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RESEARCH ARTICLE

Feeding ecology of Large Whistling Teal *Dendrocygna bicolor* (Vieillot, 1816) in Deepor Beel wetlands, Assam, India

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Abstract

The study focuses on the Large Whistling Teal's feeding ecology. The current work is significant for the study of feeding ecology since it focuses on the examination of various food sources and the feeding preferences of the large whistling teal at the only Ramsar site in Assam, the Deepor Beel wetlands. The varieties of meals were investigated using a non-destructive stomach-flushing technique. Before analysis, all samples were preserved in 5% buffered formalin. Utilizing a reference specimen, the samples were sorted and identified under the microscope. Results were displayed in terms of how frequently different meal items appeared. The examination of the Large Whistling Teal's favourite foods revealed that Euryale ferox was the bird's top choice both during the breeding season (26.3%) and non-breeding season (25%) compared to other foods. However, the Large Whistling Teal had chosen *Cynodon dactylon* least among others as food during the mating season. In the Deepor Beel Wetlands, the occurrence of various food types varied significantly. Additionally, this study demonstrated that the Large Whistling Teal employs distinct activity patterns to make use of the Deepor Beel's valuable resources.

Keywords: Deepor Beel; Breeding; Ramsar Site; Bird; Conservation; Habitat; Feeding Ecology

1. Introduction

Studies on feeding habitats are essential not only to determine the nutritional requirement of a species but also to understand how the distribution of food resources could determine local distribution, density, and social interactions among the species (Oates, 1987). Effective conservation always requires comprehensive information on habitat use and ecology of species including their diet. In the absence of this basic knowledge, the cause of decline may be incorrectly determined, which may compromise the successful management of the species (Moore, 2006). Feeding behavior and habitat use are important factors that affect bird distribution and abundance within a particular area.

Food availability plays a major role in theories of community structure and is also a major evolutionary force in avian life history (Gawlik, 2002). A look in ecology textbooks or a search in the scientific literature databases shows that food abundance is one of the first and major things ornithologists measure to understand the species under study are individual behavior, its time of reproduction, or its population dynamics (Goss-Custard, 1985; Daan et al., 1989; Newton, 1998). Food abundance is the main factor considered when ornithologists try to study patterns of individual behavior, the timing of reproduction, or the population dynamics of their study species (Peter Berthold, 2003). The timing of migration and breeding in birds is usually considered to have evolved to match variations in food availability or abundance over the year. Food always plays a major role in wetland selection by a brood-rearing female.

The choice of feeding habitat generally depends on the availability of food because the birds were not observed to feed in areas that were devoid of prey items and were flooded for a few days. Aggregation results from habitat preference for a source of food. When food becomes abundant then the birds are involved in the mutual competition for the protection of their resources. Flocking habits in birds enhance the ability of individual birds to locate scattered patches of food. Feeding in mixed species flocks of birds appears to confer a greater advantage to any bird (Harrison and Whitehouse, 2011). The abundance of food in an area attracts many birds, and as a result of this behavior, a flock of a few birds swells into a large flock.

The availability of food, cover, lack of disturbance, and disturbance from human seems to be the main reason for the species richness in a wetland. The relative abundance of bird species during seasons might be related to the availability of food, habitat conditions, and breeding season of the species. The distinct seasonality of rainfall and seasonal variation in the abundance of food resources result in seasonal changes in the species abundance of birds (Gaston et al., 2002; Roth, 1971).

Collecting food items and analyzing field diets is very difficult and time-consuming work. Numerous methods have been used over the years to evaluate the diets of bird species, including pellet dissection (Elton, 1927), flushing and forced regurgitation (Ridoux, 1994), and direct observations (Rosenberg and Cooper 1990). Recent techniques have also provided indirect methods, such as stable isotopes (Kelly, 2000) and molecular approaches, which are used to identify prey in scats in particular (Höss et al., 1992; Sutherland, 2000). Despite being laborious and time-consuming, stomach content analysis remains the most accurate way of studying the waterfowl diet since other techniques only provide a rough/qualitative overview of the diet (Hyslop, 1980). So, many works were done to study the feeding ecology of birds based on stomach content analysis.

Very few families of birds had been studied on feeding behaviour, foraging strategy, and dispersion types under natural conditions (Kahl, 1971). Clancey (1967) describes the habitat of this species in southern Africa as including fresh-water lakes, veils, marshes, and swamps, including papyrus swamps and the open portions of slowly flowing streams. Favored waters are those with rich shoreline vegetation, banks of reeds, and floating plants such as water lilies. Rice is a major food in India, but the birds there have also been reported to eat various aquatic seeds, bulbs, leaf shoots, buds, grass, and rushes.

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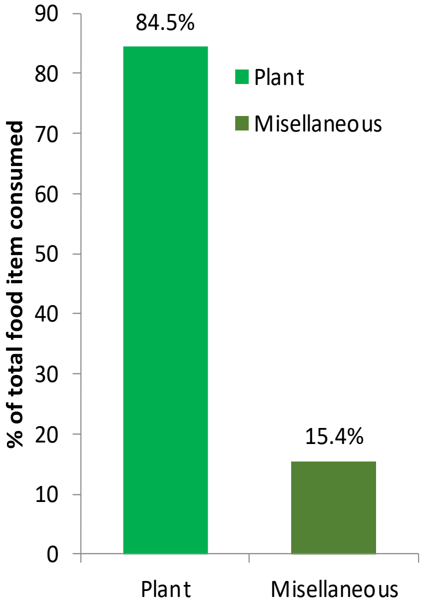

Figure 1. Percent of total food items consumed by large whistling teals in the study area.

There are few records of animal foods in the diet (Johnsgard, 2010). The skull and bill structures of this species suggest that it feeds primarily by swimming and diving, as does the wandering whistling duck, whereas the black-bellied and plumed whistling ducks are structurally adapted for grazing (Bolen, 1974). It is found mainly in larger inland waters, especially flood plains, with plentiful aquatic vegetation (Irwin, 1981). When foraging for food in deeper waters, such as ponds or small impoundments, tree ducks feed by "tipping." On occasion, they also make short dives in which their entire bodies disappear underwater. In shallow water, they poke their heads and necks beneath the surface without tipping (Meanley and Meanley, 1959).

In Deepor Beel, the population of the Large Whistling Teal is high as compared to other such wetlands in Assam (Saikia, 2005). To make use of the valuable resources of the beel, Large Whistling Teal engages in various behaviour patterns. For the species of whistling teal, the beel acts as a breeding site. Additionally, the duck favours eating mostly aquatic vegetation as a food source. Though the species is a local breeder, no special attention was previously given regarding the study of the food and feeding ecology of this particular species. Very little is known regarding the feeding ecology of Large Whistling Teal (Das et al., 2011). Therefore, the present work has importance regarding the study of feeding ecology which mainly covers the exploration of different food types as well as the feeding preference of the Large Whistling Teal in Deepor Beel wetlands, the only Ramsar Site of Assam.

2. Materials and methods

2.1. Study area

Depor Beel is a sizable floodplain wetland covering 40.14 km2 total area includes 4.14 km2 that have been designated as a bird sanctuary with significant ecological and environmental significance (Saikia and Saikia, 2010). Numerous migratory bird species, reptiles, amphibians, insects, aquatic and terrestrial plants, planktos, etc. of great ecological significance may be found in and around this prominent body of water (Bera et al., 2008). The Deepor Beel (26°03'26''-26°09'26''N and 90°36'39''-90°41'25''E) is connected to the Brahmaputra river's southern bank.

The mesothermal climate of Deepor Beel is characterised by high humidity and mild temperatures which varies from 10.6 to 30 °C. The monsoon season, which lasts from May to September, temperature lies between 32°C and 27.3°C. The temperature during the pre-monsoon season (March to May) are stays between 27°C and 24°C, with a relative humidity range of 50.7% to 76.8% (Saikia and Saikia, 2010). During the retreating monsoon (September–October) temperature remains between 27°C to 25°Cwith 82.5% relative humidity (Saikia and Saikia, 2010). During winter season (November to January) time, the relative humidity is roughly 77.5%, and the average field temperature is 20.2 °C. The average low temperature in January, the coldest month, is 7°C, however it can occasionally drop to 6°C. (Bera et al., 2008; Das et al., 2011).

A non-destructive stomach flushing method as recommended by Rosenberg and Cooper (1990) was used to study food types. A plastic tube of 4 mm outside diameter was used which was attached to a 12 cc syringe filled with a sterile 0.9% solution of sodium chloride. The tube was carefully passed through the esophagus into the stomach. Once the tube entered the stomach the bird was then inverted over a plastic cup so that, as fluid was forced into its stomach, the excess fluid plus the stomach contents flowed into the cup. The process was completed in less than two minutes. All samples were stored using 5% buffered formalin until analyzed. The stomach contents were examined under a dissecting microscope. The samples were separated and identified under the microscope with the help of a reference specimen. Results were presented as the frequency of occurrence of food items (Swanson et al., 1974). After conducting the flushing techniques, the teals were again released.

2.2. Data Analysis

The analysis of the feeding ecology of Large Whistling Teal mainly includes the calculation of relative feeding frequency, the proportion of preferred food items both in the breeding and non-breeding season, and the relative frequency of preferred food items in both the breeding and non-breeding season.

(a) The relative feeding frequency was calculated with the help of the following formula:

$$\frac{\textit{Total number of single food items (A1) recorded}}{\textit{Subtotal of all food item (A1+A2+.......... +An) recorded}} \times 100$$

(b) The proportion of preferred food item recorded both in breeding and non-breeding season was calculated with the following formula:

Proportion of single food item (A1):

$$\frac{\textit{Total number of single food item (A1) preferred}}{\textit{Subtotal of all food items (A1+ A2+...........An) preferred}}$$

(c) Likewise, the relative frequency of preferred food items recorded both in the breeding and the non-breeding season was calculated with the help of the following formula:

$$\frac{\textit{Relative frequency of single food (A1) preferred}}{\textit{Subtotal of all food (A1+ A2+...........An) preferred}} \times 100$$

The difference in percent occurrence of food items in the esophagus of Large Whistling Teal was analyzed by paired sample t-test in SPSS software. Likewise, the difference in food items preferred both in breeding and the non-breeding season was also analyzed using paired sample t-test in SPSS software. The significance level was set at a 5% level.

Table 1. Food items of large whistling teal recorded in the study area (based on stomach (flushing) content analysis.

Types of food plant species	Family	%	Remarks
Euryale ferox	Nymphaeaceae	25.7	Partly digested (seeds, shoots, leaves)
Trapa bispinosa	Trapaceae	16.4	Partly digested (seeds, shoots)
Nymphaea alba	Nymphaeaceae	14.4	Partly digested (seeds, shoots, leaves)
Cynodon dactylon	Poaceae	5.1	Partly digested (leaves)
Cyperus rotundus	Cyperaceae	9.2	Partly digested (seeds, leaves)
Oryza sativa	Poaceae	13.4	Partly digested (seeds)
Unidentified (Miscellaneous matter)		15.4	Not able to identify

3. Results

3.1. Food use type

Stomach flushing of Large Whistling Teal had shown that the bird consumed 84.5% aquatic plants and 15.4% unidentified miscellaneous matters (Figure 1). Amongst all the aquatic plants the recognized were *Euryale ferox, Trapa bispinosa, Nymphaea alba, Cynodon dactylon, Cyperus rotundus* and *Oryza sativa* (Table 1). The consumed food those very hard to identify was either crushed or digested. Plant foods eaten by Whistling Ducks consisted of seeds, leaves, and shoots. The feeding birds dive completely and often remain underwater for up to 15 seconds.

3.2. Food items of large whistling teal

The study revealed that the percent of occurrence of Euryale ferox was higher as compared to the other food type analysed through the stomach flushing technique (Figure 2). Highest of 25.5% *Euryale ferox* was consumed by large whistling teal followed by *Trapa bispinosa* 16.4%, miscellaneous food item 15.4%, *Nymphaea alba* 14.4%, *Oryza sativa* 13.4%, *Cyperus rotundus* 9.2% and *Cynodon dactylon* 5.1%. The variation of occurrence of different food types was found to be significant in the case of *Euryale ferox* vs *Trapa bispinosa, Nymphaea alba* vs *Cynodon dactylon*, and *Euryale ferox* vs miscellaneous matter at 5% level (*Euryale ferox* vs *Trapa bispinosa*: t=3.04, p=0.005; *Nymphaea alba* vs *Cynodon dactylon*: t=2.29, p=0.02; *Euryale ferox* vs miscellaneous matter: t=2.34, p=0.02, p<0.05, df=31, n=32, range= 1-33.5, Paired sample t-test, two tail) in which the most consumed food item was *Euryale ferox* and *Nymphaea alba*. There was no significant difference in food items consumed amongst *Trapa bispinosa* vs *Nymphaea alba*, *Cynodon dactylon* vs *Cyperus rotundus*, *Cyperus rotundus* vs *Oryza sativa*, and *Oryza sativa* vs miscellaneous matter at 5% level (*Trapa bispinosa* vs *Nymphaea alba*: t=-.001, p=0.99; *Cynodon dactylon* vs *Cyperus rotundus*: t=-1.52, p=0.30; *Cyperus rotundus* vs *Oryza sativa*: t=-1.07, p=0.29; *Oryza sativa* vs miscellaneous matter: t=0.11, p=0.91, df=31, n=32, range=1-33.5, Paired sample t-test; two tail), in which those food item consumed were almost similar types.

3.3. Preferred food items between breeding vs non-breeding season

While analysing the proportion of food preferred between breeding and non-breeding season, the Large Whistling Teal preferred mostly Euryale ferox during the breeding and non-breeding season than other food items (Figure 3). In the breeding season the proportion of preferred food items was *Euryale ferox* (0.26) and in the non-breeding season that proportion was 0.25. In the breeding season, the bird preferred *Cynodon dactylon* (0.01) and in the non-breeding season, the bird preferred *Cyperus rotundus* (0.07). The difference in food preference between breeding vs non-breeding seasons was not significant at 5% level (*Euryale ferox* vs *Trapa bispinosa*: t=3.33, p=0.18; *Trapa bispinosa* vs *Nymphaea alba*: t=1.0, p=0.50; *Nymphaea alba* vs *Cynodon dactylon*: t=1.33, p=0.41; *Cynodon dactylon* vs *Cyperus rotundus*: t=-.56, p=0.67; *Cyperus rotundus* vs *Oryza sativa*: t=-1.72, p=0.33; *Euryale ferox* vs miscellaneous matter: t=5.0, p=0.12, df= 1, n= 2, range= 0.1-0.26, Paired sample t-test, two tail).

3.4. Relative frequency of food preference in breeding vs non-breeding season

The analysis of the relative frequency of preferred food of the Large Whistling Teal had shown that during breeding (26.3%) and non-breeding season (25%) the bird's preference for *Euryale ferox* was highest as compared to the other food items (Figure 4). However, during the breeding season, the Large Whistling Teal had preferred *Cynodon dactylon* least amongst as food. Likewise, during the non-breeding season, *Cyperus rotundus* was least preferred as food. The difference in the relative frequency of preferred food was not significant in breeding vs non-breeding season at 5% level (*Eyryale ferox* versus *Trapa bispinosa*: t=3.63, p=0.17; *Trapa bispinosa* vs *Nymphaea alba*: t=1.0, p=0.50; *Nymphaea alba* vs *Cynodon dactylon*: t=1.43, p=0.38; *Cynodon dactylon* vs *Cyperus rotundus*: t=-.55, p=0.67; *Cyperus rotundus* vs *Oryza sativa*: t=-1.5, p=0.35; *Euryale ferox* vs miscellaneous matter: t=4.14, p=0.15;df=1, n=2, range=0.1-0.26, Paired sample t-test, two tail).

4. Discussion

Previous study (Das et al., 2011) reported that the most remarkable activities of Large Whistling Teal during the study period were

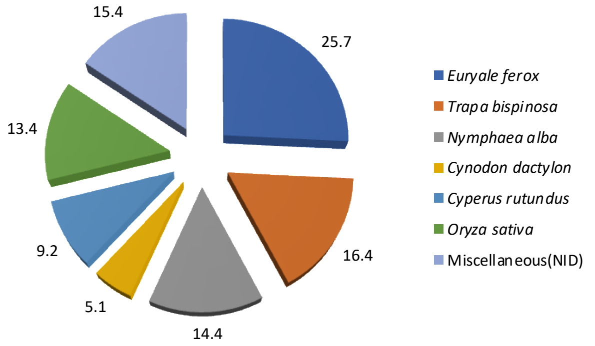

Figure 2. Percent of occurrences of consumed food items by Large Whistling Teals in the study area.

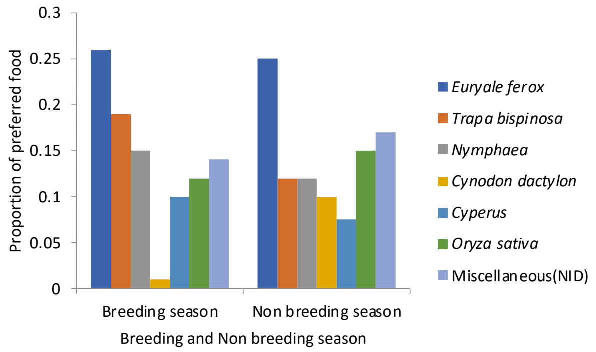

Figure 3. The proportion of preferred food between breeding vs non-breeding season.

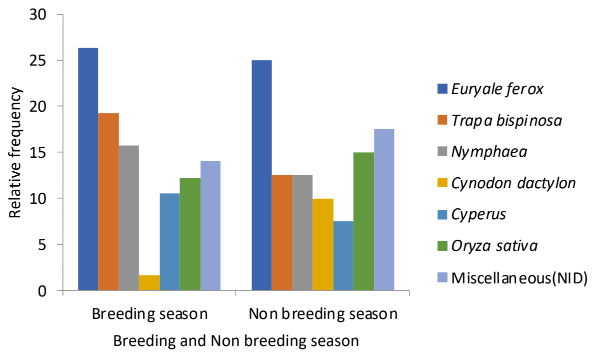

Figure 4. Relative frequency of preferred food items between breeding vs non-breeding season.

resting (36.1 %), locomotion (37.1%) followed by feeding (21.8%). In the case of feeding activity, they found the Large Whistling Teal took the highest amount of time (45.4%) in the period of May and the lowest (0.52%) in January. The Teal generally used feeding techniques such as head dipping, searching, and up-ending. Results of diet analyses reflect the importance of food plant species of Large Whistling Teal in Deepor Beel. Wersal et al (2005) reported that plant material comprised 99.4% of the total aggregate percent of food items collected while working on the food habits of Dabbling ducks during fall migration in a Prairie Pothole system. The studies conducted earlier reported that Large Whistling Teals preferred rice over other foods (Meanley and Meanley, 1959; Bruzual, 1983), whereas according to this study, Large Whistling Teal feed comprises only 13.4% of rice (Oryza sativa). Thus, the results indicate the vegetarian nature of the Large Whistling Teal. Fulvous whistling ducks feed nocturnally and are almost totally granivorous as adult birds obtain the seeds of various grasses, sedges, and other emergent vegetation by dabbling and diving (Landers and Johnson, 1976; Hohman and Lee, 2001). The types of seeds ingested vary depending on availability and whether the habitat selected is natural or agricultural (Hohman and Lee, 2001). Upadhaya and Saikia (2011) also documented the presence of 72.55% vegetable matter while working on Cotton Pygmy- goose. Again, Botero and Rusch (1994) revealed the existence of 92% plant and 8% animal material while working on Blue-winged teal in Palo Verde, among which cultivated rice was predominated. Differences between these diets and our findings may be due to food availability and selectivity (Jorge and Botero, 1994).

Both the breeding and non-breeding Large Whistling Teals prefer *Euryale ferox* as the primary food item. The teals were seen to take seeds as well as shoots of *Euryale ferox*, mostly while searching for food. During the breeding season, the *Euryale ferox* might be offering essential energy for the successful nesting and breeding of the large whistling teals. Likewise, during the non-breeding period also the *Euryale ferox* might be providing energy for active foraging. So, further investigation is strongly recommended in this aspect.

5. Conclusion

This study revealed that the Large Whistling Teal's feeding activity pattern varied depending on breeding and non-breeding session. The variation of occurrence of different food types was found to be significant in the Deepor Beel Wetlands. This study also showed that the Large Whistling Teal performs different activity patterns to utilize the valuable resources in the Deepor Beel. Effective conservation always requires knowledge of ecology and habitat use of species including diet. Without this basic information, the cause of the decline of a particular species may be incorrectly diagnosed, which may compromise the successful management of the species. One of the major threats to the Large Whistling Teal is habitat degradation and habitat loss. Wetlands are the primary habitat for these species, which are being affected by various anthropogenic activities such as urbanization and agricultural activities etc; these activities have led to a decline in the number of wetlands, which directly affects the species number. Conservation strategies for the Large Whistling Teal include protecting wetlands and other habitats where they live, implementing legal protection, such as designating wetlands as protected areas and implementing laws against hunting and poaching of this species. Moreover, establishment of captive breeding programs may also help to increase the population of Large Whistling Teals. Captive breeding program involve breeding ducks in captivity and releasing them into the wild to help boost their numbers. Another important conservation strategy is to educate people about the importance of wetlands and the wildlife that lives there. This can help to raise awareness about the need to protect these habitats and the animals that depend on them. In addition, feeding behavior and habitat use are important factors that affect bird distribution and abundance within wetlands. Therefore, it is imperative to make continuous investigations, censuses, and research activities on the feeding ecology so that future researchers can utilize knowledge regarding this as baseline data for further research and conservation planning.

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Authors' contributions
This work was carried out in collaboration among all authors. All the authors contributed to the design of the study. Author Jyotismita Das has done the laboratory work, and authors Jyotismita Das, Shatabdi Biswas, and Abhijit Chandra Roy wrote the first draft of the manuscript. Authors Shatabdi Biswas and Abhijit Chandra Roy analyzed the data, and author Jyotismita Das contributed to the management and execution of the study and supervised the whole work. Author Prasanta Kumar Saikia contributed to the management and execution of the study and supervised the whole work. All authors read and approved the final manuscript.

Conflict of interests
All authors agree to the publication of this paper, and they do not have any conflict of interest with any party or commercial identity. They have no involvement that might raise questions of bias in this reported work or its conclusions, implications, or opinions.

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