contribute in increasing knowledge on reproductive ecology, diversity, foraging as well as conservation of cattle egrets in the region.

Such studies can certainly help in developing conservation programs of

avifauna as well as wetlands in India. Foraging habits of cattle egrets make them important biological control agents and primarily insectivorous birds as they consume some insects of public health importance as well as agriculture pest that play a significant role in a variety of ecosystems. Since, there is a lacuna on the behavioural ecology of cattle egrets, particularly on symbiotic relation with cattle, diet selection and reproductive behaviour.

The whole study was carried out between 2016 to 2019 at the different sites in Lucknow district i.e. grassland, marshy land and agriculture land and this constitute the areas of approx. up to 40km around.The sites were used for reproductive study, acquiring urban, semi urban and rural areas.The geographic coordinates of Lucknow are 26.8470°N longitude and 80.9470°E latitude and the temperature ranges between 25-45°C in summers, 2-20°C in winters. According to Indian metrological department, 2018 the mean annual rainfall is approx. 35.28 inch. The symbiotic relationships and diet selection was assessed through periodical field visits categorized as at grassland marshy land and agriculture land. The data collected lasted between 0600 hrs - 1800 hrs through visual observations, digital video camera and binocular celestron up close G2, 6.8°/35FT/118M (10x50X).The feeding behaviour of *Bubulcus ibis* was studied with the cattles i.e. cow, buffalo, horse, bull and mule on the basis of number of host steps, *B. ibis* steps, number of attempt success and the number switches count of egrets with cattle, which was recorded for five minutes and in some cases, it was for one or two minutes due to the fast foraging movements by most individuals at different locations and habitats. To avoid the distracting avian behaviour at all feeding habitat, the host species availability was determined at their presence within 200 – 300 meters by counting up to 30 individuals of each species in all three habitats were observed to

determine the suitability of host. Association foraging was considered when *B.ibis* forage near the host within two to three meters to avoid the pseudo-replication method with slight modification. The swallowing behaviour was observed after capturing the prey to count the capture success rate. Host preference and foraging success were analyzed by the previous methodology described with slight modification . The attempt success rate and the relationship between the speed of both hosts and *B.ibis* were analyzed through Spearman Rank Correlation Test (SPSS version 21). The switches count per hour was calculated using Average number of switches/Average time of observation x1/60. Availability of prey items was recorded by the help of two sweeps of a long handled net from the foraging area, within $5m^2$ range and the fishes were collected with the help of local fisherman, all was done by following the similar method. Besides it, regurgitated food items were collected and preserved in a 70% ethanol for identification of the taxa. Food consumed and different foraging behaviour was recorded at every15 minute interval from dawn to dusk and noted carefully from a distance of approx. 30-40 meters with a help of binocular. The nomenclature of foraging behaviour was used on the basis of previous studies. The whole study period was divided in to three seasons, summer (March to June), monsoon (July to October) and winter (November to February). Non-invasive method was avoided. The food consumed success rate was identified by the characteristic of i.e. Head-jerk, swallowing behavior. “Shapiro wilk test” method was used for “Normality test of the data” where ($P>0.05$) therefore, prey items consumed and availability of prey items were analyzed through Krushkal Wallis-H analysis (SPSS version 21), ($P>0.05$). Periodic surveys were undertaken for one year from 2018 from March to August in order to record the various reproductive aspects of cattle egrets. Some qualitative

data was also collected by interviewing the local peoples around the breeding sites. The ecology of breeding habitats was studied by observing the size of breeding territory, distance of water resources and prey availability during field visit. All the investigations were carried out without disturbing the nesting pairs and non-invasive methods were used in monitoring the colony. Different breeding aspects i.e. nesting behaviour, courtship display, egg laying, incubation, hatching success, breeding success and parental care period in urban, semi urban and rural areas were recorded on the basis of direct visual observation by digital video camera and binocular. The nests in colony were counted as per point count method (Dodd, 1995). Nesting and hatching success were also calculated. Nesting success was calculated as NS/ (NS+NU) X100, where NS is the number of successful nest (i.e. nest in which at least, one nestling survived beyond 10 days of age) and NU is number of unsuccessful nests. Hatching success was calculated as: Number of egg hatched/ total number of eggs laid or clutch size X100 and the breeding success rate was calculated by using the formula (Number of fledglings survived) / (Number of eggs laid X 100) .Difference in prey consumed was analyzed Krushkal Wallis-H test analysis (SPSS version 21). Temperature and humidity was recorded by using hygrometer and the mean and standard deviation of prey items were also carried out by using (SPSS version 21). In this study, the foraging association of the cattle egrets with cattles, was observed in grassland, marshy land and agriculture land with the total no. of 634 hosts of cow, buffalo, bull, horse and mule. In association with cattles, the percentage was highest in grassland (36.10%), marshy land (32.10%) and agriculture land (30.68%). The percentage of egrets showed the little seasonal variations in agriculture land. *B.ibis* showed the highest frequency of association with cattle in afternoon and low association in

the early morning and late in the evening and they usually fed near the front leg or back leg or middle. In evening, small groups return from foraging areas often congregated in flocks of hundreds of individuals as they left roost in small groups to disperse in the different areas.In the attempt success correlation rate, the buffalo was the best suitable host for *B.ibis* in comparison with the others and horse was the unsuitable host. The correlation rate was significant at the ($P< 0.01$) level, based on such study the increasing order of the suitability of the host are as follows buffalo<cow<bull<mule<horse. *B.ibis* with buffalo showed highly significant positive correlation in steps and attempt success at all three lands with less number of switches per hour. In agriculture land with horse its showed less significant correlation in steps and attempt success with high number of switches per hour. Results show that foraging success could be the reason for good association between cattle and *B.ibis***.** Above results shows that, *B.ibis* shift hosts when the host's movements are within their optimal foraging range, they do not randomly select hosts. *B.ibis* could avoid or leave hosts that moved too fast by losing its accuracy of capturing the prey with increasing the host speed. In case of high feeding success rate, the foraging with cattles showed a number of steps of *B.ibis,* which was about (49.94±16.84) per five minutes and for cattle it was (37.23±13.38). The high number of switches and less time of association indicates the low foraging success and the high number of switches and less time of association indicates the low foraging success. Thus, the buffalo is a suitable host for *B.ibis*. Based on the decreasing order, suitability of hosts are as follows buffalo>cow>bull>mule>horse. Feeding habitat preferred according to the seasonal changes, *B.ibis* feed at all types of habitat in all seasons whether it was grassland, marshy land or agricultural land. The number of population of birds will decrease

or increase accordingly all seasons. Grassland proved to be more profitable than marshy land and agriculture land and plays a complementary role for *B.ibis* foraging. The foraging success of cattle egrets in two different feeding modes i.e. cattle egret forage with cattles and without cattles. Present study conlude that the cattle egrest obtained more feeding success when it feeds with cattles or alongside cattles (62.65) as compared to feed alone or without cattles (46.36). The cattle egrets are the highly insectivorous as they preferred to consume 18 orders from five phyla of prey items during the study period, which includes twelve orders of Insects, three orders of Pisces, and Anura from Amphibia, Opisthopora order of Annelids and Squamata order of Reptilia. In this study four types of prey items were identify and considerable variation was found among the prey species. Insects size was divided into four categories (0.5-1cm, 2-5cm, 5-10cm and 10-20cm). Cattle egrets chooses 0.84-17.05 cm insects and the body weight was measured 0.04±0.006 to 32.75 ±6.65. In this study mainly three types of Pisces were captured by *B.ibis*, their size varied from 5.65 – 6.25 and body weight of Pisces 10.10 – 17.91 gm. In case of amphibians, only Anura was captured by *B.ibis* and two species of annelids were captured by it, the size of annelids (11.55-16.75) and body weight 27.5-65.12 gm measured. Moreover, in 13 different common feeding behaviour of herons, the 10 behaviour i.e. walk slowly , stand and wait, walk quickly, standing fly catching, neck swaying, fly scanning and resting were observed in all habitats. Foot stirring and probing were observed only in the wetlands, while searching and pecking behaviour was not found in wetlands. Rest of three i.e. Leap frog feeding, hopping and canopy feeding behaviour of herons were not present in anyone of the feeding habitats. The descriptive study of diet and feeding behaviour is important to study the feeding ecology of the cattle egrets. According to the study, diet

selection, diet composition and foraging behaviour was influenced by symbiotic relationship. The diet of cattle egrets was also depends on the habitat where they feed, rather than on specialized food and it is concluded, that cattle egrets in Lucknow area are carnivorous. This study suggests that cattle egrets showed a dietary flexibility and habitat adaptability and the food of cattle egrets at the grasslands and agriculture sites were mainly restricted to insects, Odonata, Orthoptera and Coleopteran however, in aquatic habitat, the cattle egrets fed on a varieties of prey including insects and amphibians. The prey consumed by cattle egrets are in grassland and agricultural land and the feeding priority shows that the cattle egrets are playing major role in determining the ecological conditions of the habitats.The descriptive aspects of each behaviour and knowledge of the occurrence of various behaviours in cattle egrets shall bebeneficial to understand more about the foraging ecology of cattle egrets. The percentage of breeding success was high in rural area (85.10 %) compared to semi-urban (81.69 %) and urban (66.66 %), in which the total egg laying was observed is 52, 71, 47. The total observed nest was 18 in urban area (Lucknow), 17 in semi urban area (Barabanki) and 12 in rural area (Unnao). Rate of egg destruction was found 12 number in urban, 10 egg damaged in semi urban and 5 egg were damaged in rural area. Chick destruction rate in urban was 6, in semi urban 3 and 2 were in rural site. Breeding biology of cattle egret was found in different habitats and the time of reproductive behaviour of cattle egret varies according to the local environment of nesting habitat. The overall reproductive activity was observed from mid-June to the end of August in urban area, March to mid-May in semi urban and mid-April to end of June in rural area. A Regurgiated food pellet of cattle egrets was collected from the three different nesting trees. These nesting trees are located at a distance

of 30 to 50 km between each other. *Ficusvirens* nesting tree were present on the road side in the urban area. *Pithecellobiumdulce* nesting tree are present in semi urban area and *Vachellianilotica* found at the rural area. The diet of the cattle egrets as revealed by regurgitated food pellets is given in. Insecta, odonata and orthroptera) were found to be the most observed prey items constituting 18 and 25 % of the total prey. And other in annelidia, the opisthopora was found to be 14%. Availability of food or environmental conditions explain the variance in number of individuals along with breeding by both within and among colonies. Present study suggested that the anthropogenic changes affect the breeding colonies. Symbiotic relationship help in reproductive growth of egrets. The damage rate of eggs and chicks was observed high in the urban area. As the nesting tree is located on the side of road, the breeding success rate could be affected by the human disturbance according to the observation and the residential area around the tree is increasing due to construction of more buildings day by day.

The temperature and humidity plays a major role in incubation period of eggs. The results of this study suggest that the mortality of eggs and fledglings probably varies according to the local environmental conditions. Location is the major factor which affects the survival rate and at regular breeding habitat urbanization is the main threat to the local egrets nesting colonies, as seen in cattle egrets. The maximum temperature was recorded on agriculture land during summer (40.35±4.09) followed by grass land (35±2.73) and marshy land in monsoon (33.32±2.87). With temperature, humidity was recorded in such a way to be maximum (92.75± 21.63) on marshy land in winter, followed by grass land (78.5±13.94) in monsoon and agriculture in summer (69.6±22.01). The constant ambient temperature was recorded throughout the years in all the habitats (36.68 ±

015) in summer, but these were partial fluctuated (32.3 ± 3.95), (33.09 ± 2.77) and (33.15 ± 2.66) in grass land, marshy land and agriculture land respectively in monsoon. Moreover humidity was highly fluctuated in all habitats which was lowest on marshy and (35.3 ± 9.98) in summer and maximum on agriculture (78.5 ± 18.52) in monsoon. Mean temperature of all the breeding habitats was recorded between 32 °C to 37 °C. (Haftorn,1988) has reported about mean temperature of 34°C for the birds for breeding success. July to August was the incubation time in urban area, temperature was (35.25°C to 34.4°C) and humidity was (77 to 82%). In April to May at semi urban area, the temperature was (32.25 to 37.25

°C) and humidity was found (80 to 84) and at the rural area in May to June

temperature was 36.25°C to 35.27°C) and humidity was (82 to 84%). As a result, it concludes the temperature and humidity does not plays any role in the diet and host selection of cattle egrets while in reproductive activity it plays a major role. This summary may help in future study of the foraging behavior *and* provides a common background of cattle egret, *B.ibis.*

REFERENCES

Abdullah, M., Khan, R.A., Rafay, M., Hussain, T., Ruby., T, Rehman, F., Khalil ., S and Akhtar, S .2016. Habitat ecology and breeding performance of cattle egret (*Bubulcus ibis*) in Faisalabad, Pakistan, *Pakistan Journal of Zoology* 49:1863-1870.

Aboushiba, A. B. H and Ramli, R. M .S .2015. Foraging behaviour of five egret species in pome pond area at carey island, peninsular Malaysia. *JAPS* 23:129-135.

Adam, J., Richardson and Taylor, I. R.2003. Are rice field in Southeastern Australia an adequate substitute for natural wetlands as foraging areas for egrets. *Waterbird Society* 26: 353-363.

Ali S and Ripley SD .1968. *Hand book of the birds of India and Pakistan*. Oxford University Press, Bombay 66-68.

Ali, S .1996.*The book of Indian birds*, Ist edition. Oxford University Press, New Delhi.

Anastasios, Dimalexis, Myrtopyrovetsii and Stefanos, S.1997. Foraging ecology of the Grey heron (Ardeacinerea), Great egret (Ardea alba) and Little egret (Egrettagarzetta) in response to habitat. *Colonial waterbirds* 20:261-272.

Ashoori, A., Varasteh, H.M., Rezaie,H.R and Salmanmahiny, A. 2019. Breeding ecology of the Little egret *Egretta garzetta* in the Anzali Wetland, Northern Iran. *Podoces* 14: 1–9.

Aynalem, S and Bekele, A .2008. Species composition, relativeabundance and distribution of bird fauna of riverine and wetland habitats of Infranz and Yiganda at southern tip of Lake Tana, Ethiopia. *Trop. Ecol* 49:199-209.

Bauder, E.T.1989. Drought stress and competition effects on the local distribution of

Pogogyne abramsii. Journal of Ecology 70:1083-1089.

Bennetts ,R., Fasola, M., Hafner, H and Kayser, Y. 2000. Influence of environmental and density-dependent factors on reproduction of little egrets. *The Auk* 117:634-639.

Birdlife International.2014. *Bubulcus ibis*. T he IUCN Red List of Threatened Species. Breed, M. D. 2001. Animal Behaviour, An Online Text Book. URL: http://www.animalbehavioronline. com/ Web Accessed 4th September, 2012.

Brichetti, P and Grussu, M .1992. Airone guardabuoi *Bubulcus ibis*. In:Brichetti P, De Franceschi P, Baccetti N (eds). Fauna d'Italia. XXIX. Aves. I. Edizioni Calderini, *Bologna* 165-171.

Brown, C.R., Stutchbury, B.J and Walsh, P.D.1990. Choice of colony size in birds. *Trends in Ecology and Evolution* 5:398-403.

Bull, J and Farrand, J. J .2000. Field guide to North American birds. Eastern region. National Audubon Society, New York.

Burger ,J and Gochfeld ,M.1999. The foot-in-the-door compliance procedure: a multiple-processanalysis and review. *SAGE Journal*.

Burger, J and Gochfeld,M .1982. Host selection as an adaptation to host- dependent foraging success in the Cattle Egret *(Bubulcus ibis).* Behaviour 79: 212-229.

Burger, J and Gochfeld, M .1981. Discrimination of the threat of direct versus tangential approach to the nest by incubating herring and great black-backed gulls. *Journal of Comparative and Physiological Psychology*. 95:674–676.

Burger, J and Gochfeld, M. 1993.Making foraging decisions: Host selection by Cattle egret (*Bubulcus ibis) .ornis Scandinavica* 24:229-236.

Burger,J.and Gochfeld, M.1989. Age differences in Cattle egrets, *Bubulcus ibis*, Foraging with ungulates in Kenya. *Ardea* 77:201-204.

Calvin, and W.H.1983. Foraging ecology of heron in aSouthern San Francisco Bay Salt Marsh. *Colonial Water birds* 6:37-44.

Cezilly, F., Boy, V and Hafner, H. 1990. Group foraging in Little egrets (Egretta garzetta):From field evidence to experimental investigation.*Behavioural Process* 21:69-80.

Chandramouli, C .2011. Census of Rural urban distribution of population India. *Ministry of home affairs.*

Chapman RF, Simpson SJ and Douglas AE .2013.The insects structure and function, Fifth edition. *Cambridge University Press.*

Chaskda, A. A., Iniunam, I .A., Dami, D. F and Wansat, M. G. S.2018. Foraging success of the cattle egret bubulcus ibis in relation to insect abundance, herd and flock size. *Journal of Research in Forestry, Wildlife & Environment* 10:41-47.

Choi, Y. s., Inki, K and Jeong, C. Y. 2007. Foraging Habitat Preferences of Herons and Egrets. *J. Ecol. Field Biol* 30: 237 244.

Choi, Y.S., Kim, S.S and Yoo, J.C. 2010. Feeding activity of Cattle egrets and intermediate egrets at different stages of rice culture in Korea. *J. Ecol. Field Biol* 33:149-155.

Choi, Y.S., Kwon, I and Yoo, J. 2008. A Study of Feeding Methods in Five Species of Herons and Egrets in Korea. *J. Ecol. and Field Biol* 31: 147–151.

Cody, M. L. 1985. Habitat selection in birds Academic Press, ress, Orlando,F.L. Cramp, S .1980. The Birds of the Western Palearctic. I. Oxford University Press, Oxford.

Cristina, R., Eduardo, A and Jordi, f., Manuel, M and Andy, J. G. 2013.Long term population trends of colonial wading birds breeding in Donana (SW Spain) in relation to environmental and anthropogenic factors. *Ardeola* 60:305-326.

Custer, C. M., Suarez,S.A and Olsen, D.A .2004. Feeding habitat characteristics of the great blue heron and great egret nesting along the upper Mississippi River, 1995-1998. Waterbirds, 27: 454-468.

Czech, B., Krausman, P.R and Devers,P.K .2000. Economic associations among causes of D. A.; Ed.; Lewis Publishers: Chelsea, MI, USA, 1989: 5-19.

Danchin, E., Giraldeau, L and Cezilly,F .2008. Behavioural Ecology. New York: Oxford University Press. ISBN: 978-0-19-920629-2.

Dawn, W. 1959. Cattle egrets provoke cattle to move and pick flies off the bulls. *Auk* 76: 97–98.

De la Pena, M. R .1992. *Gui ´a de Aves Argentinas: No. 1: Rheiformes–Tinamiformes–Sphenisciformes–Podicipediformes–Procellariiformes–Pelecaniformes–Ardeiformes–Phoenicopteriformes–Anseriformes*, 2nd edn. L.O.L.A. Santa Fe, Argentina.

Delacour, J .1946. Under wing fishing of the black heron, Melanophoyx ardesiaca . *Auk* 63: 441-442.

Delhoyo, J., Elliiot, A and Sargatal, J. 1992. Handbook of the Birds of the World. Ostrich to Ducks.

Dinsmore, J.J.1973. Foraging success of Cattle egrets, *Bubulcus ibis*. *American Midland Naturalist.* 89:242–246.

Dodd, M,G .1995. Accuracy and precision of techniques for counting Great Blue Heron nests. *Journal of Wild Life*. 59:667-673.

Doumandji,S.E., Doumandji,M. B and Hamadache, H. 1992. Places des orthopteres en milieu agricoledans le regime alimentaire du Heron grade en Grand Kabylie (Algerie).*Mededelingen van de Faculteit .Landbouwwetenschappen. Rijksuniversiteit Gent*. 58:365-372.

Dragonetti, M and Giovacchini, P.2009. Aspects of breeding biology of Cattle Egret *Bubulcus ibis* in a Grosseto province colony (Tuscany, central Italy). *Avocetta* 33: 199-204.

Ducommun, M. P., Quiroga, M .A ., Beltzer, A. H and Schnack, J .A 2008. Diet of cattle egrets in the flood valley of the parana river, North Argentina . *Avian Biology Research* 1: 145-151.

Dwevedi, R., Kumar, A., and Mylswamy, M. 2015. A monospecific colony of Cattle Egret (*Bubulcus ibis*) in agricultural landscape of central Uttar Pradesh, India. *Indian BIRDS* 10 (6): 149–150

Elgood , J. A .1979. Birds of the West African Towns and Gardens. *West African Nat.*

Handbook . H. J.Savory (ed.) Longman GP.LTD. London. Wachheony Printing Press Ltd. Hong Kong, China.

European Commission .2005. Why do we need to take care of our birds. unpublished report.

Fasola, M .1986. Distribuzione e populazione del Laridi e Sternidi nidificanti in Italia. *Ricerche Biologia Selvaggina* 11:169-176.

Fazili, M. F .2002. *Studies on annual cycle of some birds of Wular Lake Kashmir*. Ph.D. thesis submitted to University of Kashmir.

Fazili, M. F.2014. Reproductive parameters of little egret, Egretta garzetta in Hokersar wetland and Kashmir arts emporium park *International Journal of Current Research* 6:6067-6073.

Fellowes, J.R., Fang, Z ., Shing. L.K. , Hau, B.C. , Lau, M.W and Lam, V.W. 2001.

Status updates of white eared night heron gorsachius magnificus in south China. *Bird Conservation International* 11:101-111.

Fernandez, E.V., Shi, X and Li, Z. 2016. Ritualized fights among foraging Cattle egrets following Pere Davids deer in Dafeng Nature Reserve. *Journal of Zoology* 302 :187-205.

Fogarty, M. J and Hetrick, W. M .1973. Summer foods of Cattle Egret in North Central Florida. *Auk* 90:268–280.

Frederick , P.C and Collopy, M.W .1989. The role of predation in determining reproductive success of collonially nesting wading birds in the Florida Everglades. *The Condor* 91: 869-867.

Giovacchini, P.,Manfreda ,V and Moroni, C .2001. Primi casi di nidificazione per *Podiceps cristatus* e *Bubulcus ibis* in provincia di Grosseto. Atti del Museo di Storia Naturale della Maremma 19: 89-92.

Gonzalez, J.A. 1997. Seasonal variation in the foraging ecology of the Wood Stork in the Southern Llanos of Venezuela. *Condor*, 99:671-680.

Goutner , V.,Furness, R and Papakpostas,G .2001. Mercury in feathers of squacco heronN(*Ardeola ralloides*) chicks in relation to age, hatching order, growth and sampling dates. *Environmental Pollution*, 11: 107-115.

Grobicki, A .2016. An introduction to the Ramsar Convention on Wetlands. Ramsar hand book 7th edition. Ramsar convention Secretariat Rue

Mauvernery28 Switizerland.

Grubb, T.C.1976. Adaptiveness of foraging in the cattle egret, *Wilson Bull* 88: 145- 148.

Hafner, H and fasola,M.1992. The relationship between feeding habitat and colonial nesting. Ardedae in Managing Mediterranean wetlands and their birds. *IWRB U.K* 20: 194-201.

Haftorn, S .1988. Incubating female passerines do not let the egg temperature fall below the 'physiological zero temperature' during their absences from the nest. *Ornis Scandinavica.* 19: 97-110.

Heatwole, H.1965. Some aspects of the association of Cattle Egrets with cattle. *Animal Behavior* 13: 79–83.

Hilaluddin., Shah, J. N and Shawl, T. A. 2003. Nest site selection and breeding success by Cattle Egret (Bubulcus ibis) and Little Egret Egretta garzetta in Amroha, Uttar Pradesh, India. Waterbirds 26: 444–448.

Hilden. 1965. Habitat selection in birds. *Ann. Zool. Fenn* 2:53-75.

Holt, F .1961. Foot stirring in the Green Heron. *Wilson Bull* 73:386.

Itzkowitz,M and Makie, D . 1986. Food Provisioning and foraging behavior of the Snowy egret, *Egrettathula* . *Biology of Behavior* 11:111-115.

Jakubas, D.2011. The influence of climate conditions on breeding phenology of the grey heron Ardea cineria L. in northern Poland. *Polish Journal of Ecology* 59 : 179-192.

Jehle, G., Adams, A.A.Y., Savidge, J. A and Skagen ,S.K .2004. Nest survival estimation: a review of alternatives to the Mayfield estimator. *Condor* 106 : 472-484.

Jenni .A.D. 1969.A study of the ecology of four species of herons during the

breeding seaso at lake Alice, Alachoa county, Florida*, Ecol. Monographs* 39:245-270.

Jha, K. K. 2012. Some breeding and ecological aspects of heronry birds at Soor Sarovar bird sanctuary Agra, Northern India. Asian journal of conservation Biology 1:35-41.

Joshi,P and Shrivastava ,V,K .2012. Breeding biology and nest site selection of cattle egret (*Bubulcus ibis)* in Tawa Reservoir and surrounding area of Hoshangabad District (M.P). *Asian Journal of experimental biological Sciences* 3: 525-530.

Kamler, J.F., Suinyuy, T.N and Goulding W. 2008. Cattle Egret and Common Ostrich associations in South Africa. *Ostrich* 79:105–106.

Kannaujiya, A., Kumar and A., Kushwaha, S.2013. Diversity of waterbirds in Lucknow Districts, Uttar Pradesh, India. *International Journal of Science and Research* 4: 862-866.

Kaufman, K .1996. Lives of North American birds. *Houghton Mifflin Company, Boston*.

Kazantzidis, S and Goutner, V. 2005. The diet of nestlings of three Aedeidae species (Aves, Ciconiformes) in the Axios Delta, Greece. *Belg. J. Zool*., 135 : 165-170 Kazantzidis, S., Hafner, H and Goutner, V .1996. Comparative breeding ecology of Little egrets Egretta garzetta in the Axios Delta (Greece) and the Camargue (France). *Reve Ecologie* (*Teree et Vie*) 49: 53-62.

Kenya: climate and land use changes, population pressures, governance, policy and human wildlife conflicts. *The Open Ecology Journal* 7:9-31.

Kioko, J.,Boyd, E., Schaeffer, E., Tareen, S and Kiffner, C.2016. Cattle egret Bubulcus ibis interactions with large mammals in the Tarangire-Manyara Ecosystem, Northern Tanzania. *Scopus* 36 :15-20.

Kopij, G. 1999. Breeding success in the Cattle egret in relation to clutch size . *S.Afr.*

J.Wild.Res 29:112.

Kopij,G.2003. Diet of Cattle egret *Bubulcus ibis* chicks in an intensively managed farmland South Africa *S.Afr. J. Wildl. Res*. 38:155-157.

Kour ,D. N and Sahi, D. N.2012. Studies on the community ecology of Cattle Egret (*Bubulcus ibis*) coromandus (Boddaert) in Jammu (Jammu and Kashmir), India. *International Journal of Biodiversity & Conservation* 4:439-445.

Kour, D,N and Sahi, D,N .2013. Aspects of breeding biology of cattle egret, *bubulcus ibis coromandus* (boddaert) in Jammu, India. *International Journal of environmental Science* 3: 1547-1561.

Kour, D. N., Koul, S and Sahi, D. N .2014. A Preliminary survey on the diet selection and feeding strategies employed by cattle egrets (Bubulcus ibis coromandus) in Jammu (J&K), India. *International Journal of Applied Science-Research and Review* 13:144-149.

Krebs, J. R., Ashcroft, R and Van Orsdol, K. 1981. Song matching in the great tit Parus major L. *Animal Behaviour* 29:918–923.

Krebs, J.R .1978. Optimal foraging: Decision rules for predators. In: Behavioural Ecology .*Evolutionary Approach* 23-63.

Kumar, J.P., Sati, P.C., Tak and Alfred.J.R.B. 2005. *Handbook of Indian wetland birds and their conservation*. Director Zoological Survey India. 167-170.

Kuranchie, A., Rosina, k., Daniel, A and Holbech, L.H. 2013. Gut contenet of Cattle egrets (*Bubulcus ibis*) in three distinct habitats in the Accra Metropolitan Area, Ghana. *Journal of Agriculture and Biodiversity Research* 2:124-128.

Kushlan, J. A .1976. Feeding behaviour of North American Herons. *Auk* 93:86-94.

Kushlan, J. A .1978. Feeding ecology of wading birds. In A. Sprunt, J. Ogden, and S.

Winckler (eds) Wading Birds. Research Report No. 7. *National Audubon Society*.

Kushlan, J. A .1986. Responses of wading birds to seasonal fluctuating water levels: strategies and their limits. *Colonial Waterbirds* 9:155-162.

Kushlan, J.A and Hafner, H .2000. *Heron conservation*. Academic Press, London, UK.

Kushlan, J.A and Hafner, H., 2000. Heron Conservation. Academic Press, Hardback. Kushlan, J.A and Hancock, J. 2005. The Herons. Oxford University Press.

Kushlan, J.A. 1993. Waterbirds as bioindicatators of wetland change: Are they a valuable tool? 48-55. In: *Waterfowl and Wetland Conservation in the 1999s- a global perspective*. (M. Moser, R.C. Prentice, and J.Van Vessem, eds.). IWRB Special Publication No. 26. International Waterbird and Wetland Research Bureau, Slimbridge, U.K.

Kushlan,J.A. 2010.White Ibis (Eudocimus albus) nesting in the Bahamas. *Florida Field Naturalist* 38:68-70.

Kushlan,J.A.1978. Commensalism in the Little blue heron. *Auk* 95:677-681.

Li, X ., Xian, Z. , Xinrong, X. , Shicheng. L., Yongqiang, Z., Danxi ,C., Chenxi, H., Bingyao, C and Guang Y .2016. Bird diversity in the buffer zone of the largest coastal nature reserve of China and conservation implications. *Pakistan Journal of Zoology* 48: 1193-1199.

Liordos, V and Goutner, V. 2007. Diet of the great Cormorant (*Phalacrocorax carbo*

L. 1758) at two Greek colonies. *Journal of Biological Research* **7**: 51 – 57.

Lombardini, K., Robert, E and Tourenq, C. 2001. Foraging success and foraging habitat use by Cattle egrets Little egrets in the Camargue, France. *The Condor* 103:38-44.

Lowe-Mc Connell, R.H .1967. Biology of the immigrant cattle egret *Ardeola ibis* in Guyana, South America. *Ibis International Journal of Avian Biology* 109: 168- 179.

Ludwig, E., Vanicsek, L., Torok, J and Csorgo, T .1994. The effect of nest height on the seasonal pattern of breeding success in blackbirds, *Tardus merula*. *Ardea* 83: 411-418.

Maccarone, A.D and Parsons, K.C .1988. Differences in flight patterns among nesting ibises andegrets. *Colonial Water bird* 11: 67-71.

Maddock, M and Geering, D.1993. Cattle Egret migration in south-eastern Australia and NewZealand: An update. *Notornis* 40: 109-122.

Maharana, I., Rai,S,C and Sharma, E .2000. Valuing ecotourism in a sacred lake of the Sikkim Hymalaya, *India. Environmental Conserv*ation 27:269-277.

Manakadan, R and Pittie, A .2001.Standardised common and scientific names of the birds of the Indian subcontinent. *Buceros* 6: 1–37.

Martinez-Vilalta, A., & Motis, A. (1992). Family Ardeidae (Herons). *Handbook of the Birds of the World*, *1*, 376-429.

Mathew, K. L., & Gadvi, I. R. 2004. Distribution pattern and the size of cattle egret Bubulcus ibis heronries in Saurashtra region of Gujarat, India. In *International Conference on Bird and Environment, Haridwar, India*.

Mayntz, M. (2012). Forage. *URL: http://birding. about. com/od/Bird-Glossary-EG/g/Forage. htm. Web Accessed 4th September*

McKilligan, N. 2005. *Herons, egrets and bitterns: Their biology and conservation in Australia*. CSIRO publishing.

Meyerricks, A. J.1962. Diversity typifies heron feeding, *Nat. Hist* 71: 48-59.

Meyerriecks, A. J .1959. Foot Stirring feeding behaviour in herons. *Wilson Bull*

71:153-158.

Meyerriecks, A. J .1960. Success story of a pioneering bird. *Nat. Hist* 69:46-57.

Mikula, P., Hadrava, J., Albrecht, T and Tryjanowski, P. 2018. Large-scale assessment of commensalistic– mutualistic associations between African birds and herbivorous mammals using internet photos. *The Journal of Life and Environmental Sciences*. 1-23.

Mincey, H.D.2006. Foraging behavior and success of herons aand egrets in Natural and Artificial wetlands. Electronic Theses &Dissertations. 703.

Mohammedi, A., Doumandji, S., Ababou, A.,Koudj, M., Rouabhi, A .2015. Impact of predation by cattle egret bubulcus ibis l. on wildlife of farmlands in chlef region, Algeria. *Lebanese Science Journal* 17 : 117-129.

Mukherjee, A. 2000. Adaptiveness of cattle egret's (*Bubulcus ibis*) foraging. *Zoos' Print Journal* 15: 331-333.

Murton, R .K .1972. The ecology and status of Swinhoe's egret, with notes on other herons in southeastern China. *Biological Conservation*. 4:89-96.

Nefla, A., Tlili, W., Ouni, R and Nouira, S. 2015. Habitat use and breeding biology of herons in the Ramsar wetlands of Northern Tunisia. *The Journal of Animal & Plant Science* 25:1572-1584.

Nirmala, T. (2016). Food availability influences the seasonality of bird community in tropical forest, Western Ghats. *International Journal of Current Research and Review*, *8*(2), 74-83.

Ogutu, J. O., Piepho, H. P., Said, M. Y., & Kifugo, S. C. (2014). Herbivore dynamics and range contraction in Kajiado County Kenya: climate and land use changes, population pressures, governance, policy and human-wildlife conflicts. *The Open Ecology Journal*, *7*(1)

Pain, D. J., & Pienkowski, M. W. (1997). *Farming and birds in Europe: the Common Agricultural Policy and its implications for bird conservation*. Academic Press

Parejo, D. E. S. E. A. D. A., Sánchez-Guzmán, J. M., & Avilés, J. M. (2001).

Breeding biology of the Cattle Egret Bubulcus ibis in southwest Spain. *Bird Study 48* :367-372.

Parmesan, C and Yohe, G. 2003. A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421: 37-42.

Patankar, P. , Desai, I ., Shinde, K and Suresh, B .2007. Ecology and breeding biology of the cattle egret (*Bubulcus ibis*) in an industrial area at Vadodara, Gujarat. *Zoos' Print Journal* 22:2885-2888.

Prasad, P., Kumari, J. A., Mathew, M., & Thomas, R. (2012). Human-Bird Conflicts and Management Issues: A Case Study of Birds at Uppalapadu Lake, Andhra Pradesh, India. *International Journal of Zoology*, *2012*.

Rand, A.L. 1954. Social feeding behavior of birds. *Fieldiana Zoology* 36: 1-71.

range expansion. Journal of Biogeography 19, 135e150.

Rao ,V.V. 2004. Egrets and their role in environment. International conference on Birds and environment, Haridwar, India. (Unpublished)

Recher, H. F and Holmes, R. T .1982. The foraging behaviour of herons and egrets on the Magela Crrk floodplains, Northern Territory. Supervising Scientist for the Alligator Rivers Region, *Tech. Mem* 4-17.

Recher, H.F., Holmes, R. T., Davis, W. E and Morton, S. 1983. Foraging behaviour of Australian herons. *Colonial Waterbirds* 6:1-10.

Sahi, D.N., Gandotra, R., Kaur, P and Koul, S. 2017. Clutch characteristics and egg diametrics of Indian Pond heron (Ardeola grayii) in Jammu region (J&K). *Int. J. Adv. Res.* 5: 474-479.

Salazar, R.D., Riddiford, N.J and Vicens, P. 2005. A comparative dietary study of Cattle egrets (Bubulcus ibis) and Little egrets (Egretta garzetta) in S'Albufera Natural Parks, Mallorca. *Boll. Soc. Hist. Nat. Balears* 48:154-162.

Samraoui, F., Menaï R and Samraoui, B .2007. Reproductive ecology of the cattle egret (*Bubulcus ibis*) at Sidi Achour, North-Eastern Algeria. *Ostrich* 78: 481- 487.

Scoccianti, C., & Tinarelli, R. (1999). *Le garzaie in Toscana: status e prospettive di conservazione*. WWF, Sezione regionale Toscana

Scott, D.1984. The feeding success of cattle egrets in flocks. *Animal Behavior*

32:1089-1100.

Scott, D.A and Rose, P.M. 1989. *Asian Waterfowl Census 1989*. International Waterfowl and Wetlands Research Bureau, Slimbridge, UK.

Seedikkoya, K .2004. *Comparative ecology of certain paddy field birds with emphasis on the habitat quality*. Ph.D thesis, university of Calicut, Kerala, India.

Seedikkoya, K., Azeez, P.A., Shukkur, E.A.A.2005. Cattle Egret, *Bubulcus ibis* habitat use and association with Cattle. *Forktail* 21:174-176.

Sharma, M and Soni ,K. C .2014. Feeding behaviour and success of cattle egret (*Bubulcus ibis*) inhabiting rural and urban area of Laxmangarh city, Rajasthan, India. *Journal of Advances in Biology* 4 : 393-403.

Sheehy, D.P., *Vavra, M* .1996. Ungulates foraging areas on seasonal range land in north eastern. Oregon. *Journal of the University of Arizona* 49:16-23.

Shukla, U.N and. Lone,A.A .2010.Water Birds of Sur Sarovar Bird Sanctuary Agra, Uttar Pradesh. *Research Journal of Agricultural Sciences* 1:135-139.

Si Bachir, A., Ferrah, F., Barbraud, C., Cereghino, R and Santoul, F. 2011. The recent expansion of an avian invasive species (the Cattle Egret Ardea ibis)

in Algeria. *Journal of Arid Environments* 75:1232-1236.

Si Bachir, A., Hafner, H., Toureng, J.N and Doumandji, S. 2001. Diet of adult Cattle egrets (Bubulcus ibis) in a new North Africa colony (Soummam Kabylie, Algeria): Taxonomic composition and seasonal variability. *International Journal of Ornithology* 48:217-223.

SiBachir, A.,Hafne, Hr., Tourenq, J.N and Doumandji, S .2000. Structure de l'habitat et biologie de reproduction du Héron Garde-bœuf, *Bubulcus ibis*, dans une colonie de la vallée de la Soummam (Petite Kabylie, Algérie). *Reve Ecologie* (*Teree et Vie*) 55: 33-43.

Siegfried, W. R.1978. Habitat and the modern range expansion of the cattle egret, National Audubon Research Report 7. 315-324.

Siegfried, W.R.1971. The food of the Cattle egret. *Journal of Applied Ecology* 8: 447- 468.

Siegfried, W.R.1972. Aspects of the feeding ecology of cattle egrets (*Ardeola ibis*) in South Africa. *Journal Animal Ecology* 41:71-78.

Skead, D.M. 1963. Cattle egret *Bubulcus ibis* feeding on flies off the Cape Eland *Taurotragus oryx*. *Ostrich* 34: 166.

Stephens, D.W., Krebs, J.R. 1986. Foraging Theory. Princeton University Press. Subramanya, S., 1996. Distribution, status and conservation of Indian herons. *J. Bombay Nat. Hist.Soc* **93**: 459-486.

Taylor, I.R and Schultz, M.C .2008. Breeding season diets of egrets in Southeast Australia: implications for future population viability. *Waterbirds* 31:593-601.

Telfair, R. C.II. 2006. "Cattle Egret (*Bubulcus ibis*)". The Birds of North America online (A. Poole, Edition.) Ithaca. *Cornell lab of ornithology*.

2006; 1-13.

Telfair, R.C. II.1994. Cattle egret (*Bubulcus ibis*). In the birds of North America, No.

113 (A. Poole and F. Gill, EDs.).Philadelphia:The academy of Natural Science; Washington, D.C:The American Ornithologists Union.

Thomas, J., Chellappan, M and Bhaskar, H .2004. *Role of insectivorous birds in rice pest management*. International Conference on Bird and Environment, Haridwar, India.

Thompson, C.F., Lanyon, S.M., Thompson, K.M. 1982. The influence of foraging benefits on association of cattle egrets (*Bubulcus ibis*) with cattle. *Oecologia* 52: 167–170.

Trocki, C. L and Paton,P.W.C .2006. Assessing habitat selection by foraging egrets in salt marshes at multiple spatial scales. *Wetlands* 26: 307–312.

Turner, D. 2011. Checklist and status of herons in East Africa. *Journal of Heron Biology and Conservation* 1:1-9.

Van Der Bosh, F., Hengeveld, R and Metz, J.A.J., 1992. Analysing the velocity of animal range expansion. *Journal of Biogeography* 19: 135-150.

Van Der Bosh, F., Hengeveld, R., Metz, J.A.J., 1992. Analysing the velocity of animal

Vijayan, V.S .1980. Breeding biology of bulbuls, Pycnonotus cafer and Pycnonotus luteolus (Class: Aves, Family: Pycnonotidae) with special reference to their ecological isolation, *Journal of the Bombay Natural History Society* 75: 1090– 1117.

Wahungu, G.M., Mumia, E.N and Manoa, D.2003.The effects of flock size, habitat type and cattle herd sizes on feeding and vigilance in cattle Egrets

(*Ardeola ibis*). *African Journal of Ecology* 41: 287–288.

Weber, W. J .1972. A new world for the cattle egret. *Nat. Hist*. 81:56 – 63.

Williams, S.E., Middleton, J .2007. Climatic seasonality, resource bottlenecks, and abundance of rainforest birds: Implications for global climate change. *Divers. Distributions* 14:69-77.

Wittenberger and Hunt .1985. The adaptive significant of coloniality in birds. *Avian Biology* 8:1-78.

Xin Lu. 2011. Reproductive Ecology of Three Tibetan Waterbird Species, with Special Reference to Life-History Alterations along Elevational Gradients. *Zoological Studies* 50: 192-202.

Yadav, D. N., & Tindall, B. D. N. (2000). All India Network Project on Agricultural Ornithology, Annual Report. *Gujarat agriculture university, Anand* 1-14.

You, Y., Feng, J., Wang, Wang, J., Dong, C., Xunnoi, S.,Hanmel, S and Gab, wel. 2009. Variation in egg and nestling growth rate in relation to clutch size and laying sequence in Great tits Parus major. *Progress in Natural Science* 19:427- 433.

Zaccagnini,M. E and Beltzer , A .H .1982. Alimentacion de *Bubulcus ibis ibis L*. 1758 y su relacion trofica con Egretta thula thula en Leales, Tucuman (Ciconiiformes: Ardeidae)- *Rev. Asoc. Cienc. Nat. Litoral* 13: 73–80.

PUBLICATIONS

J. Exp. Zool. India Vol. 23, No. 2, pp. 000-000, 2020 | www.connectjournals.com/jez | *ISSN 0972-0030*

SEASONAL DIET COMPOSITION AND FORAGING BEHAVIOUR OF CATTLE EGRET, *BUBULCUS IBIS* IN LUCKNOW, UTTAR PRADESH

Manisha*, V. Elangovan and Akanksha Dwivedi

Department of Zoology, School for Life Science, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Raebarali Road, Lucknow - 226 025, India.

*e-mail : manishav309@gmail.com

(Received 12 April 2020, Accepted 26 May 2020)

ABSTRACT : The cattle egret is globally widespread bird. Egrets are considered as an opportunistic feeder, they feed on easily obtained prey from the feeding habitat. This study reveals an analysis of seasonal diet composition with the diverse foraging behaviour used by cattle egret (*Bubulcus ibis*) in four different sites at Lucknow, Uttar Pradesh. The observations at the study sites results in, that cattle egrets are the highly insectivorous bird. They preferred to consume 18 orders from five phyla of prey items during the study period, which includes twelve orders of insects, three orders of Pisces, an Anura from Amphibia, Opisthopora order of Annelids and Squamata order of Reptilia.

Moreover, in 13 different common feeding behaviour of herons, the 10 behaviour *i.e.* Walk slowly, stand and wait, walk quickly, standing fly catching, neck swaying, fly scanning and resting were observed in all habitats. Foot stirring and probing were observed in only wetlands, while Search and pecking behaviour was not found in wetlands. Rest of three *i.e.* Leap frog feeding, hopping and canopy feeding behaviour of herons were not present in anyoneof the feeding habitats. The descriptive study of diet and feeding behaviour is an important for the study of feeding ecology of the cattle egret.

Key words : Cattle egret, foraging behaviour,feeding habitat, prey items.

INTRODUCTION

Cattle egrets (*Bubulcus ibis*), belonging to the family Ardeideae, this is cosmopolitan bird of heron species. It occupies a big geographic area (Zaccagnini and Beltzer, 1982). In India, it is commonly foundin various habitats like wetlands, fresh water sources, marshylands ponds, grassland, roadsides, dumps, parks, sport lawns and agricultural farms etc. (Meyerricks, 1962 and Seedikkoya, 2004) they are terrestrial foragers as they picks the disturbed insects alongside grazing animals, without causing any inconveniences or disturbances to them (Wittenberger and Hunt, 1985). Egrets are gregarious birds feeding in flocks, breeds colonially and form large ''roosting places'' in permanent and temporary swamps or trees (de laPen a, 1992). Several studies have been reported regarding the habitat and diet selection of egrets, that the both habitat and diet selection get changed with the change in seasons and prey availability (Fogarty and Hetrick, 1973; Ducommun *et al*, 2008). Their prey quality and quantity also changesin different habitats with the time of foraging (Kour *et al*, 2014) they described about cattle egrets diet, that it feed primarily grasshoppers, crickets, flies, moths, spiders, frogs, crayfish, earthworms (Mckilligan, 2005). Rarely, they also consume fish and snake. At garbage dumps they feed like scavengers.

A wide range of food taken by the egret shows that it consumes whatever could be captured by its primary tactile foraging method (Siegfried, 1971). The good foraging habitat provides an easy availability and accessibility in selectingthe prey at a reduced predation risk (Wahungu *et al*, 2003). It play significant roles in a variety of ecosystems, as their foraging habit contributes in controlling the agricultural pests and helpfulto public health. Seasonal changes effects the insect prey population, many species of insects prey disappear after the rain. This also effects the cattle egrets feeding and foraging behaviour (Elgood, 1979).

Aim of this study include:Analysis of seasonal diet of egret through food consumed by egret and foraging behaviour observed on the basis of different postures and actions displayed by this bird at respective habitat used. Practically nothing has been revealed on these aspects of cattle Egrets from study areas at Lucknow.

MATERIALS AND METHODS

The study was carried out weekly between 2016 to 2018 at the different sites in Lucknow district *i.e.* Mawaiya: grassland, Vrindavan: marshyland, Jagatkheda: agriculture landand kallipaschim:wetland. The geographic coordinates of Lucknow are 26.8470°N and 80.9470°E (Kannaujiya, 2013) and the temperature ranges between 25-45°C in summers, 2-20°C in winters. The study was assessed through periodical field visits at Grassland (an area which was included of ecosystem where grasses and forbs were in dominant), Marshy land consisting of (wetland associated with pond, swampy) and agriculture land (includes intensively managed or grazed wet meadow or pastures) and wetlands (A deep-water body such as lake and pond surrounded by land) (Grobicki, 2016).

Availability of prey items was recorded by the help of two sweeps of a long handled net from the foraging area, with in $5m^2$ range. While fishes were collected with help of local fisherman, all was done by following the similar method as of Fasola (1986). Besides it, regurgitated food itemswere collected and preserved in a 70% ethanol for identification of taxa (Chapman, 2013). Food consumed and different foraging behaviour was recorded at every 15 minute interval from dawn to dusk and was noted carefully from a distance of 30-40 meters with a help of binocular. The nomenclature of foraging behaviour was used as Mayerricks (1962) and Kushlan (1978).

The sampling had been done between 0600 h - 1800 h, the observation carried out visually during the feeding time of cattle egrets with the help of digital video camera and binocular (Celestron up close G2, 6.8°/35FT/118M 10x50X). Non-invasive method was avoided. The whole study period was divided in to three seasons, summer (March to June), monsoon (July to October) and winter (November to February). The food consumed success was identified by the characteristic of *i.e.* Head-jerk, swallowing behaviour (Dinsmore, 1973 and Scott, 1984). "Shapiro wilk test" method was used for Normality test of the data where ($P>0.05$), therefore, prey items consumed and availability of prey items were analyzed through Krushkal Wallis-H analysis (SPSS version 21). ($P>0.05$).

RESULTS

In the present study, the total number of 1,443 cattle egrets were observed at different foraging sites, the percentage in agriculture land (34.21%) followed by grassland (26.57%), marshy land (21.70%) and wetland (17.49%). Most of cattle egrets showed a little seasonal variations at foraging sites *i.e.* in rainy season they feeds in large number as compared to summer and winter. It was observed that the bird has a highest frequency of feeding in early morning and late in the evening (Aboushiba, 2015).

A total of 18 orders from five phyla of prey items consumed during the study period including twelve orders of Insects, three orders of Pisces, Anura of Amphibia, Opisthopora order of Annelida and Squamata order of Reptilia. We observed that the prey items of cattle egret were found varied according to the seasons. The maximum prey fedwere insects among the phylum included twelve orders alone. Odonata was maximum fed by cattle egret in all the seasons, whereas the result was,a maximum fed in monsoon (16.5 ± 5.80) and minimum in winter (4.5 ± 3.69). Kruskal Wallis H test also showed significant difference in all season ($H=6.031$, $P= 0.049$) (Tabel 1). While secondly maximum consumed prey item wereColeoptera in every season *i.e.* in monsoon (14.25 ± 5.57), summer (8.75 ± 3.30) and in winter (3.75 ± 3.30). Statistically asignificant variation among the season was observed ($H=6.89$, $P=0.032$) (Table 1). It was seen that, when food availability was limited, the Pisces was the main food item of cattle egret. As in winter the channa (8.25 ± 2.87) was maximum consumed by cattle egret, while minimum in summer (0.75 ± 0.95). Whereas Kruskal Wallis H test showed significant deference among the seasons ($H=6.026$, $P= 0.049$) (Tabel 1). Furthermore, other prey items including Amphibian, Annelids and Reptilia were consumed in less quantity in all three seasons (Table 1).

A total prey items availability was observed among 18 orders of five phyla at foraging sites during the study period. In the whole study, the maximum orders of prey items were found *i.e.* Odonata, Coleoptera and Opisthopora in monsoon, while presence of Coleoptera was also seen maximumin summer and Cypriniformes, Siluridea and Channa in monsoon and winter (Table 2).

During the feeding of cattle egret, the series of foraging behaviour were observed. Each behaviour had a different postures and actions. According to habitats some differences were also noticed in the number of displayed foraging behaviours. From 13 different common feeding behaviour of herons, 10 behaviour were seen in cattle egret. From these only seven *i.e.* Walk slowly, stand and wait, walk quickly, standing fly catching, neck swaying, resting and fly scanning were seen at all habitats. While foot stirring and probing were observed in only wetlands. Search and pecking behaviour was not found in wetlands. Leap frog feeding, hopping and canopy feeding behaviour were also not found in any habitats.

Table 1 : The seasonal variation in consumption of prey items by cattle egret is given as mean ± SD of three distinct seasons. The Kruskal Wallis H test is Significant at the 0.05 level.

Taxa	Summer	Monsoon	Winter	Statically value	
	Mean ± SD	Mean ± SD	Mean ± SD	H	P
Insect					
Hymenoptera	4.5 ± 4.50	3.75 ± 4.11	2.5 ± 3.78	1.09	0.58
Hemiptera	-	1.75 ± 1.70	-	7.157	**0.028**
Odonata	9.5 ± 6.60	16.5 ± 5.80	4.5 ± 3.69	6.031	**0.049**
Lepidoptera	-	3.75 ± 3.30	-	7.031	**0.239**
Orthoptera	4.25 ± 3.5	10.5 ± 2.38	2.5 ± 2.64	6.934	**0.031**
Diptera	4.25 ± 2.06	7.75 ± 8.38	2.75 ± 3.09	1.012	0.603
Dermapetra	-	2.5 ± 1.91	-	10.507	**0.005**
Areanea	1.5 ± 1.29	2.5 ± 3	3.75 ± 0.95	0.792	0.673
Ixodida	2.2 ± 1.70	2.5 ± 1.91	2.5 ± 1.91	0.396	0.82
Coleoptera	8.75 ± 3.30	14.25 ± 5.56	3.75 ± 3.30	6.89	**0.032**
Diplopoda	-	12.75 ± 4.99	1.25 ± 1.5	9.116	**0.01**
Chilopoda	-	13.5 ± 4.43	2.75 ± 1.89	9.116	**0.009**
Pisces					
Cypriniformes	1.25 ± 0.95	4.75 ± 3.09	7.75 ± 3.30	7.372	**0.025**
Siluridae	1.75 ± 2.06	3.25 ± 1.5	7.25 ± 1.70	7.577	**0.023**
Channa–punctatus	0.75 ± 0.95	3.75 ± 3.86	8.25 ± 2.87	6.026	**0.049**
Amphibia					
Anura	-	9.25 ± 2.06	-	6.715	**0.035**
Annelida					
Opisthopora	-	8.75 ± 4.11	-	6.958	**0.031**
Reptilia					
Squamata	1.25 ± 1.25	1.75 ± 1.25	2.25 ± 1.5	1.131	0.568

DISCUSSION

This study discusses about the diet selection, diet composition and foraging behaviour of cattle egret. Cattle egret obtains their food items usually from the grasslands, marshylands, agriculture lands and wetlands. Terrestrial food items are present such as insects, damsel fly, beetles, grasshopper etc. Although, aquatic organisms were also seen in their diet. Cattle egret were found with less dependency on vertebrate prey items as pisces and reptilians in comparison to invertebrates prey items, those belongs to Arthropoda, Annelida. However, the differences in the diet selection and composition were observed in cattle egret. For example among insects, the cattle egret consumed more dominantly Odonata, Orthoptera and Coleoptera (Table 1). Weber (1972) and Kaufman (1996) also considered that the diet of egret was mainly insectivorous, it can be assumed that, the Cattle Egret is also having some impact on particular prey species and it shall be classified as a beneficial addition to the native fauna.

This present study also reflects the variation in their food items according to seasonal changes (Tables 1 and 2). It reveals the egrets foraged more extensively in monsoon as compare to summer and winter. As the number of insects or aquatic organism increases in rainy season in all type of feeding habitats. The wide range of food items in the diet of cattle egret indicates that it consume the suitable prey items, abundantly available at the foraging sites according to season.

It is useful to study about the types of posture and actions, as they could be used in distinguishing of the sitting behaviour and provide sub categories, which were observed in all the habitats mentioned in Table 3. The series of foraging behaviour displayed by the egrets were found to be very immense (Table 3).

Searching of food items on feeding ground and in water bodies from short distancing height was noticed as one of the foraging behaviour. Perhaps it is recorded for the first time in this study. The explanation and nomenclature of feeding behaviour along with total behaviour cataloguing were found to bethe most important in foraging studies of the cattle egret.

Leap frog feeding : A herons jumps into the air and flies a short distance to a potential prey item and often stabs simultaneously with landing. Siegfried (1971) suggests, that it helps birds to maintain contact in the long grass. In observation, the cattle egret was not found

Table 2 : The availability of prey items of cattle egret in three distinct seasons respectively summer, monsoon and winter.

Taxon		Season		
Vernacular name	**Order**	**Summer**	**Monsoon**	**Winter**
Wasp, Bees, Ants	Hymenoptera	+	++	+
Rice bug, Truebug	Hemiptera	-	+	-
Damselfly, Dragonfly, Nymph	Odonata	+	++++	+
Caterpillar	Lepidoptera	-	+	-
Grasshopper, Cricket	Orthoptera	+	++	+
House fly	Diptera	+	+	-
Earwig	Dermaptera	-	+	-
Spider	Areanea	+	+	+
Ticks	Ixodida	+	+	+
Ladybird beetle, Ground beetle, Blister beetle	Coleoptera	++	+++	+
Millipedes	Diplopoda	-	++	-
Centipedes	Chilopoda	+	+	-
Labeo rohita, Catla	Cypriniformes	+	++	++
Mystus seenghala	Siluridae	+	++	++
Spotted snakehead	Channapunctatus	+	++	++
Frog, Tadpole	Anura	-	++	-
Earthworm	Opisthopora	-	+++	-
Lizard, snake	Squamata	+	+	+

Where, (-) absent, (+) 10 % (++) 20%, (+++) 30-35%, (++++) 40-50% observation.

Table 3 : Different foraging behaviour displayed by cattle egrets at different habitats.

Foraging behaviour	Grassland	Marshyland	Agricultureland	Wetland
Leapfrog feeding	_	_	_	_
Searchand pecking	+	+	+	_
Walk slowly	+	+	+	+
Stand and wait	+	+	+	+
Walk quickly	+	+	+	+
Foot stirring	_	_	_	+
Probing	_	_	_	+
Standing flying catching	+	+	+	+
Neck swaying	+	+	+	+
Canopy feeding	_	_	_	_
Fly scanning	+	+	+	+
Resting	+	+	+	+
Hopping	_	_	_	_

Where, (-) absent, (+) Present observation.

feeding in dense high grass, therefore this behaviour was not observed in cattle egret.

Search and pecking : Cattle egret displayed this behaviour at all feeding habitats accept in wetland. There the cattle egret easily picks up the food materials from the substrate or ground, with the help of their bills. It also reported by Heatwole (1965), Sharma and Soni (2014).

Walk slowly : In this behaviour walking becomes slower as the heron examines items or area of interest, just before striking, the heron may walk too slow (Recher *et al*, 1983). This kind of behaviour was observed at all types of feeding habitats. In this behaviour egret does not make extra effort to exhibit.

Stand and wait : Cattle egret commonly execute this behaviour at feeding sites. The egret stands for some time towatch the prey item for capturing (Kushlan, 1976). In this behaviour less energy is consumed.

Walk quickly : This kind of behaviour indicates about the chase disturb feeding (Kushlan, 1976). They observed that, the running and quick walking activity was used by the birds for capturing the moving prey and spotting the prey in a better way. It was seen that in solitary mode of feeding, cattle egrets feeds in absence of cattle and other disturbing objects *i.e.* Moving vehicle and farmers etc. (Recher and Holmes, 1982).

Foot stirring : The special use of feet in this type of foraging seen in cattle egret. It is also comes under categoryof disturb and chase feeding (Holt, 1961) a heron extends one leg forward and vibrates its leg and foot, or it vibrates its foot while wading forward normally. This motion disturbs the area around its foot, the disturbed prey get captured. Foot stirring can occur in mud, vegetation, mid-water. In present study, it was observed only at wetlands.

Probing : This feeding movement noticed when cattle egret placed its bill half and more than half inside the water to pick up a prey items. It was observed in stagnant water bodies and in the natural wetlands. (Meyerriecks, 1959).

Standing fly catching : This feeding behaviour involves catching of flying preys, while the birds are in standing posture (Sharma and Soni, 2014). This behaviour however rarely used and was noticed only in few cattle egret. During the study period this behaviour was seen

in foraging lands and margins of wetlands.

Neck swaying : While the egret is in standing or walking posture, it use to move the neck forward and backward, this keeps the egret to remain in parallel position for maintaining a precise estimated distance and location of the object (Kushlan, 1986). Thus, it catches the easily escapable prey in a single strike. Egret used this behaviour at all type of feeding habitats.

Canopy feeding : The large wading birds are bringing their both wings forward to form a canopy type structure, the shadow in front of their own body attracts the fish and insects (Delacour, 1946). This type of technique was not observed in cattle egret, as the size of cattle egrets is smaller than other larger heron.

Fly scanning : Cattle egret scans the ground or wetland to search their food while flying from a distance between 5-10 meter. This behaviour is used more at wetlands in compare to other habitats. Perhaps this behaviour is reported first time in this investigation.

Resting : This behaviour was observed at all type of feeding habitats. Cattle egret displays this activity after the feeding. They usually stand on one leg (Sharma and Soni, 2014) and after 10-15 minute interval they change their leg position.

Hopping : The characteristic of this behaviour is that, the herons follow the flying insects for short distance and often stabs the insects simultaneously with landing (Meyerriecks, 1960). In present study this behaviour wasabsent in cattle egret. In place of hopping, it commonly use the standing fly catching and neck swaying behaviour in capturing the flying insects.

Foraging behaviour helps in understanding the ecology of herons (Murton, 1972 and Kushlan, 1976) the beginning of their study on ecology of herons provides about the role of habitat in determining heron's feeding behaviour. The observations suggest that the variation in availability of prey may also effects the feeding efficiency, diet and habitat selection along with other parameters of the feeding site, *i.e.* Differs fromone location to the next. The present study shows the variations in prey type and density, density of cattle egret and other parameters of the feeding site differ fromone location to the next. And the feeding efficiency also differs.

CONCLUSION

According to the study, it is concluded, that cattle egrets in Lucknow area are carnivorous. This study suggests that the diet of cattle egrets is influenced by the habitat where they feed, rather than on specialised food. Cattle egrets showed a dietary flexibility and habitat adaptability. The food of cattle egrets at the grasslands and agriculture site were mainly restricted to insects, asodonata, orthoptera and coleoptera however, at the aquatic habitat, the cattle egrets fed on a variety of prey including insects and amphibians. Regarding to the type and amount of prey consumed by cattle egrets at grassland and agricultural land. The feeding priority shows that the cattle egrets are playing major role in determining the ecological conditions of the habitats. Clear understanding of the descriptive aspects of each behaviour and knowledge of the occurrence of various behaviours in cattle egrets shall be beneficial to understand more about the foraging ecology of cattle egrets. This present paper may provide a common background and may help in future studies.

REFERENCES

Aboushiba A B H and Ramli R M S (2015) Foraging behaviour of five egret species in pome pond area at carey island, peninsular Malaysia. *JAPS* **23**(1), 129-135.

Chapman R F, Simpson S J and Douglas A E (2013) *The insects structure and function*. Fifth edition.

De la Pena M R (1992) *Guý´a de Aves Argentinas: No. 1: Rheiformes–Tinamiformes–Sphenisciformes–Podicipediformes–Procellariiformes–Pelecaniformes–Ardeiformes–Phoenicopteriformes–Anseriformes*, 2nd edn. L.O.L.A. Santa Fe, Argentina.

Delacour J (1946) Under wing fishing of the black heron, Melanophoyx ardesiaca. *Auk* **63**, 441-442.

Dinsmore J (1973) Foraging success of cattle egrets, *Bubulcus ibis*. American Midland Naturalist. *The University of Notre Dame* **89**(1), 242-246.

Ducommun M P, Quiroga M A, Beltzer A H and Schnack J A (2008) Diet of cattle egrets in the flood valley of the parana river, North Argentina. *Avian Bio. Res*. 145-151.

Elgood J A (1979) Birds of the West African Towns and Gardens. *West African Nat.* Handbook. Savory H J (ed.) Longman GP.LTD. London. Wachheony Printing Press Ltd., Hong Kong, China.

Fasola M (1986) Distribuzione e populazione del Laridi e Sternidi nidificanti in Italia. *Ricerche Biologia Selvaggina* No.9.

Fogarty M J and Hetrick W M (1973) Summer foods of Cattle Egret in North Central Florida. *Auk* **90**, 268–280.

Grobicki A (2016) An introduction to the Ramsar Convention on Wetlands. Ramsar hand book 7th edition. Ramsar convention Secretariat Rue Mauvernery 28 Switizerland.

Heatwole H (1965) Some aspects of the association of Cattle egret with Cattle. *Anim. Behav*. **13**, 79-83.

Holt S F (1961) Foot stirring in the Green Heron. *Wilson Bull*. **73**, 386.

Kannaujiya A, Kumar A and Kushwaha S (2013) Diversity of waterbirds in Lucknow Districts, Uttar Pradesh, India. *IJSR* 862-866.

Kaufman K (1996) *Lives of North American birds*. Houghton Mifflin Company, Boston.

Kour D N, Koul S and Sahi D N (2014) A Preliminary survey on the diet selection and feeding strategies employed by cattle egrets

(*Bubulcus ibis* Coromandus) in Jammu (J & K), India. *Int. J. Appl. Sci.-Res. and Review* **13**, 144-149.

Kushlan J A (1976) Feeding behaviour of North American Herons. *Auk* **93**, 86-94.

Kushlan J A (1978) Feeding ecology of wading birds. InA.Sprunt, J. Ogden, and S. Winckler (eds) Wading Birds. Research Report No. 7. *National Audubon Society* pp 249-90.

Kushlan J A (1986) Responses of wading birds to seasonal fluctuating water levels: strategies and their limits. *Colonial Waterbirds* **9**, 155-162.

McKilligan N G (2005) Herons, Egrets and Bitterns. Their Biology and Conservation in Australia. *CSIRO Publishing*. P. 144.

Meyerricks A J (1962) Diversity typifies heron feeding. *Nat. Hist*. **71**, 48-59.

Meyerriecks A J (1960) Success story of a pioneering bird. *Nat. Hist*. **69**(7), 46-57.

Meyerriecks A J (1959) Foot Stirring feeding behaviour in herons. *Wilson Bull*. **71**, 153-158.

Murton R K (1972) The ecology and status of Swinhoe's egret, with notes on other herons in southeastern China. *Biol. Conserv*. **4**, 89-96.

Recher H F, Holmes R T, Davis W E and Morton S (1983) Foraging behaviour of Australian herons. *Colonial Waterbirds* **6**, 1-10.

Recher H F and Holmes R T (1982) The foraging behaviour of herons and egrets on the Magela Crrk floodplains, Northern Territory.Supervising Scientist for the Alligator Rivers Region, *Tech. Mem*. 4-17.

Scott D (1984) The feeding success of cattle egrets in flocks. *Animal Behaviour.* **32**, 1089-1100.

Seedikkoya K (2004) Comparative ecology of certain paddy field birds with emphasis on the habitat quality. *Ph.D thesis*, University of Calicut, Kerala, India.

Sharma M and Soni K C(2014) Feeding behaviour and success of cattle egret (*Bubulcus ibis*) inhabiting rural and urban area of Laxmangarh city, Rajasthan, India. *J. Adv. Biol*. **4**(2), 393-403.

Siegfried W R (1971) The food of the cattle egret. *J. appl. Ecol.* **8**, 447-468.

Wahungu G M, Mumia E N and Manoa D (2003) The effects of flock size,habitat type and cattle herd sizes on feeding and vigilance in cattle egrets (*Ardeola ibis*). *Afri. J. Ecol*. **41**, 287 - 288.

Weber W J (1972) A new world for the cattle egret. *Nat. Hist*. **81**, 56–63.

Wittenberger and Hunt (1985) Theadaptive significant of coloniality in birds. *Avian Biol.* **8**, 1-78.

Zaccagnini M E and Beltzer A H (1982) Alimentacion de *Bubulcus ibis ibis L.* 1758 y su relacion trofica con *Egretta thula thula* (Molina, 1782) en Leales, Tucuman (Ciconiiformes: Ardeidae)- Rev. *Asoc. Cienc. Nat.* Litoral. **13**, 73–80.

CIBTech Journal of Zoology ISSN: 2319–3883 (Online)
Online International Journal Available at http://www.cibtech.org/cjz.htm
2020 Vol.9, pp.21-29/Manisha et al.
***Research Article** [Open Access]*

REPRODUCTIVE BEHAVIOUR AND HABITAT USE OF CATTLE EGRET (*BUBULCUS IBIS*) IN LUCKNOW, UTTAR PRADESH

***Manisha, V. Elangovan and Akanksha dwivedi**
Department of Zoology, School for Life Science, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Raebarali Road, Lucknow, Uttar Pradesh, 226025, India
**Author for Correspondence: manishav309@gmail.com*

ABSTRACT
The most sensitive bio-indicator of avifauna is the reproductive behaviour that influences the population, community and ecosystem. This study was carried out to investigate the effect of environmental factors on, egg laying, hatching success, nesting success and survival rate of cattle egret in urban, semi-urban and rural areas in Lucknow, Uttar Pradesh. Reproductive parameter, data were recorded during breeding season, and was visually observed using a binocular during study period. Breeding behaviour of cattle egret was found varied with different habitats. The reproductive activity was observed from mid-June to the end of August in urban area, March to mid-May in semi urban and mid-April to end of June in rural area. A total number of 18 nests from urban, 17 nests from semi-urban and 12 nests from rural area used for the experiment. The Percentage of breeding success was high in rural area (85.10%) compared to semi-urban (81.69%) and urban (66.66%). The outcome of the study shows that, the urbanization does effect negatively on reproductive biology of cattle egret.

Keywords: *Cattle Egret, Habitat, Reproductive Behaviours, Urbanization*

INTRODUCTION
Heron are the aquatic birds, and are indicating species for wetland areas. Cattle egrets, *Bubulcus ibis* belongs to the order Ciconiformes and family Ardeidae (Ali, 1996). They are small, white and widely distributed herons, they usually nests in large colonies. Conservation of aquatic birds is an extensive understanding of their eco biological requirements. (Fellowes *et al*., 2001; Li *et al.*, 2016). It Prefers habitat near water bodies and feeds in grassland, pastureland, freshwater marshes, salt marshes, rice fields, river and estuaries (Taylor and Schultz, 2008). Egrets are good subject for breeding study as they are large, abundant and consume easily identified prey. Availability of food and feeding environments influences the selection of habitat by the birds (Samraoui *et al*., 2007). Many studies (Robert *et al*., 2000) shows that, The environmental changes does effects in motivating them in their distribution, habitat use, reproductive parameters and foraging behaviour. They are also the best indicators of pollution (Lowe Mc Connell, 1967; Kazantzidis and Goutner, 1996; Kushlan and Hafner, 2000; Goutner *et al*., 2001) food is believed to be one of the main resources for the survival and reproduction of all living organisms. Cattle egrets show dietary elasticity and adaptability in feeding on varieties of prey in a suitable environment (Mckilligan, 2005). Numbers of studies have shown that the diet of Cattle egrets keeps changing according to the seasons, time period of the day, prey availability and abundancity (Ducommun *et al*., 2008). They also feed in flocks on insects at freshly ploughed fields (Patankar *et al*., 2007). As its insectivorous behaviour, cattle egret is considered as a biological pest control agent in an agro-ecosystem (Thomas *et al*., 2004). The cattle egret is the best-known social bird that feeds in close association with cattles. Such as, cow, buffalo, horse, bull etc. and also with some other domestic and wild host. In breeding ecology of these birds, especially the phenology, relates to climatic conditions (Jakubas, 2011). The climatic changes does effects the arrival dates and the breeding time of birds (Parmesan and Yohe, 2003). Such information could be used as an indicating tool and impact assessment on the breeding ecology of the bird. This bird has been described to nest in agro-ecosystems, in both urban and rural environment, it depends upon safe nesting places, food availability, and other environmental factors (Abdullah, 2016).A good nesting site generally provides protection against predators, necessary support in making the nest, and access to feeding sites within foraging areas (Rao, 2004). Nesting sites also support in hatching success and positive rearing of chicks for species survival (Ludwig *et al*.,1994).Well known theory in ecology known as the “Food availability breeding time” hypothesis suggests, that for the effectual survival , it is very important that, birds

breed at the most advantageous time of the year for upbringing their offspring . Favourable time of the year constitute the supportive environment factors like, optimal temperature, photoperiod, availability of nest sites. The selection of habitat and environmental requirements of cattle egret as well as breeding parameters of the species were studied i.e. egg laying, hatching success, nesting success and survival rate of cattle egret in urban, semi-urban and rural areas .The outcome of this study provides the survival rate of the birds on the basis of habitat use, additionally effect of urbanization on reproductive biology of cattle egret.

MATERIALS AND METHODS

The study was carried out in Lucknow and its associated areas, within in 40 km distance .The Site I was in Khuajapur: Urban area (*Ficus virens*) nesting tree in Lucknow, Site II in Deva :Semi urban area (*Pithecellobium dulce*) nesting tree in Barabanki and Site III at Bichiya: Rural area (*Vachellia nilotica*) nesting tree in Unnao. In order to record various eco-biological aspects of cattle egrets periodic surveys were undertaken for one year 2018 from March to August. Some qualitative data was also collected by interviewing the local peoples around the breeding sites. The ecology of breeding habitats was studied during field visit by observing the size of breeding territory, distance of water resources, prey availability. This makes the site attractive for breeding (Patankar *et al.,* 2007). Non-invasive methods were used in monitoring the colony; therefore all the investigations were carried out without disturbing the nesting pairs. Different breeding aspects of bird appearance, nesting behaviour, courtship display, egg laying, incubation, hatching success, breeding success and parental care period were based on the direct visual observation by digital video camera and binocular Celestron up close G2, 6.8°/35FT/118M (10x50X) (Joshi and Shrivastava, 2012; Kour and Sahi, 2013). Urban area have a population of at least 1500 person per sq. km ,semi urban area, which have at least 300 person per sq. km and rural area, consists mostly low-density per sq. km according to (Chandramouli, 2011). The nests in colony were counted as per point count method (Dodd, 1995). Nesting and hatching success were calculated by following the method of (Fazili, 2002). Nesting success was calculated as NS/ (NS+NU) X100, where NS is the number of successful nest (*i.e.* nest in which at least, one nestling survived beyond 10 days of age), NU is number of unsuccessful nests.

Hatching success was calculated as: Number of egg hatched/ total number of eggs laid or clutch size X100. Breeding success was calculated by the formula (Number of fledglings survived) / (Number of eggs laid X 100) (Vijayan, 1980; Jehle *et al*., 2004). Food items consumed by a cattle egret were recorded on the basis of direct observation while feeding. The contents of regurgitated food from the nests was collected and preserved in a 70% ethanol for identification of taxa (Chapman, 2013). Availability of prey items was recorded by the help of 2 sweep of a long handled net from the foraging area, with in 5x5 metre range, fishes were collected with help of fisherman (Chaskda *et al*.,2018).Difference in prey consumed was analysed by Krushkal Wallis-H test analysis (SPSS version 21). Temperature and humidity was recorded by using hygrometer. Mean and standard deviation of prey items were also carried out by using (SPSS version 21).

RESULTS AND DISCUSSION

Table 1: The reproductive event performance by cattle egret during reproductive season at three distinct habitats such as urban, semi urban and rural in 2018 with the number of sample and percentage

Nesting Variable	Urban (n=23)		Semi urban (n=19)		Rural (n=12)	
	No. sample	%	No. sample	%	No. sample	%
Abandoned nest	5	21.73	2	10.52	0	0
Successful nest	18	78.26	17	89.47	12	100
Total no. of eggs laying	52	-	71	-	47	-
No. of damaged eggs	12	21.56	10	10.34	5	8.51
Hatching success	40	78.43	61	85.91	43	89.36
No. of die fledglings	6	11.76	3	4.22	2	4.25
Breeding success	33	66.66	58	81.69	40	85.1

Table 2: Reproductive behaviour performance by cattle egret during breeding season in three distinct habitats i.e. urban, semi-urban and rural in 2018

Reproductive events	Urban	Semi- urban	Rural
Plumage	26-May-18	13-Mar-18	3-Apr-18
Nest construction	17-June-18	28-Mar-18	20-Apr-18
Egg laying and incubation	23-Jul-18	13-Apr-18	16-May-18
Hatching	15-Aug-18	7-May-18	8-June-18
Parental care	18-Aug-18	13-May-18	17-June-18

Table 3: The mean and SD of prey item consumed by cattle egret in three distinct habitats, urban, semi-urban and rural, whereas Kruskal Walish H test of statistical value at 0.05 level.

Habitat	Prey item	Month						Statistical value	
		March	April	May	June	July	August	H	P
Urban	Insects	10.75 ± 6.02	13.25 ± 7.84	5.75±4.57	7.75±6.29	14.25±3.40	22.5±5.97	11.908	0.036
	Annelidians	-	-	-	-	4.25±3.40	2.75±3.09	19.011	0.002
	Amphibians	-	-	-	-	1.75±1.70	2.25±1.70	14.992	0.01
	Reptilians	2.5 ± 1.91	4.5 ± 2.38	3.75±3.59	4.25±3.20	3.5±2.5	3.25±3.86	2.286	0.808
	Pisces	-	-	-	-	-	-	-	-
Semi urban	Insects	11.5 ± 3.69	13.5 ± 6.75	3.75±2.75	7.5±7.72	16.5±5.25	21.75±4.27	13.582	0.018
	Annelidians	3.75 ± 3.86	-	-	3.5±4.35	9.75±2.98	14.75±10.59	16.485	0.006
	Amphibians	0.75 ± 0.96	-	-	1.75±0.95	8.25±3.30	9.5±6.02	20.495	0.001
	Reptilians	1.5 ± 1.29	2.75 ± 2.5	0.25±0.5	0.75±0.95	2.75±3.09	1.75±2.36	5.094	0.404
	Pisces	3.25 ± 2.98	-	-	2.5±2.64	9.45±9.53	12.75±8.26	13.886	0.016
Rural	Insects	22.25 ± 3.5	16.5 ± 9.57	8.25±3.40	17.5±9.11	20.25±8.30	24.5±3.10	13.039	0.023
	Annelidians	5.75 ± 4.25	-	-	4.75±5.61	13.25±3.68	17.5±4.65	18.631	0.002
	Amphibians	3.75 ± 2.5	2.25 ± 2.87	-	-	10.25±5.73	11.25±5.56	18.555	0.002
	Reptilians	2.25 ± 2.06	1.25±0.95	2.25±0.95	3.5±2.38	4.25±2.36	2.75±3.09	4.072	0.539
	Pisces	4.5 ± 5.31	3.5 ± 2.88	-	2.75±2.75	10.5±4.04	13.25±4.27	16.238	0.006

Table 4: The prey taxon collected from foraging ground in three habitats i.e. urban, semi-urban and rural. Whereas (-) absent, (+) 10 % (++) 20%, (+++) 50% observation.

Habitat	Taxon	March	April	May	June	July	August
Urban	Pisces	_	_	_	_	_	_
	Amphibians	_	_	_	+	++	++
	Insects	++	+	+	+	++	+++
	Annelidians	+	_	_	+	+	++
	Reptilians	+	+	+	+	+	+
Semi-urban	Pisces	+	_	_	+	++	++
	Amphibians	+	_	_	+	++	++
	Insects	++	++	++	++	+++	++++
	Annelidians	+	_	_	_	++	+++
	Reptilians	+	+	_	+	+	+
Rural	Pisces	+	+	+	+	+++	+++
	Amphibians	+	_	_	+	++	++
	Insects	+++	++	++	++	+++	+++
	Annelidians	+	_	_	+	++	+++
	Reptilians	+	+	+	+	+	+

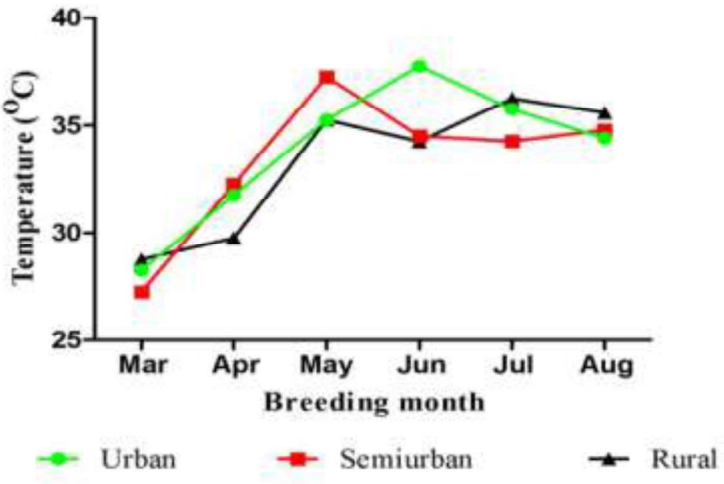

Figure 1: Ambient temperature of three distinct habitats including urban, semi-urban and rural.

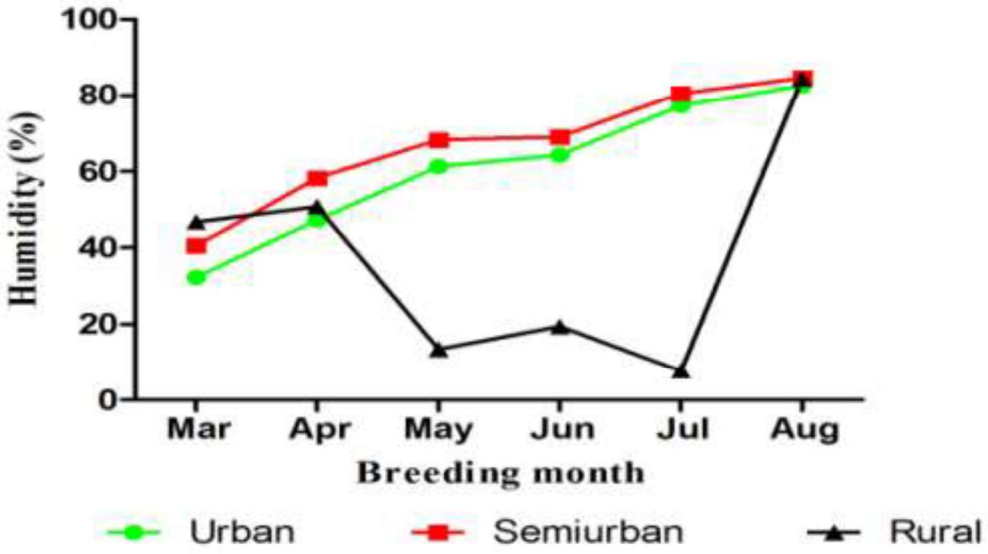

Figure 2: Ambient humidity of three distinct habitat including Urban, semi-urban and rural area.

Results

The total observed nest were 18 in urban area (Lucknow), 17 in semi urban area (Barabanki) and 12 in rural area (Unnao).In which total egg laying was observed is 52, 71, 47. Rate of egg destruction was found 12 number in urban, 10 egg damaged in semi urban and 5 egg were damaged in rural area. Chick destruction rate in urban was 6, in semi urban 3 and 2 were in rural site. The Percentage of breeding success was high in rural area (85.10%) compared to semi-urban (81.69%) and urban (66.66%) (Table 1).

Breeding biology of cattle egret was found varying different habitats. The overall reproductive activity was observed from mid-June to the end of August in urban area, March to mid-May in semi urban and mid-April to end of June in rural area. Time of reproductive behaviour of cattle egret vary according to the local environment of nesting habitat. (Table 2).

Prey items

Breeding success is apparently depends on the quality of prey items in the diet, mainly during the peak of their development period (Kazantzidis *et al*., 1996).Growth of Reproductive behaviour was highly influenced from the prey consumed by egret and availability of prey items at reproductive sites. As the high prey availability of insects increases in the prey consumed rate and high prey consumption provides the healthy reproductive growth in cattle egret. In this study cattle egrets diet was observed, i.e. that Reptilians have no significant difference at different habitat and in different month. The availability of reptilians did not decrease or increase according to month or habitat is recorded. Insects occupied 30 to 40% part in diet of egret, as the availability was high as compare to Pisces, Amphibians, Annelida's and reptilians (see Table 3 and 4). In urban area Pisces was absent in diet and availability too. While Amphibians, Annelidians and Pisces number was found increased, in both availability and in consumption during month of (rainy season) July and August (20 to 30%) (Table 3 and 4) at all three breeding habitats. Because of monsoon season started from last week of June in Lucknow region. The Pisces, Amphibians, Insects and Annelidians were observed with having significant difference in availability and consumption throughout the breeding time at all breeding habitats. While overall prey items was highly available in semi urban area, of which the influence was recorded, The breeding activity in semi urban area started much earlier than in rural and urban area. The first juvenile was observed in the month of May. While in urban and rural area it was observed in August and June.

Temperature and humidity

Mean temperature of all breeding habitats was recoded between 32 °C to 37 °C. (Haftorn, 1988) has reported about mean temperature of 34°C for birds in general for breeding success. July to August was incubation time in urban area, temperature was (35.25°C to 34.4°C) and humidity was (77 to 82%). In April to May at semi urban area temperature was (32.25 to 37.25 °C) and humidity was found (80 to 84).at rural area in May to June temperature was 36.25°C to 35.27°C) and humidity was (82 to 84%)(Figure 1and 2)

Discussion

In semi urban and rural area, nesting tree was observed is *Pithecellobium dulce* (18.918m height ,6.7m dbh)and *Vachellia nilotica (*9.52m height ,4.5m dbh).Apart from these nesting tree different species of nesting were also found like *,Arecaceae , Vachellia nilotica,and Ficus racemosa* . Source of water was the pond, present with in the 500m range in both sites. While in urban area only one nesting tree was observed in fact, at this site only one nesting was found i.e. *Ficus virens (*22.94 m height, 7.5 m dbh). Source of water was not present with in the 500m range.

Availability of food or environmental conditions may explain variance in the number of individuals breeding both within and among colonies (Brown *et al*., 1990). Anthropogenic changes do affect the breeding colonies in the study of bird species, as (Frederick and Collopy, 1989).

The damage rate of eggs and chicks die was observed high in urban area. According to observation the breeding success rate, could be affected by the human disturbance. As the nesting tree is located on the side of road. And the residential area around the tree is increasing due to construction of more buildings day by day.

Breeding season

In general the breeding season of cattle egret was observed from March to August, while various studies in India supports that, breeding period of cattle egret vary according to seasons and locations, as the (Patankar *et al*., 2007) in Vadodara, Gujarat reported that breeding month was April to July. And in Jammu, India (Kour and Sahi, 2013) reported from March to July was breeding month. And in present study the overall breeding month was considered from March to July. This study agreed with (Joshi and Shrivastava, 2012; Abdullah, 2016), that in non-breeding season Orange colour plumage was completely disappears. Whole body appears in white colour, bill becomes yellow; legs were black in both male and female birds. In breeding season, the orange colour plumage is appeared on head, neck and back of the bird, however bill and legs becomes yellow reddish in colour. The breeding plumage are used mainly in courtship behaviour and were absent in non-breeding season.

Nest Construction

The process of nest construction was observed in the month of June in urban area, in March at semi urban area and in April at rural area. However, the practice of nest repairing was seen to be continued even after eggs laying, incubation and hatching. Although the activity of nest construction was slowly decreased, also reported by (Kour and Sahi, 2013). It was observed that cattle egrets formed their colonies where water sources are present nearby trees and at the edge of the village area, road side and human vicinity. It was observed at each study site I, II, III, both male and female birds build the breeding territory. Nest construction were typically started in second week of June in urban area, fourth week of March in semi urban area and in rural area third week of April.

Nest was made up of rough sticks, shrubs and twigs retained in wedge of branches in trees. Egrets started constructing the nest much earlier of their mating. They were observed to collect nesting materials from the nearby fields, from old nest and other branches from same nesting trees. Nests were found completed in 8 to 10 days in all the three breeding habitats. Nesting colonies were observed in this study were polyspecific with pond heron, snowy egret (Ali and Ripley, 1968; Maccarane and Parsons, 1988).

Courtship behaviour

Courtship behaviour of egret was observed after they had completed their nests in the fourth week of June in urban, second week of March in semi urban and in first week of May in rural site. In all sites egret mating was observed near the nesting sites. All study was done from one to five meter range distance of the nest (Mackilligan, 2005; Kour and Sahi, 2013).In the present study mating was observed mostly in the morning and at the middle of day.

Egg laying

Egg laying behaviour were seen after mating activity in second week of July at urban, fourth week of March at semi urban and in first week of May at rural site. Female birds were seen sitting in nest or around the nest whole day. After egg laying, the male egret takes care in maintaining nest. Eggs were medium in size, oval in shape and light blue in colour, (Kour and sahi, 2013) also reported similar characteristics of eggs.

Incubation period

The incubation periods started with the laying of first egg and during incubation, one of the two partners sat on the eggs, but mostly the female was noticed. The variation in incubation period was observed from 24-26 days in urban site. (Joshi and Shrivastava, 2012; Kour and Sahi, 2013) has also reported about incubation periods from 21-24, in both semi urban and rural sites.

Clutch size

The clutch size was observed at all breeding sites after 4 to 5 days of egg laying. Results revealed, that the clutch size was (Mean ± SD) (4.17±1.38) in semi urban area, (3.91±1.37) in rural area and (3.27±1.17) in urban area. The range of the clutch size was observed as 02 to 06 eggs (n=), 03 eggs being the common and exceptionally 06 (Table).

Hatching

Hatching time of eggs differs according to the time of egg laying. At site (urban, semi urban) it was observed in third week of August and first week of May and in site (rural) it was observed in second week of June.

Parental care

Parental care was started just after hatching of eggs, it vary nest to nest. Cattle egrets searches food to their chicks from nearby areas after hatching, the parent birds starts to bring the regurgitated food to their chicks and teach to eat regurgitated food in their partly opened beak. The chicks grew their feeding method regularly to change from nest feeding to ground feeding. Over all parental care was observed for three to four week at each site respectively. During parental care chicks make an effort to fly within the branches of nesting trees or around the nests. After the age of four weeks, juveniles were found able to fly.

Availability of aquatic organisms in food is one of the main factors for breeding success of cattle egret. In urban area the Pisces and Amphibian were absent in the diet of egret. This may be the reason of reducing of clutch size. The food resources availability also an effect on the time of breeding season begins. As many of study reported that the fishes and aquatic organisms are the rich source of nutrition for the herons. According to (Si Bachir *et al.,* 2000) study indicates that the difference between the clutch sizes, nestling survivorship depends on the food availability at different sites.

Conclusion

This study highlights the basic breeding ecology of cattle egrets. Availability of food resources and foraging environments influence the selection of habitat by the cattle egret. The results of this study suggest that the mortality of eggs and fledglings probably varies according to the local environmental conditions, especially the temperature and humidity plays a major role in incubation period of eggs. Nest location is the major factor which affects the survival rate, as seen in cattle egret. The urbanization at regular breeding habitats is the main threat to the local egrets nesting colonies.

REFERENCES

Abdullah M, Khan RA, Rafay M, Hussain T, Ruby T, Rehman F, Khalil S and Akhtar S (2016). Habitat ecology and breeding performance of cattle egret (*Bubulcus ibis*) in Faisalabad, Pakistan*, Pakistan Journal of Zoology*, **49**(5) 1863-1870.

Ali S (1996). *The book of Indian birds*, Ist edition. Oxford University Press, New Delhi.

Ali S and Ripley SD (1968). *Hand book of the birds of India and Pakistan*. Oxford University Press, Bombay,pp.66-68.

Brown CR Stutchbury BJ and Walsh PD (1990). Choice of colony size in birds. *Trends in Ecology and Evolution* **5**(12) 398-403.

Chandramouli C (2011). Census of Rural urban distribution of population India. *Ministry of home affairs.*
Chapman RF, Simpson SJ and Douglas AE (2013). The insects structure and function, Fifth edition. *Cambridge University Press.*
Chaskda AA, Iniunam IA, Dami DF, Mwansat GS (2018). Foraging success of the cattle egret Bubulcus ibis in relation to insect abundance, herd and flock size. *Journal of Research in Forestry,Wildlife and Environment* ,**10**(1)41-47.
Dodd MG (1995). Accuracy and precision of techniques for counting Great Blue Heron nests. *Journal of Wild Life*. **59** 667-673.
Ducommun M, Dela P, Quirogaa MA, Beltzera AH and Schnack JA (2008). Diet of cattle egrets (*Bubulcus ibis*) in the flood valley of the Parana River, North, Argentina. *Avian Biology Research,* **1** 145-151.
Fazili M F (2002). *Studies on annual cycle of some birds of Wular Lake Kashmir*. Ph.D. thesis submitted to University of Kashmir.
Fellowes JR, Fang Z , Shing LK , Hau BC , Lau MW, and Lam VW(2001). Status updates of white eared night heron gorsachius magnificus in south China. *Bird Conservation International*, **11**_101-111.
Frederick PC and Collopy MW (1989). The role of predation in determining reproductive success of collonially nesting wading birds in the Florida Everglades. *The Condor*, **91** 869-867.
Goutner V, Furness R and Papakpostas G (2001). Mercury in feathers of squacco heron (*Ardeola ralloides*) chicks in relation to age, hatching order, growth and sampling dates. *Environmental Pollution*, **11** 107-115.
Haftorn S (1988). Incubating female passerines do not let the egg temperature fall below the 'physiological zero temperature' during their absences from the nest. *Ornis Scandinavica.* **19** 97-110.
Jakubas D (2011). The influence of climate conditions on breeding phenology of the grey heron Ardea cineria L. in northern Poland. *Polish Journal of Ecology*, **59** 179-192.
Jehle G, Adams AAY, Savidge JA and Skagen SK, (2004). Nest survival estimation: a review of alternatives to the Mayfield estimator. *Condor,* **106** 472-484.
Joshi P and Shrivastava VK (2012). Breeding biology and nest site selection of cattle egret (*Bubulcus ibis)* in Tawa Reservoir and surrounding area of Hoshangabad District (M.P). *Asian Journal of experimental biological Sciences,* **3** 525-530.
Kazantzidis S, Hafner H and Goutner V (1996). Comparative breeding ecology of Little egrets Egretta garzetta in the Axios Delta (Greece) and the Camargue (France). *Reve Ecologie* (*Teree et Vie*) **49** 53-62.
Kour DN and Sahi DN (2013). Aspects of breeding biology of cattle egret, *bubulcus ibis coromandus* (boddaert) in Jammu, India. *International Journal of environmental Science,* **3** 1547-1561.
Kushlan JA and Hafner H (2000). *Heron conservation*. Academic Press, London, UK.
Li X , Xian Z , Xinrong X , Shicheng L, Yongqiang Z, Danxi C, Chenxi H, Bingyao C and Guang Y (2016). Bird diversity in the buffer zone of the largest coastal nature reserve of China and conservation implications. *Pakistan Journal of Zoology,* **48** 1193-1199.
Lowe-Mc Connell RH (1967). Biology of the immigrant cattle egret *Ardeola ibis* in Guyana, South America. *Ibis International Journal of Avian Biology,* **109** 168-179.
Ludwig E, Vanicsek L, Torok J and Csorgo T (1994). The effect of nest height on the seasonal pattern of breeding success in blackbirds, *Tardus merula*. *Ardea,* **83** 411-418.
Maccarone AD and Parsons KC (1988). Differences in flight patterns among nesting ibises and egrets. *Colonial Water bird,***11** 67-71.
McKilligan NG (2005). Herons, egrets and bitterns: Their biology and conservation in Australia. *CSIRO Publishing*, pp. 144.
Parmesan C and Yohe G (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, **421** 37-42.
Patankar P , Desai I , Shinde K and Suresh B (2007). Ecology and breeding biology of the cattle egret (*Bubulcus ibis*) in an industrial area at Vadodara, Gujarat. *Zoos' Print Journal,* **22** 2885-2888.
Rao VV (2004). *Egrets and their role in environment*. International Conference on Bird and Environment, Haridwar, India, pp. 40.
Roberte, Bennetts, Fasola M, Hafner H, and Kayser Y (2000). Influence of environmental and density-dependent factors on reproduction of little egrets. *The Auk*, **117**(3) 634-639.

Samraoui F, Menaï R and Samraoui B (2007). Reproductive ecology of the cattle egret (*Bubulcus ibis*) at Sidi Achour, North-Eastern Algeria. *Ostrich,* **78** 481-487.
SiBachir A, Hafne Hr, Tourenq JN and Doumandji S (2000). Structure de l'habitat et biologie de reproduction du Héron Garde-bœuf, *Bubulcus ibis*, dans une colonie de la vallée de la Soummam (Petite Kabylie, Algérie). *Reve Ecologie* (*Teree et Vie*), **55** 33-43.
Taylor IR and Schultz MC (2008). Breeding season diets of egrets in Southeast Australia: implications for future population viability. *Waterbirds,* **31** 593-601.
Thomas J, Chellappan M and Bhaskar H (2004). *Role of insectivorous birds in rice pest management*. International Conference on Bird and Environment, Haridwar, India.
Vijayan VS (1980). Breeding biology of bulbuls, Pycnonotus cafer and Pycnonotus luteolus (Class: Aves, Family: Pycnonotidae) with special reference to their ecological isolation, *Journal of the Bombay Natural History Society*, **75** 1090–1117.

Bulletin of Pure and Applied Sciences
Vol.40A (Zoology), No.1,
January-June 2021: P.6-14

Print version ISSN 0970 0765
Online version ISSN 2320 3188
DOI 10.5958/2320-3188.2021.00002.4

Content Available online at: https://www.bpasjournals.com/zoology

Original Research Article

Foraging Behaviour and Host Selection of Cattle Egret (*Bubulcus ibis*) Among Different Host Species in Lucknow (Uttar Pradesh)

[1]Manisha Verma*, [2]V. Elangovan, [3]Akanksha Dwivedi, [4]Mukesh Kumar

Author's Affiliation:
[1,2,3,4]Department of Zoology, School for Life Science, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Raebarali Road, Lucknow, Uttar Pradesh 226025, India
E-mail:
[1]manishav309@gmail.com,
[2]elango70@yahoo.com,
[3]akkiau90@gmail.com,
[4]mukeshcomm@yahoo.co.in

***Corresponding author:**
Manisha Verma
Department of Zoology, School for Life Science, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Raebarali Road, Lucknow, Uttar Pradesh 226025, India

E-mail:
manishav309@gmail.com

Article Info:
Received on 22.09.2020
Accepted on 01.01.2021
Published on 15.06.2021

ABSTRACT:
Objective: The main focus of the study was to investigate the host selection behaviour in the foraging strategy of *Bubulcus ibis* with their feeding rate.
Methods: Study was carried out to analyze the host steps rate, *B. ibis* steps rate, attempt success rate and the number of switches, with different host at different lands i.e. grassland, marshy land and agriculture land in the associated areas of Lucknow from 2018 - 2019, was recorded through visual observations, digital video camera and binoculars. The host steps rate, *B. ibis* steps rate and the attempt success rate was analyzed by the Spearman correlation (SPSS version 21) and the number of switches per hour were calculated by using the formula an Average number of switches/Average time of observation x1/60.
Findings/Application: *B. ibis* with Buffalo showed highly significant positive correlation in steps and attempt success at all three lands with less number of switches per hour. In agriculture land with horse it's showed less significant correlation in steps and attempt success with high number of switches per hour. Results show that foraging success could be the reason for good association between cattle and *B. ibis*.

Keywords: Attempt success, Foraging behaviour, Host selection, Switches, Steps of hosts, Steps of *B. ibis*.

INTRODUCTION

Cattle Egret (*Bubulcus ibis*) has a worldwide distribution in the tropics, sub-tropics and warm temperate regions. In India, it is very common in varieties of habitat especially grassland, marshy land and in some wetlands such as paddy fields, marshes and mangroves, etc. They are the part of the environment and nature belongs to the family Ardeideae, which are small white herons of approx. 50 cm tall at standing position. They play an important role in the food chain in the ecosystem. *B. ibis* is a diurnal feeder commonly foraging around grazing animals in the wild or domesticated

How to cite this article: Verma, M., Elangovan, V., Dwivedi, A., Kumar M. (2021). Foraging Behaviour and Host Selection of Cattle Egret (*Bubulcus ibis*) Among Different Host Species in Lucknow (Uttar Pradesh).*Bulletin of Pure and Applied Sciences-Zoology,* 40A (1), 6-14.

livestock. (Del Hoyo et al., 1992; Kushlan and Hancock, 2005)

In the late 19th century, such species became established in South America (Turner, 2011) and the present century has established itself in Australia, Asia, New Zealand, North America and Europe. It plays a significant role in a variety of ecosystems with their foraging habits and makes them efficient as an important biological control agent. Such insectivorous birds consume insects like grasshopper, cricket, flies, moths, spiders and some insects of public health as well as agricultural pest. (Doumandji et al., 1992; Telfair and Raymond, 2006).*B. ibis* is an opportunistic predator feeding on an abundant and accessible prey (Kushlan and Hafner,2000). *B. ibis* is the best-known bird that feeds in close association with cattles. The capability of foraging mostly seen in the close association with cattles (Dinsmore,1973; Thompson et al.,1982; Wahungu et al.,2003; Kamler et al.,2008) such as, cow, buffalo, horse, bull etc. and also with some other domestic and wild host. *B. ibis* support symbiotic relationship through foraging association with cattles in gaining more benefits of feedings (Rand, 1954 and Siegfried, 1978). At inter specific levels, host selection of egrets are most effective with the host species such as cow, buffalo, horse, bull, wildebeest, zebra, hippopotamus and other ungulates in various habitats (Burger and Gochfeld, 1993;Kour and Sahi,2012; Ogutu et al.,2014). *B. ibis* feeds with cattle, captures more food than those are feeding alone. The birds appear to exploit their beating effect whereby insects and other prey disturbed by the cattle and hence are easier to detect or capture (Heatwole, 1965). However, the strategy implemented by egrets for improving the success rate was examined (Grubb,1976; Burger and Gochfeld,1999).

The *B. ibis* follow animals specifically because they move and flush prey items. This method is effective for the egret that they must follow the animals closely (Burger and Gochfeld, 1981). In India (Kour and Sahi, 2012; Seedikkoya et al., 2005) have reported about the factors influencing preferences of the host by cattle egret and the characteristics of certain cattle, as "suitable host". The term attempt success rate is the number of food items obtained and swallowed by the *B. ibis* per five minutes (Burger and Gochfeld, 1981). *B. ibis* keeps feed near the cattles until the cattle ignore its presence otherwise it starts tail wagging and shakes the head to remove the *B. ibis* (Burger and Gochfeld, 1993).The activity of switching counts of *B. ibis* means the time duration of association and disassociation counts with the host (Burger and Gochfeld, 1981). The present study was aimed to investigate the relationship between speed, capture success rate and different aspects of host preference i.e. attempt success rate and switches of host. Both concepts have been referred to as success rates, time of association i.e. "time spent by the *B. ibis* in foraging with cattle.

MATERIALS & METHODS

The study was conducted weekly between 2018 to 2019 in the sites of Lucknow district and its associated areas up to 40km i.e. grassland, marshy land, and agriculture land. The geographic coordinates of Lucknow are 26.8470°N and 80.9470°E (Seedikkoya et al., 2005; Kannaujiya et al., 2013). And the temperature ranges between 25-45°C in summers, 2-20°C in winters. According to India metrological department, 2018 mean annual rainfall is approx. 35.28inch.The study was assessed through periodical field visits at Grassland (an area which included ecosystem where grasses and forbs were dominant), Marshy land (wetland associated with lakes, swampy) and agriculture land (including intensively managed or grazed wet meadow or pastures) (Grobicki, 2016).

The collection of the data lasted between 0600 h - 1800 h through visual observations, digital video camera and binocular Celestron up close G2, 6.8°/35FT/118M (10x50X). *Bubulcus ibis* feeding behaviour was studied with the cattle i.e. cow, buffalo, horse, bull, mule on the basis of number of host steps, *B. ibis* steps, number of attempt success, foraging time and the number of time *B. ibis* switching, which was recorded for five minutes and in some cases it was for one or two minutes due to the fast foraging movements by most individuals at

different locations and habitats. Host species availability was determined at each present within 200 – 300 meters by counting to avoid distracting avian behaviour at all feeding habitat. Up to 30 individuals of each species at each habitat were observed to determine the host suitability. Association foraging was considered when *B. ibis* for age near the host within two to three meters to avoid the pseudo-replication method (Chaskda et al., 2018) with slight modification. Swallowing behaviour was counted after capturing the prey as the capture success rate of egret, identified. Host preference and foraging success were analyzed by the previous methodology described by with slight modification (Heatwole, 1965; Dinsmore, 1973; Grubb, 1976; Scott,1984). The relationship between the speed of both hosts and *B. ibis* with the attempt success rate was analyzed by Spearman Rank correlation test (SPSS version 21). The switches count per hour calculated by Average number of switches/Average time of observation x1/60.

RESULTS

In the present study, the foraging association of the cattles was observed with the total no. of 634 hosts of cow, buffalo, bull, horse and mule in grassland, marshy land and agriculture land. In association with cattles, the percentage was highest in grassland (36.10%), followed by marshy land (32.10%), agriculture land (30.68%). The percentage of egrets associated with cattle showed the little seasonal variations in agriculture land. In afternoon, *B. ibis* showed the highest frequency of association with cattle and low association in early morning and late in the evening (Aboushiba et al., 2015). In such association, they usually fed near the front leg or back leg or middle (Kour and Sahi, 2012). They left roost in small groups to disperse in the different areas. In evening, small groups return from foraging areas often congregated in flocks of hundreds of individuals. The buffalo was the best suitable host for *B. ibis* in the attempt success correlation rate in comparison with the others and horse was the unsuitable host as compare to another host. The correlation rate is significant at the (p < 0.01) level. Based on such study the increasing order of the suitability of the host are as follows, buffalo<cow<bull<mule<horse.

Foraging behaviour with cow:

B. ibis showed significant positive correlation in steps of cow. *B. ibis* with the number of switches per hour in such a way was about (r= 0.451**, 4.1) in grassland, (r=0.379**, 4.8) in marshy land and (r=0.434**, 4.2) in agricultural land. The attempt success resultant showed the cow was a satisfying host to *B. ibis* with the significant positive correlation i.e. in grassland (r=0.774**), (r=0.481**) in marshy land and (r=0.619**) in agriculture land (Table 1, 2 and fig1).

Foraging behaviour with buffalo:

The feeding association relationship of *B. ibis* with buffalo, steps showed significant positive correlation and switches per hour was very low in grassland (r=0.546**, 3.3), marshy land (r=0.297**, 3.6) and in agriculture land (r=0.559**, 3.2)(Table 1 and fig.1), hence the resultant attempt success showed highly significant positive correlation and reaches maximum range of feeding success i.e. (r=0.761**), (r=0.678**) and (r=0.811**) (Table 2). Therefore, it is concluded that buffalo was the best suitable host to *B. ibis*.

Foraging behaviour with bull:

In foraging behaviour with bull grassland and agriculture land steps showed significant positive correlation and switches per hour were as (r=0.411**, 6.8) and (r= 0.212**, 7.2) (Table 1)therefore, *B. ibis* attained attempt success rate (r=0.503**, r=0.488**)(Table 2) and also showed the significant positive correlation, which was approximately fifty percent feeding success in grassland and agriculture land. While in marshyland this feeding association showed lowest steps correlation rate and high number of switches per hour (r=0.272**, 7.3)(Table 1). Therefore, in marshy land, *B. ibis* achieved less attempt success rate (r=0.334**) (Table 2), accordingly it I sconcluded that feeding association relationships of *B. ibis* with bull was less satisfying association.

Table 1: Foraging behaviour of *B. ibis* with different host

Habitats	Host	Step rate of host	Step rate of *B. ibis*	R-Value
Grassland	Cow	36.09±19.2	46.71±18.11	0.451**
	Buffalo	41.1±14.06	53.71±14.59	0.546**
	Bull	41.90±13.02	55.98±14.55	0.411**
	Horse	41.74±12.54	53.52±17.23	0.283**
	Mule	29.64±20.20	37.94±17.31	0.099
Marshyland	Cow	39.51±15.57	52.69±15.88	0.379**
	Buffalo	40.80±13.26	53.36±15.95	0.297**
	Bull	39.57±13.46	57.05±14.78	0.272**
	Horse	40.00±13.74	57.09±17.39	0.220**
	Mule	35.23±15.10	46.17±13.98	0.233**
Agricultureland	Cow	39.83±13.17	53.83±16.72	0.434**
	Buffalo	37.23±13.38	49.94±16.84	0.559**
	Bull	36.82±11.66	52.18±13.82	0.212**
	Horse	55.92±21.89	43.10±16.20	0.169**
	Mule	37.47±11.92	51.69±15.11	0.219**

R-value: Spearmean Rank correlation value between steps of host and steps of *B. ibis* Steps was recorded at per five minute.
**. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Foraging success of *B. ibis* with different host

Habitats	Host	Attempts	Success	R-Value
Grassland	Cow	18.63±9.15	9.35±6.74	r=0.774**
	Buffalo	17.10±8.05	8.50±5.79	r=0.761**
	Bull	18.02±7.63	7.461±4.87	r=0.503**
	Horse	16.18±8.05	7.28±5.67	r=0.548**
	Mule	18.92±8.19	6.29±4.81	r=0.363**
Marshyland	Cow	20.47±7.12	8.39±5.76	r=0.481**
	Buffalo	18.46±6.60	10.63±5.49	r=0.678**
	Bull	18.83±8.45	7.42±5.15	r=0.334**
	Horse	17.55±8.56	6.01±4.69	r=0.409**
	Mule	18.92±8.19	6.34±4.80	r=0.346**
Agricultureland	Cow	21.64±8.88	10.5±6.70	r=0.619**
	Buffalo	15.94±7.90	7.98±5.57	r=0.811**
	Bull	20.31±6.95	9.81±7.39	r=0.488**
	Horse	18.79±8.49	7.30±5.02	r=0.131*
	Mule	18.77±8.67	6.51±4.51	r=0.419**

R-value: Spearman Rank correlation value of attempt success rate of *B. ibis*. Attempt success was recorded at per five minute.
**. Correlation is significant at the 0.01 level (2-tailed).
*.Correlation is significant at the 0.05 level (1-tailed).

Bulletin of Pure and Applied Sciences
Vol.40A (Zoology), No.1,
January-June 2021: P.6-14

Print version ISSN 0970 0765
Online version ISSN 2320 3188
DOI 10.5958/2320-3188.2021.00002.4

Content Available online at: https://www.bpasjournals.com/zoology

Foraging behaviour with horse:
In foraging behaviour with horse in agricultureland, steps showed significant positive correlation (r=0.169**, *P*<0.01) (Table 1) and the switches per hour was high (12.6)(Fig. 1) hence, *B. ibis* attained (r=0.131*, *P*<0.05)(Table 2) attempt success rate. *B. ibis* with horse achieved lowest attempt success rate as compared to other hosts. The attempt success and switches per hour in grassland were higher with horse in comparison to the other hosts such as (r=0.283**, *P*<0.01, 9.0) and in marshy land it was (r=0.220**, *P*<0.01, 8.7) (Table 1, fig.1). Therefore, it attained attempt success rate (r=0.548**and r=0.409**) (Table 2). Based on the step correlation, switches and attempt success rate in this relationship was less than satisfying.

Foraging behaviour with mule:
In foraging behaviour with a mule in grassland not showed significant negative correlation in steps, while attempt success showed a significance positive correlation i.e. (r=0.099), (r= 0.363**). In marshyland and agriculture land, steps and attempt success both showed the significant positive correlation i.e. (r= 0.233**), (r=0.219**) and (r=0.346**), (r=0.419**) and the switches per hour were (7.7) in grassland, (7.1) in marshyland and (8.5) in agriculture land (Table 1,2 and fig.1). Based on the steps correlation, switches and attempt success, this relationship was less than satisfying.

Switches:
In Fig.1, *B. ibis* showed the lowest switches per hour with buffalo at all the three feeding habitats in comparison to all other hosts i.e. grassland(3.3/hour), (3.6/hour) marshyland and (3.2/per hour) in agriculture land. In respect with horse, it shows the highest switches per hour at all the three lands such as (9.0/hour, 8.7/hour and 12.6/hour).

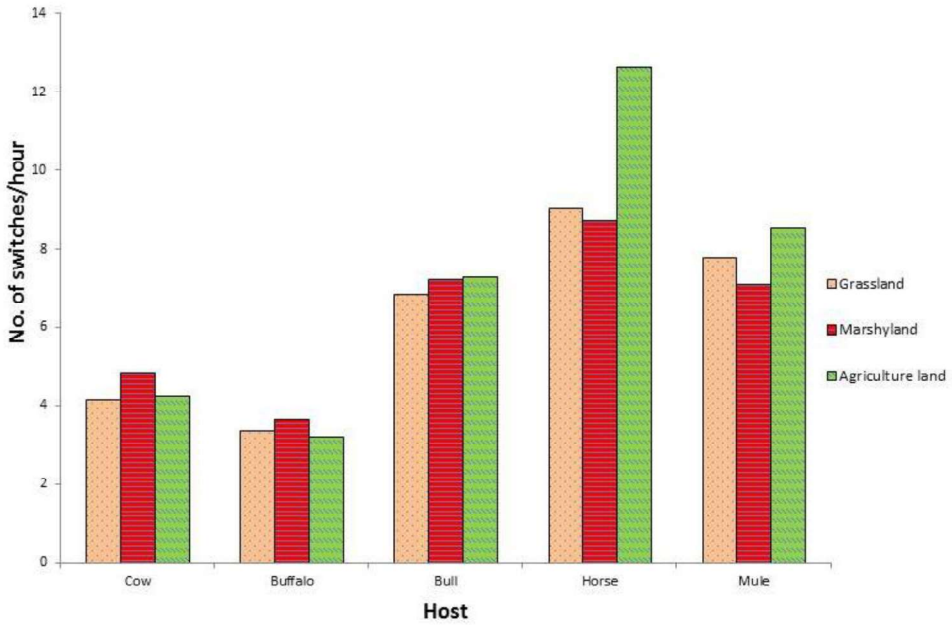

Figure 1: Number of Switches of *B. ibis* with different hosts at different habitats

How to cite this article: Verma, M., Elangovan, V., Dwivedi, A., Kumar M. (2021). Foraging Behaviour and Host Selection of Cattle Egret (*Bubulcus ibis*) Among Different Host Species in Lucknow (Uttar Pradesh).*Bulletin of Pure and Applied Sciences-Zoology,* 40A (1), 6-14.

DISCUSSION

The host preferences by *B. ibis* are more effective to gain their opportunity to capture more prey. They prefer to select the host species which moves neither too much fast nor too much slow. If the host moves very slow or rapidly the egrets switch their hosts. The steps of hosts affect the steps of egrets simultaneously (Itzkowit and Makie, 1986). The capture rate depends on the optimal speed of the host steps as well as egret steps (Burger and Gochfeld, 1993).When *B. ibis* associated with large bodied cattle over small bodied as the large bodied cattle disturbs more prey (Mikula et al., 2018) so, they caught prey items at a faster rate and spent less energy to achieve this, as has been noted in other studies on this Species (Heatwole, 1965; Grubb, 1976).

In this study, it was observed that *B. ibis* usually showed feeding association relationships with cattle on grassland, marshy land and agriculture land (Anastasios et al., 1997). According to an analysis of all the variables, buffalo seems profitable and best suitable host to *B. ibis*.

Steps of hosts and *B. ibis*:
B. ibis showed highest attempt success relationship with buffalo (r=0.811**), lowest with horse (r=0.131**) (Table 2). As we know buffalo was grazing with slow speed (37.23 ± 13.38) compare to horse (55.92 ± 21.89) at per five minute (Table 1), as a result steps of egret with buffalo (49.94 ± 16.84) and with horse (43.10 ± 16.20) was differed. *B. ibis* showed less switches with buffalo (3.3/hr) compare to other hosts as well as horse i.e. (12.63) (Fig. 1).

Due to its ignorance behaviour towards *B. ibis*. Overall switches count with horse was very high than other hosts, as it starts tail wagging and shakes the head to remove the *B. ibis* (Kour and Sahi, 2012). And when its moves too fast, *B. ibis* usually makes switches or ignore them, or takes stand and wait position. Based on increasing order, the switches counts hosts are as follows, buffalo<cow<bull<mule<horse. *B. ibis* forage in single, pairs and flocks by searching, running and flying after catching the prey. *B. ibis* occasionally feeds with donkey or goat but do not spend so much time to forage with them.

During the study period, *B. ibis* was present regularly in grassland as the prey was present throughout the observation period and due to the less human disturbance with the fixed time of cattles grazing. Therefore, this shows the high percentage of birds association in grassland. Marshy habitat was followed by few numbers of vegetation. Grass was present only at the edge of habitat with a number of pits were present. In summers, as the temperature increases the marshy land dried out and it converted into dry land (Bauder, 1989) therefore, cattle were not preferred much grazing in such habitat because of low vegetation. But in monsoon season, the marshy habitat converted into wetland due to the water logging, rushes and grasses over the whole land. Hence, the cattles start grazing in marshy land during monsoons as it shows the less percentage of association of birds comparatively than grassland. Buffalo preferred such area of low wetland and grazes comfortably for the long time than other grazers such as cow, horse and bull.

Therefore *B. ibis* obtained more feeding success with buffalo than others. In agriculture land, at the time of uncultivation we observed a good percentage of association and the number of birds. In cultivation period, from middle of December - February last we observed very less association feeding of *B. ibis*. The availability of bird populations in habitat varies depending on the requirements of the bird species and conditions offered by the habitat. However, the trapping way in habitat studies revealed the uncultivated fields offers more prey to predatory birds,

especially *B. ibis* (Mohammedi et al., 2015). *B. ibis* regularly foraged in agriculture land.

During the study all host cattle showed a good correlation in steps and attempt success rate with *B. ibis* except horse and mule (Rao, 2004). Horse and mule prefer grassland for grazing (Sheehy and Martin, 1996) and other cattles such as buffalo, cow and bull grazes so comfortably as the grasses was less as compare to the crops. Horse and mule need to move faster in searching of more green grass that result the percentage of switches goes high and the time of association becomes less (Burger and Gochfeld, 1981). *B. ibis* can forage without cattles, when hosts are not available or are in resting phase (Siegfried, 1971). It was observed that the *B. ibis* get more food items with host at per five minutes than, those offeeding alone. Switching and association time is a basic factor of *B. ibis* foraging with cattles, i.e. allowing birds to repeatedly prefer host with more suitable movement. The high number of switches and less time of association indicates the low foraging success. We found that about 90% of the egrets switched the hosts, which is an important factor that influences the foraging success of *B. ibis*. In foraging success our result revealed that of *B. ibis* does not select hosts randomly but they prefer the host which seems to be tolerant along with easy and long association. It was observed that in all sites the *B. ibis* feeds mainly orthopterans insects (Siegfried, 1972).

Cow is the most selected host by *B.ibi* (Burger and Gochfeld, 1981). While this study showed that the buffalo is the most appropriate and selected host due to the widespread distribution than other hosts in the study areas. The walking steps of the cow as well as buffalo, were in an optimal feeding range of *B. ibis*.

CONCLUSION

Above results shows that, *B. ibis* shift hosts when the host's movements are within their optimal foraging range, they do not randomly select hosts. *B. ibis* could avoid or leave hosts that moved too fast by losing its accuracy of capturing the prey with increasing host speed. In case of high feeding success rate, foraging with cattles showed a number of steps of *B. ibis,* which was about (49.94 ± 16.84) at per five minutes and for cattle it was (37.23 ± 13.38). The high number of switches and less time of association indicates the low foraging success. Thus, the buffalo is a suitable host for *B. ibis*. Based on decreasing order, the suitability of hosts are as follows, buffalo>cow>bull>mule>horse. The high number of switches and less time of association indicates the low foraging success. Feeding habitat preferred according to the seasonal changes, *B. ibis* feed at all types of habitat in all season whether it was grassland, marshy land or agricultural land. The number of population of birds will decrease or increase accordingly. Grassland proved to be more profitable than marshyland and agricultureland plays a complementary role for *B. ibis* foraging.

Acknowledgement

Statistical data analysis was done by the help of Dr. Subhash Kumar Yadav (Assistance professor) of biostatistic department of BBA University, Lucknow. Research work is not funded by any National and International bodies.

REFERENCES

1. Del Hoyo J, Elliiot A, Sargatal J. (1992). Handbook of the Birds of the World. Ostrich to Ducks.
2. Kushlan JA, Hancock J. (2005). The Herons. Oxford University Press.
3. Turner D. (2011). Checklist and status of herons in East Africa. *Journal of Heron Biology and Conservation*. 1, 1-9.
4. Doumandji SE, Doumandji-Mitiche B, HamadacheH. (1992). Places des orthopteres en milieu agricoledans le regime alimentaire du Heron grade en Grand Kabylie (Algerie). *Mededelingen van de Faculteit Land bouwweten schappen. Rijksuniversiteit Gent*. 58(2a), 365-372.
5. Telfair II, Raymond C. (2006). "Cattle Egret (*Bubulcus ibis*)". The Birds of North America online (A. Poole, Edition.) Ithaca. *Cornell lab of ornithology*. 2006; 1-13.

6. Kushlan J A, HafnerH. (2000). The Heron conservation. Academic Press. London.

7. Dinsmore JJ.(1973). Foraging success of Cattle egrets, *Bubulcus ibis*. *American Midland Naturalist.* 89, 242–246.

8. Thompson CF, Lanyon SM, Thompson KM. (1982). The influence of foraging benefits on association of cattle egrets (*Bubulcus ibis*) with cattle. *Oecologia.* 52, 167-70.

9. GM Wahungu, EN Mumia, D Manoa. (2003).The effects of flock size, habitat type and cattle herd sizes on feeding and vigilance in cattle Egrets (*Ardeola ibis*). *African Journal of Ecology*. 41, 287–288.

10. Kamler JF, TN Suinyuy, W Goulding. (2008). Cattle Egret and Common Ostrich associations in South Africa. *Ostrich*. 79, 105–106.

11. Rand AL. (1954). Social feeding behavior of birds. *Fieldiana Zoology*. 36, 1-71.

12. Siegfried WR. (1978). Habitat and the modern range expansion of the cattle egret. National Audubon Research Report 7. 315-324.

13. Burger J, M Gochfeld. (1993). Making foraging decisions: Host selection by Cattle Egrets (*Bubulcus ibis*). *OrnisScandinavica.* 229-236.

14. Kour D N, Sahi D N. (2012). Studies on the community ecology of Cattle Egret (*Bubulcus ibis*) coromandus (Boddaert) in Jammu (Jammu and Kashmir), India. *International Journal of Biodiversity & Conservation*. 4, 439-445.

15. Ogutu JO, Owen Smith N, Pieoho HP, Said MY, Kifugo SC. (2014). Herbivore dynamics and range contraction in Kajiado country Kenya: climate and land use changes, population pressures, governance, policy and human wildlife conflicts. *The Open Ecology Journal*. 7, 9-31.

16. Heatwole H. (1965). Some aspects of the association of Cattle Egrets with cattle. *Animal Behavior*. 13, 79–83.

17. Grubb TC. (1976). Adaptiveness of foraging in the cattle egret. *The Wilson Bulletin*. 88, 145-148.

18. Burger J, Gochfeld M. (1999). The foot-in-the-door compliance procedure: a multiple-process analysis and review. *SAGE Journal*.

19. Burger J, Gochfeld M. (1981). Discrimination of the threat of direct versus tangential approach to the nest by incubating herring and great black-backed gulls. *Journal of Comparative and Physiological Psychology*. 95, 674–676.

20. Seedikkoya K, Azeez PA, Shukkur EAA. (2005). Cattle Egret, *Bubulcus ibis*habitat use and association with Cattle. *Forktail*. 21,174-176.

21. Kannaujiya A, Kumar A, Kushwaha S. (2013). Diversity of waterbirds in Lucknow Districts, Uttar Pradesh, India. *International Journal of Science and Research*.862-866.

22. Grobicki A. (2016). An introduction to the Ramsar Convention on Wetlands. Ramsar hand book 7th edition. Ramsar convention Secretariat Rue Mauvernery 28 Switizerland.

23. Chaskda A A, Iniunam I A, Dami D F, Wansat MGS. (2018) Foraging success of the cattle egret bubulcus ibis in relation to insect abundance, herd and flock size. *Journal of Research in Forestry, Wildlife & Environment*. 10(1), 41-47.

24. Scott D. (1984). The feeding success of cattle egrets in flocks. *Animal Behavior*. 32, 1089-1100.

25. Aboushiba ABH, Ramli R, M S. (2015). Foraging behavior of five egret species in pome pond area at carey island, peninsular Malaysia. *The journal of Animal & Plant Science*.23 (1), 129-135.

26. Itzkowitz M, Makie D. (1986). Food Provisioning and foraging behavior of the Snowy egret, *Egrettathula .Biology of Behavior*. 11, 111-115.

27. Mikula P, Hadrava J, Albrecht T, Tryjanowski P. (2018). Large-scale assessment of commensalistic–mutualistic associations between African birds and herbivorous mammals using internet photos. *The Journal of Life and Environmental Sciences*. 1-23.

28. Anastasios, Dimalexis, Myrtopyrovetsii, Stefanos S. (1997). Foraging ecology of the Grey heron (Ardeacinerea), Great egret (Ardeaalba) and little egret (*Egrettagarzetta*) in response to habitat. *Colonial waterbirds*. 20 (2), 261-272.

29. Bauder ET. (1989). Drought stress and competition effects on the local

distribution of *Pogogyneabramsii*. *Journal of Ecology*. 70, 1083-1089.

30. Mohammedi A, Doumandji S, Ababou A, Koudj M, Rouabhi A. (2015). Impact of predation by cattle egret bubulcus ibis l. on wildlife of farmlands in chlef region, Algeria. *Lebanese Science Journal*. 17 (2), 117-129.

31. Rao VV. (2004). Egrets and their role in environment. International conference on Birds and environment, Haridwar, India. (Unpublished)

32. Sheehy DP, Vavra M. (1996). Ungulates foraging areas on seasonal range land in north eastern. Oregon. *Journal of the University of Arizona*. 49,16-23.

33. Siegfried WR. (1971). The food of the Cattle egret. *Journal of Applied Ecology*. 8(2), 447-468.

34. Siegfried WR. (1972). Aspects of the feeding ecology of cattle egrets (*Ardeola ibis*) in South Africa. *Journal Animal Ecology*. 41, 71-78.

Curiginal

Document Information

Analyzed document	Thesis of Manisha.pdf (D116661600)
Submitted	2021-10-28 13:44:00
Submitted by	O. P. Saini
Submitter email	gbl.bbau@gmail.com
Similarity	0%
Analysis address	gbl.bbau.bbau@analysis.urkund.com

Sources included in the report