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FOOD CONTENTS ANALYSIS OF WATERFOWL PASSING THROUGH INDUS THE RIVER AT TAUNSA, SOUTH PUNJAB, PAKISTAN

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ABSTRACT

A study was carried out to assess the food composition of migratory waterfowl in Bet Makwal Kalan, near the Head Taunsa Barrage, along the River Indus passage. Migratory water birds are thought to be important components in dispersal of total living entity especially seeds due to their proclivity for extensive relocations. They might be found in large numbers in the muddy sections. Migratory water birds are important components of total plant dispersal due to their proclivity for making extensive migrations. A sum of 459 gizzard samples was collected, during their Fall migration, relating to 10 Waterfowl species i.e. Northern Pintail (n=56), Eurasian Wigeon (n=17), Garganay (n=07), Mallard (n=02), Northern Shoveler (n=22), Common Teal (n=129), Gadwall (n=158), Tufted Duck (n=04), Common Pochard (n=29) and Ferruginous Duck (n=34). During their winter migration, the Waterfowl species picked plants over animals as their primary source of sustenance when travelling through Taunsa. Food research revealed that all 10 species of birds consumed large amounts of seeds. Out of ten duck species, two plant species (*Naias marina* and *Potamogeton pusillus*) consistently ranked among the top seeds ingested by six of the duck species (Eurasian Wigeon, Garganey, Mallard, Gadwall, Tufted Duck, and Common Pochard). Whereas the Northern Pintail, Northern Shoveler, Common Teal, and Ferruginous Duck have been found to consume large amounts of seeds from *Potamogeton pectinatus* and *Poligonum spp*. It was determined that molluscans and crustaceans residues were found to be well-represented in the gizzard samples of ducks. The recent study also highlighted that various vegetations play vital role in wetland ecosystems as a basic wild food provider. A larger population of migrating Waterfowl yield better findings for this study, which is currently being undertaken.

Keywords: Waterfowl, Food Contents, Food analysis, Plant Species, Seeds.

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1. INTRODUCTION

Dietary studies of waterfowl are an essential to comprehend their environmental adaptations. Also, it includes details on the nutritional makeup of food and species overlaps for ducks (Huntley and Scarponi 2021). Depending on the goals of each study, different techniques must be utilized to collect data from diet studies. Intensity of diet studies, concentration, duration, and analysis are determined by the questions being answered, not by some hypothetical "perfect" approach for studying diets (Fox et al. 2017). Water birds that migrate vast distances are thought to be important contributors to the global distribution of living species. They can be seen in great numbers in the marshy regions. They are both appealing and bright because of these factors. Waterfowl are essential components that highlights the ecology and diversity of these wetlands. They are also seen as being very significant for a variety of participating agents, including aboriginal people, hunters (both for fun and for food), scientific explorers, tourists, and possibly financial investors. They may have a significant impact on the pelf in the areas where the skin is delicate (Dundas et al. 2021). Also, the protection of migratory Waterfowl might provide income for local residents only if an effective strategy is established for this biota and their habitat that is also cost-effective. Yet, among the various species that live in these wetlands, waterfowl are the major bright avian species. In addition to this, it is also listed as one of the supporting groups when wetlands are marked as being crucial to the ecosystem. Increasing waterfowl populations in a particular marshy zone are described as having great ecological values by the literature (Baschuk et al. 2012).

Bird counts might be used as an acceptable technique for the preservation of these spheres (Dundas et al. 2021). The divergence of these wetlands might be assessed if their populations were taken for granted. An articulation could be withdrawn from the research that "population level data show special promise as watchman bio-indicators". The continuity of this process pretends to have strong impact over determination of Wetlands of International Importance (Ramsar sites). They are believed to be the sites under designation by the East Asian–Australasian Flyway Site

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Network and the Important Bird Areas programmed and secured zones. Waterfowl could be enumerated on the first instance, as most of the species could be observed at the same cites in the following spans of a year. Whereas none of the bird groups perceived so far and fast. According to the world largest organization of data collection, International Waterbird Census (IWC), a gain in this long-lasting probation could be detected in Asia (from the AWC). This data is then regarded as a bottom line for predicting population and trends, if compared with other counterparts of globe. The information provided by IWC is widespread gaining scientific attention, collected by a well correlating exercise and considered as a pliable source at the local, national and international levels (Li et al. 2009; Giatas et al. 2022).

Anticipation of Pakistan in the AWC was observed in 1987. Till four years from 1987 and since 2006, and exercise seems to be executed by National Council for the Conservation of Wildlife. A number of institutes worked together at the smaller and the larger scales included the Zoological Survey Department (1987-2001), Sind Wildlife Management Board (1988-2004) and Punjab Wildlife Department (1989-2004) (Li et al. 2009). The most available species with a population of slightly more than 50 thousand were perceived including Common Teal, Common Pochard, Northern Pintail, Northern Shoveler, Eurasian Wigeon and Gadwall, with an array of losing strength (Giatas et al. 2022).

The avifauna of southern Asia especially Pakistan is one of the abundant in the world. Yet, it remains insufficiently studied using modern methods. There is imperative need for a better understanding food contents and food methodology of birds Asia especially birds of Pakistan because there is rare and insufficient data present about food of birds. If we go to migratory waterfowl, then there is almost little data present about their food in Pakistan. There are 26 migratory duck species reported in Pakistan (Grimmett et al. 2008). Therefore, this exploration was aimed to ascertain the importance of local habitats by analyzing the food resources available to migrating waterfowl, with particular reference to *Anatinae* and to analyses the priority food intake in migrating duck species at Indus near Taunsa at South Punjab of Pakistan.

2. MATERIALS AND METHODS

2.1. Study area

Taunsa barrage (30°N, 70°E) is located 20 km in Northwest of Kot Addu, Muzaffargarh District, Punjab Province since 1958 on River Indus spreading over area of 16890 acres as a reservoir at 139 m high from the sea level in Thar Desert. It was regarded as a wildlife sanctuary (16890) in 1972. International importance in 1996 included Taunsa Barrage among such marshy areas according to Ramsar Convention (Daryadel and Talaei 2014). The study site, Bet Makwal Kalan (30°N, 70°E), was located at the western bank of Indus River near Taunsa Barrage (Fig.1). For providing water to the cultivated lands, a small outlet was originated from Indus River in vicinity of Taunsa. Five sub-branches open into the water storage and keep level of ponds at the same level when the main river surfaces lower down. Zones that bear low water potential are allocated to indigenous cultivars. Although, the water may stand 5.0-11.5m from the river surface, with a pH value almost near to the neutral water (Pakistan Meteorological Department, unpublished, data).

2.2. Climatic conditions

It is a dry subtropical climate with annual average rainfall of 200-450mm and a relative humidity ranging from 25-85%. In Southern Punjab: a hot and dry Summer (April to June), a hot and wet Monsoon (July to September) and a cool dry Winter (October to March), three seasons could be observed, in which temperature fluctuates from 5.6°C in the early year rising, to a peak value of 42.3°C in midyear (Pakistan Meteorological Department, unpublished, data).

2.3. Major Vegetation

Some species like *Carex fedia, Hydrilla verticella, Nelumbium speciosum, Nymphaea loctus, phragmites karka, Potamogeton crispus, P. pectinatus, Ranunculus aquatilus, Saccharum spontaneum, Typha angustata, Vallisneria spiralis* and *Zannichellia palustris* are the water living plants which could be found deep in the ponds. A large proportion of region which is situated near the water body, used for growing of agricultural crops like cotton, sugar cane, wheat and fodder crops. Riverine forest nearby the Indus might be more visible along with *Dilbergia sissoo* and *Poplus euphratica* in association with *Tamarix dioca*. Other natural vegetation includes *Acacia nilotica, Prosopis cineraria, Pisum arvense, Salsola barysoma, Cynodon dactylon, Eluesine compressa* and *Panicum antidotale*.

2.4. Methodology

The waterfowl food was inferred from the contents of their gizzards. In total of 460 waterfowl's gizzard samples were procured from 11 waterfowl species collected from September 2012 to December 2012. The area of collection was Bet Makwal Kalan near Taunsa Barrage along the passage of Indus River. All the procured samples were

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provided by the courtesy of local hunters. The contents of each of gizzard sample were separated and stored in zipper bags.

Thereafter, these samples were allowed to desiccate at 60°C for 24 h and their measured mass taken as dried material. From the dried material, the identifiable products were analyzed e.g., seeds and crushed crustaceans and molluscs shells. The identification of food contents was done with the help of previously published research. And a web-based atlas also proved helpful while defining anonymous seed species (Legagneux et al. 2007).

By taking the availability and dried biomass into consideration, the role of individual seed specie, in correspondence to one another, in the waterfowl meal was evaluated. The comparative mean of dehydrated samples was found out by dividing the dry weight of each seed species in the same gizzard by the total dry biomass of all seeds in the identical gizzard, followed by average of over all individuals in case of single species. Specific dry weights were taken according to the protocol given by Arzel et al. (2007), although, for some species the desiccation of a sample of seeds with a familiar quantity was performed at 60°C for one day and taken as dried samples weight. For each species, the Index of Relative Importance (Hart et al. 2002) of individual specie was determined. This index accounts for the frequency of occurrence, relative weight and relative abundance (in terms of number), following the formula: IRI = Occurrence (%) × (Average dry weight (%) + Average number of seeds (%)). As IRI is worldwide human made analysis so, it can define all three self-regulating attributes of an entity regarding its availability of particular bird species. It seems to be evaluating each species' status in accordance with accessibility of each bird species intake (Hart et al. 2002).

The physical observation of upper ground portions of plants was taken into consideration. The edible part of plants in accordance with their usage and availability was defined as their role in the gizzards. Then Relative Abundance was computed, the frequency of its occurrence rank to the commutative values of all in each gizzard which having vegetative parts. The mean value was taken including all gizzards of a given bird species. The same procedure was followed for all other animal parts and stones.

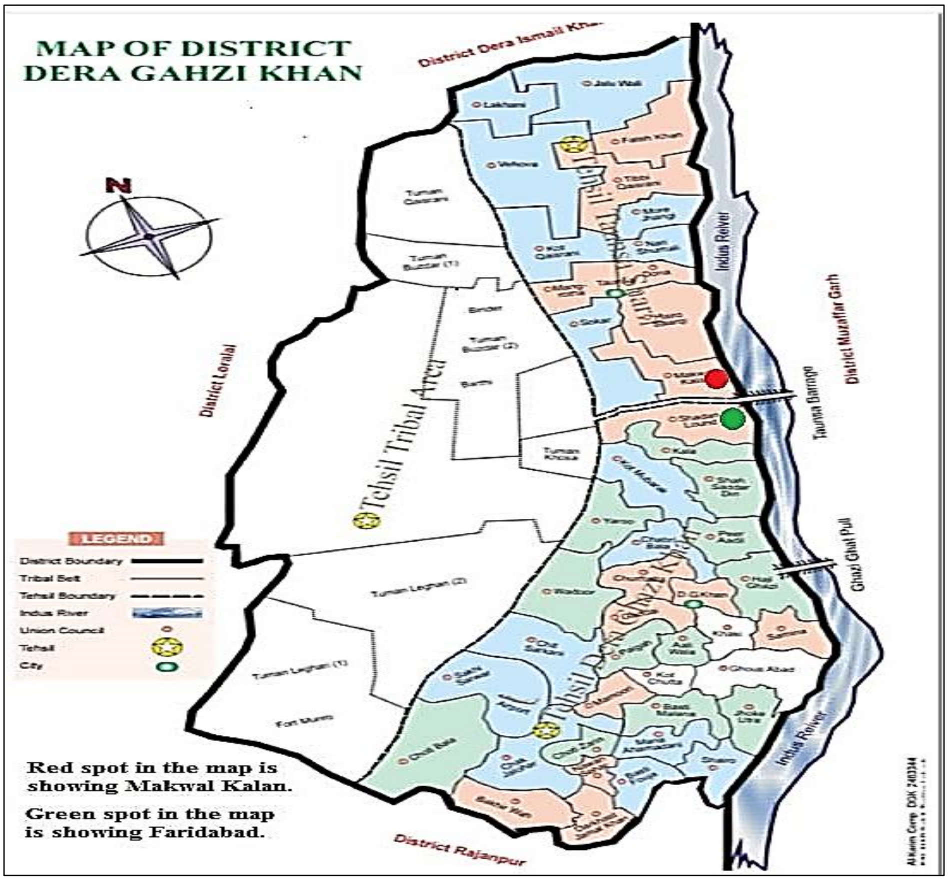

Fig. 1: Research zone layout of showing Makwal Kalan and Faridabad near Taunsa Barrage.

3. RESULTS

A sum of 460 gizzard samples was collected, related to 10 waterfowl species. Out of which, 22 were found empty and excluded from the analysis. The material in gizzards included seeds, vegetative parts of plant material, crushed

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mollusks, crustacean shells, and stones. The dry mass of each food contents was calculated in terms of relative abundance. The index accounted for the frequency of occurrence, relative weight, and relative abundance in terms of numbers, following the formula: IRI = Occurrence (%) × (average dry weight (%) + average number of seeds (%)). IRI, therefore, is a global and synthetic assessment, summarizing three independent descriptors of an item's presence and abundance within given bird species. IRI is limited to seeds only. It was not found suitable for mollusks, crustaceans and vegetations because mollusks, crustacean and vegetative parts could not be counted in proper manner thus could not be expressed in terms of IRI.

3.1. Northern Pintail (*Anus acuta*)

A sum of fifty-six gizzard samples was collected. Out of the total contents studied, the seeds were 90% (n=50). The variety of seeds in Pintail's diet was *Potamogeton pectinatus*, *Najas guadalupensis*, *Nupher variegatum*, *Poligonum amphibium*, *Holeochloa schoenoides*, *Cyperus spp.* and *Echinochloa crusgalli*. Five birds (8.90%) also ingested vegetative parts of plants, but in limited quantities. The seeds were more in numbers with higher dry weight, showed high values of IRI (Index of Relative Importance) e.g. *Potamogeton pectinatus*. Eight birds (14.30 %) contained molluscs and crustaceans prey in their gizzards, which were less in number and not diverse (Fig. 2; Table 1).

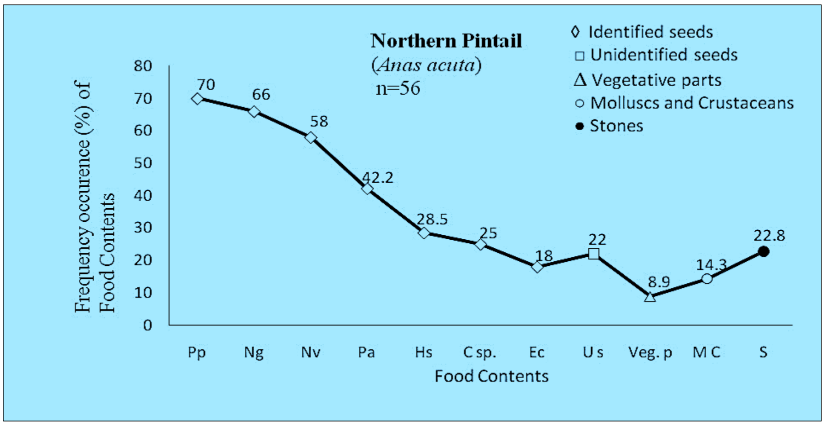

Fig. 2: The frequency occurrence (%) of different food items. Food material is abbreviated (e.g. "Pp" for *Potamogeton pectinatus*, "Ng" for *Najas guadalupensis*, "Nv" for *Nupher variegatum*, "Pa" for *Poligonum amphibium*, "Hs" for *Holeochloa schoenoides*, "C. sp" for *Cyperus sp*, "Ec" for *Echinochloa crusgalli*, "Us" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 1: Frequency occurrence (%), relative abundance and IRI of food contents in Northern Pintail's (*Anas acuta*) diet

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1	Seeds belonging to				
	Potamogeton pectinatus	70.0 (35)	0.2178±0.1536	0.02590	0.218
	Najas guadalupensis	66.0 (33)	0.1714±0.0997	0.01687	0.166
	Nupher variegatum	58.0 (29)	0.1957±0.1870	0.03535	0.134
	Poligonum amphibium	42.2 (21)	0.1741±0.1218	0.02794	0.678
	Holeochloa schoenoides	28.5 (16)	0.1129±0.0674	0.01742	0.0392
	Cyperus spp.	25.0 (14)	0.0944±0.0405	0.01082	0.0227
	Echinochloa crusgalli	18.0 (09)	0.5580±0.0511	0.01704	0.0090
	Unidentified seed species **(05)**	22.0 (11)			
2	Vegetative parts	08.90 (05)	0.0951±0.0405	0.01816	
3	Molluscs and Crustaceans	14.30 (08)	0.1951±0.1860	0.06596	
4	Stones	22.80 (11)	0.4550±1.2560	0.37706	0.0273

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.2. Eurasian Wigeon (*Anas penelope*)

A sum of seventeen gizzard samples were examined, with no one empty. Again, seeds were in abundance (n=17). Seeds of *Potamogeton pusillus* were abundant followed by *Eleocharis palustris, Potamogeton pectonatus, Poligonum lapathifolium, Potamogeton nataus* which were less frequent and less abundant than *P. pusillus*. Five species of seeds with 41.17% frequency were unidentified. Seeds of *Potamogeton pusillus* showed high IRI, having greater relative abundance than any other seed species. No vegetative parts of any plant were found in any of sample, but molluscs and crustaceans were recorded in three samples (Fig. 3; Table 2).

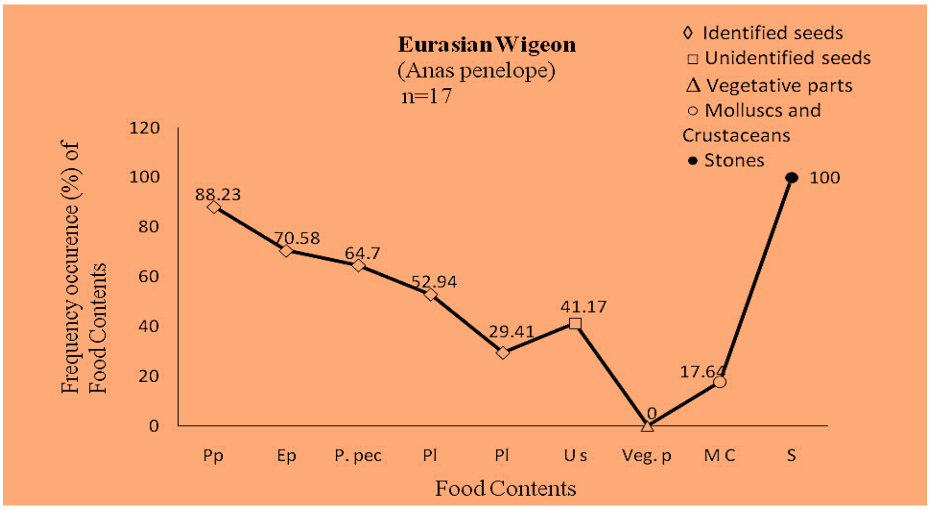

Fig. 3: The frequency occurrence (%) of various food contents. Food species are abbreviated ("Pp" for *Potamogeton pusillus*, "Ep" for *Eleocharis palustris*, "P.pect" for *Potamogeton pectonatus*, "Pl" for *Poligonum lapathifolium*, "Pn" for *Potamogeton nataus*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 2: Percent frequency of occurrence, relative abundance and IRI for food contents of Eurasian Wigeon's (*Anas penelope*) diet

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Potamogeton pusillus	88.23(15)	0.144±0.1534	0.039	0.229
	Eleocharis palustris	70.58(12)	0.092±0.504	0.145	0.159
	Potamogeton pectonatus	64.70(11)	0.0427±0.019	0.005	0.121
	Poligonum lapathifolium	52.94(09)	0.067±0.033	0.011	0.0601
	Potamogeton nataus	29.41(05)	0.040±0.036	0.016	0.0291
	Unidentified seed species **(05)**	41.17(07)			
2.	Vegetative parts	00.00	0.0000±0.0000	0.00000	0.00000
3.	Molluscs and Crustaceans	17.64(03)	0.0781±0.1260	0.07275	0.0244
4.	Stones	100.0(17)	0.7610±0.9720	0.23575	0.255

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.3. Garganey (*Anas querquedula*)

A total of seven individuals were collected with filled gizzards. All contained seeds related to ten plant species (n=07). *Potamogeton pusillus, Eleocharis palustris, Naias marina, Nupher variegatum, Ruppia maritime* and *Eleocharis parvula* formed the diversed bulk of seeds. *P. pusillus* and *E. palustris* were equally abundant and frequent. Four seed species of two samples were unidentified. Like Wigeon, Garganey (*Anas querquedula*) showed higher IRI values for *Potamogeton pusillus*. No molluscs, crustacean and vegetative parts were present. Stones and sand were frequently and abundantly distributed in whole samples (Fig. 4; Table 3).

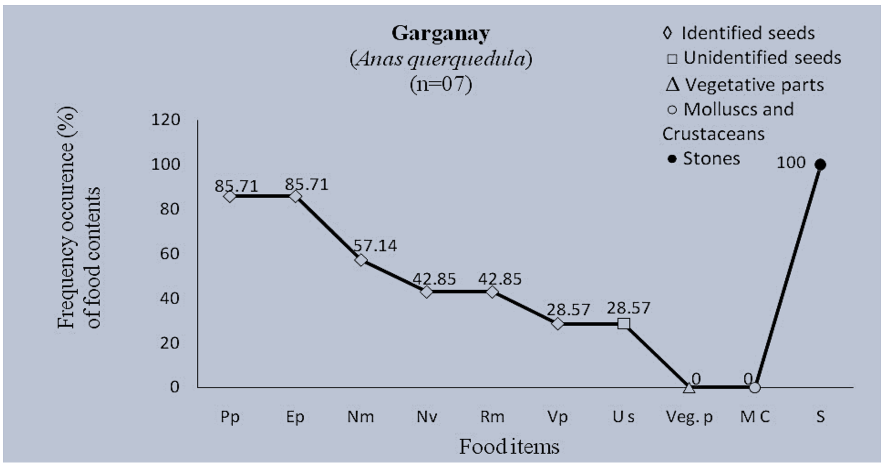

Fig. 4: The frequency occurrence (%) of different food items. Food material is abbreviated (e.g. "Pp for *Potamogeton pusillus*, "Ep" for *Eleocharis palustris*, "Nm" for *Naias marina*, "Nv" for *Nupher variegatum*, "Rm" for *Ruppia maritime*, "E.par" for *Eleocharis parvula*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

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Table 3: Frequency of occurrence (%), relative abundance and IRI of food items of Garganey's (*Anas querquedula*) diet

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Potamogeton pusillus	85.71(06)	0.0563±0.03110	0.01269	0.263
	Eleocharis palustris	85.71(06)	0.0491±0.01726	0.00704	0.229
	Naias marina	57.14(04)	0.0330±0.02170	0.01085	0.125
	Nupher variegatum	42.85(03)	0.0390±0.01386	0.00693	0.078
	Ruppia maritime	42.85(03)	0.01133±0.0162	0.00936	0.100
	Eleocharis parvula	28.57(02)	0.0270±0.03110	0.02199	0.0645
	Unidentified seed species **(04)**	28.57(02)			
2.	Vegetative parts	00.00	0.0000±0.00000	0.00000	0.00000
3.	Molluscs and Crustaceans	00.00	0.0000±0.00000	0.00000	0.00000
4.	Stones or Sand	100.0(07)	0.0572±0.03210	0.01214	0.266

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.4. Mallard (*Anas platyrhyncos*)

A small number of Mallard samples was obtained because of their non-migratory season during the sampling period i.e. n=02. Eight plant seed species were identified from the gizzards, with two unidentified one. Bulk of seeds contained *Potamogeton pusillus, Poligonum spp., Myriophyllum spicatum, Potamogeton pectinatus, Eleocharis palustris* and *Spyragnum emersum*. Seeds of *Potamogeton pusillus* and *Poligonum spp.* were mainly abundant. Here, *Potamogeton pusillus* also occupied the peak for IRI. There were no vegetative parts in both gizzards. Only a sample contained crushed molluscs and crustacean fragments (Fig. 5: Table 4).

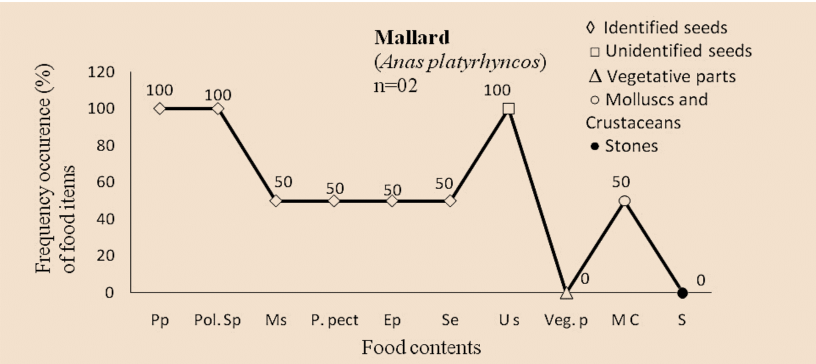

Fig. 5: The frequency occurrence (%) of different food contents. Food material is abbreviated (e.g. "Pp" for *Potamogeton pusillus*, "Pol. sp." for *Poligonum species*, "M s" for *Myriophyllum spicatum*, "P.pect" for *Potamogeton pectinatus*, "Ep" for *Eleocharis palustris*, "Se" for *Spyragnum emersum*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 4: Frequency occurrence (%), relative abundance and IRI of food items of Mallard's (*Anas platyrhynchos*) diet.

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Potamogeton pusillus	100.0(02)	0.0915±0.0969	0.06852	0.1500
	Poligonum spp.	100.0(02)	0.0600±0.0382	0.02702	0.1306
	Myriophyllum spicatum	50.00(01)	0.412±0.214	0.0167	0.0553
	Potamogeton pectinatus	50.00(01)	0.387±0.203	0.0145	0.4520
	Eleocharis palustris	50.00(01)	0.321±0.174	0.0124	0.0352
	Spyragnium emersum	50.00(01)	0.315±0.134	0.112	0.0252
	Unidentified seed species **(02)**	100.0(02)	0.0891±0.0876	0.0577	0.1300
2.	Vegetative parts	00.00(00)	0.00	0.00	0.00
3.	Molluscs and Crustaceans	50.00(01)	0.421±0.234	0.0178	0.0244
4.	Stones or Sand	00.00(00)	0.00	0.00	00.00

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.5. Northern Shoveler (*Anas clyeata*)

A sum of twenty-two gizzard samples was collected with no one empty. Six species of seeds were identified from sixteen gizzard samples with three unidentified seed species. *Poligonum lapathifolium*, *Potamogeton pusillus, Scirpus maritimus, Eleocharis palustris, Bidens spp.* and *Naias marina* were major contents in diet. *Poligonum lapathifolium* showed higher values of IRI, having greater relative abundance. Only two individuals had vegetative parts in their diet. Crushed molluscs and crustacean shells were recorded in eight samples, but in less quantity. However, stones were studied in whole twenty-two samples with their abundance (Fig. 6: Table 5).

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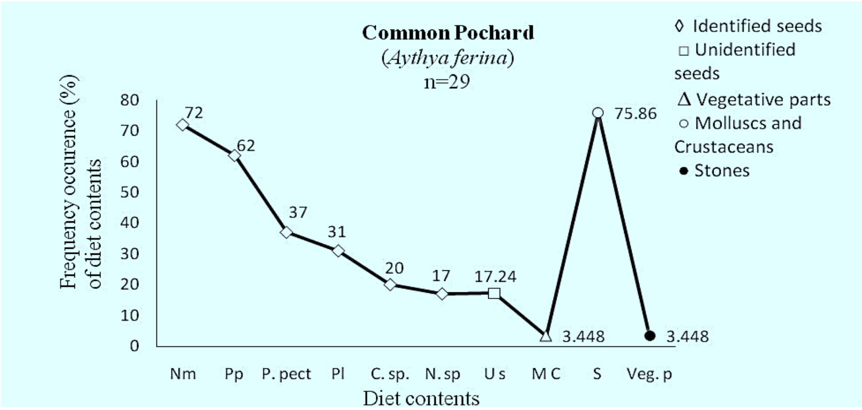

Fig. 6: The frequency occurrence (%) of various diet contents. Diet contents are abbreviated (e.g. "Nm" for *Naias marina*, "Pp" for *Potamogeton pusillus*, "P.pect" for *Potamogeton pectinatus*, "Pp" for *Potamogeton lucens*, "C.sp" for *Chara species*, "N.sp" for *Nitella species*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 5: Frequency of occurrence (%), relative abundance and IRI for food contents of Northern Shoveler's (*Anas clyeata*) diet.

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Poligonum lapthifolium	81.25(13)	0.1872±0.1929	0.05351	0.133
	Potamogeton pusillus	68.75(11)	0.1374±0.0899	0.02711	0.0757
	Scirpus maritimus	56.25(09)	0.0618±0.0458	0.01527	0.0507
	Eleocharis palustris	37.50(07)	0.0978±0.1183	0.04464	0.0336
	Bidens spp.	18.75(03)	0.083±0.01760	0.01017	0.0127
	Naias marina	06.25(01)	0.0800±0.00283	0.00283	0.00311
	Unidentified seed Species (03)	18.75(03)			
2.	Vegetative parts	09.090(02)	0.0672±0.0175	0.01237	0.00542
3.	Molluscs and Crustaceans	36.36(08)	0.0962±0.1174	0.04152	0.0336
4.	Stones or Sand	100.0(22)	0.1761±0.1885	0.04019	0.213

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.6. Common Teal (*Anas crecca*)

A total of 129 gizzard samples were analysed including seven empty one. Thirteen species of seeds were identified with four unidentified ones from one hundred and fourteen samples. This bulk of seeds consisted of *Potamogeton pectinatus*, *P. pusillus*, *Eleocharis palustris*, *Ceratophyllum demursem*, *Persiceria persiceria*, *Poligonum spp*., *Chara spp*., *Nupher variegatum* and *Mycrophyllum spicatum*. IRI showed higher values for the seeds of *Potamogeton pectinatus* than any other seed species. Vegetative parts were recorded in four individuals but in a little amount. Molluscs and crustaceans had greater abundance than vegetation, examined in ten individuals. Stones were frequently distributed in 96 samples (Fig. 7; Table 6).

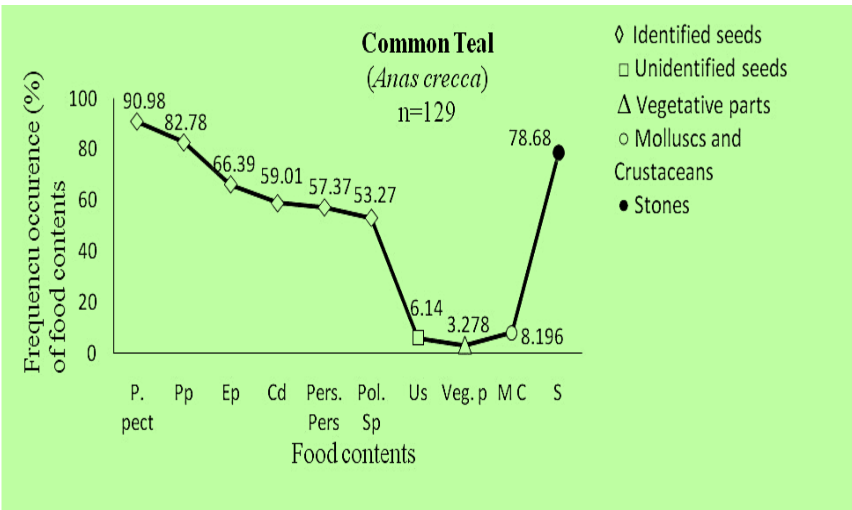

Fig. 7: The frequency occurrence (%) of different food contents. Food contents are abbreviated (e.g. "P.pect" for *Potamogeton pectinatus*, "Pp" for *Potamogeton pusillus*, "Ep" for *Eleocharis palustris*, "Cd" for *Ceratophyllum demersum*, "Pers. pers" for *Persiceria persiceria*, "Pol.sp" for *Poligonum species*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

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Table 6: Frequency occurrence (%), relative abundance and IRI for food items of Common Teal's (*Anas crecca*) diet

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Potamogeton pectinatus	90.98(118)	0.051±0.185	0.01703	0.3150
	Potamogeton pusillus	82.78(114)	0.048±0.162	0.01518	0.2540
	Eleocharis palustris	66.39(81)	0.042±0.091	0.01011	0.1910
	Ceratophyllum demursum	59.01(72)	0.037±0.083	0.00978	0.1470
	Persiceria persiceria	57.37(70)	0.033±0.075	0.00896	0.1360
	Poligonum spp.	53.27(65)	0.031±0.073	0.00905	0.1110
	Chara spp.	45.00(55)	0.026±0.680	0.09169	0.0082
	Nupher variegatum	20.01(25)	0.022±0.610	0.12200	0.00324
	Myriophyllum spicatum	09.03(11)	0.016±0.450	0.13595	0.00109
	Unidentified seed species **(04)**	06.140(09)			
2.	Vegetative parts	03.278(04)	0.405±0.181	0.09050	0.0124
3.	Molluscs and Crustaceans	08.196(10)	0.106±0.095	0.03006	0.00103
4.	Stones or Sand	78.680(96)	0.512±0.425	0.04341	0.2320

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.7. Gadwall (*Anas strepera*)

A sum of 158 samples was collected including fifteen empty gizzards. Analysis showed abundance of seeds than any other food items. Ten species of seeds were present with four unidentified one. *Potamogeton pusillus*, *Eleocharis palustris*, *Naias marina*, *Nupher variegatum*, *Ruppia maritime* and *Eleocharis parvula* were the abundant in diet. Higher values of IRI were recorded for *Potamogeton pusillus* than any seed species. Fragments of vegetative parts of plant were found in twelve samples with less abundance. Molluscs and crustaceans were not frequent and likely to be less abundant in only ten gadwalls. Sand with less stones was frequently and abundantly distributed in all food samples (Fig. 8; Table 7).

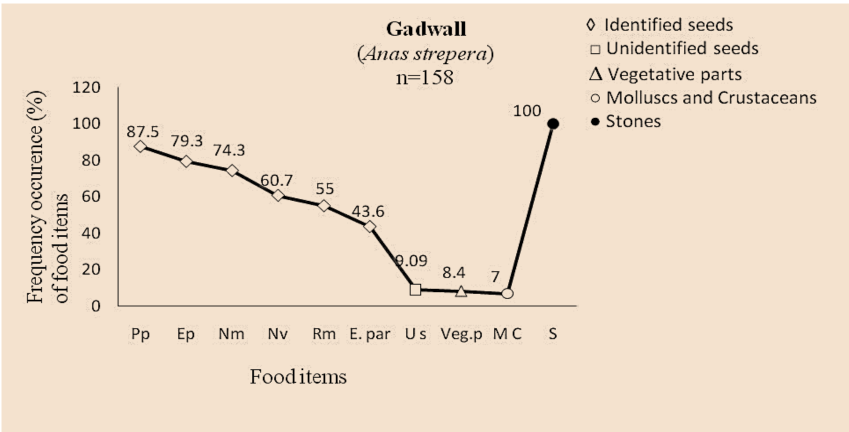

Fig. 8: The frequency occurrence (%) of various food items. Food material is abbreviated (e.g. "Pp" for *Potamogeton pusillus*, "Ep" for *Eleocharis palustris*, "Nm" for *Najas marina*, "Nv" for *Nupher variegatum*, "Rm" for *Ruppia maritime*, "E.parv" for *Eleocharis parvula*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 7: Frequency occurrence (%), relative abundance and IRI for food items of Gadwall (*Anas strepera*)

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Potamogeton pusillus	87.5(123)	0.084±0.145	0.01307	0.139
	Eleocharis palustris	79.3(111)	0.075±0.132	0.01252	0.126
	Naias marina	74.3(104)	0.060±0.1178	0.01156	0.111
	Nupher variegatum	60.7(77)	0.055±0.1025	0.01168	0.066
	Ruppia maritime	55.0(61)	0.0551±0.10256	0.01313	0.049
	Eleocharis parvula	43.6(55)	0.053±0.0946	0.01276	0.030
	Unidentified seed species **(04)**	09.09(15)	0.0672±0.0175	0.01237	0.0542
2.	Vegetative parts	08.40(12)	0.071±0.127	0.03666	0.0103
3.	Molluscs and Crustaceans	07.00(10)	0.088±0.131	0.04145	0.0167
4.	Stones or Sand	100.0(143)	0.188±0.972	0.08133	0.0124

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

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3.8. Tufted Duck (*Aythya fuligula*)

Four gizzard samples were obtained and analysed. Out of which four contained seeds. Ten types of seeds were present with four unidentified species. The seed collection consisted of *Naias marina*, *Potamogeton pusillus*, *Najas guadalupensis*, *Nupher variegatum*, *Poligonum amphibum* and *Holeochloa schenoides*. Here, IRI's value for *Naias marina* was greater than any other seed species. Molluscs, crustaceans and vegetation were observed in single sample respectively. Analysis revealed that stones were frequently distributed throughout all gizzards (Fig. 9; Table 8).

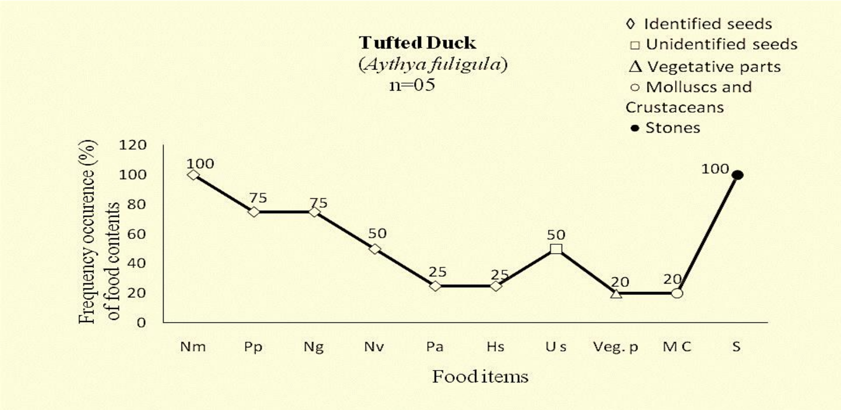

Fig. 9: The frequency occurrence (%) of various food items. Food species are abbreviated (e.g. "Nm" for *Naias marina*, "Pp" for *Potamogeton pusillus*, "Ng" for *Najas guadalupensis*, "Nv" for *Nupher variegatum*, "Pa" for *Poligonum amphibium*, "Hs" for *Holeochloa schoenoides*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 8: Frequency occurrence (%), relative abundance and IRI of food contents of Tufted Duck (*Aythya fuligula*)

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Naias marina	100.0(04)	0.1195±0.1105	0.5525	0.1312
	Potamogeton pusillus	75.0(03)	0.0317±0.0254	0.01468	0.0902
	Najas guadalupensis	75.0(03)	0.0040±0.00141	0.00008	0.0675
	Nupher variegatum	50.0(02)	0.0175±0.0177	0.01251	0.0250
	Poligonum amphibium	25.0(01)	0.0030±0.00141	0.00141	0.0175
	Holeochloa schoenoides	25.0(01)	0.01350±0.0106	0.01061	0.0225
	Unidentified seed species (04)	50.0(02)	0.0175±0.0177	0.01251	0.0250
2.	Vegetative parts	25.0(01)	0.0030±0.00141	0.00141	0.0175
3.	Molluscs and Crustaceans	25.0(01)	0.0040±0.00131	0.00131	0.0164
4.	Stones or Sand	100.0(04)	0.1090±0.1005	0.05025	0.1123

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.9. Common Pochard (*Aythya ferina*)

A sum of twenty-nine gizzard samples was collected with no one empty. Ten seed species including four unidentified ones constituted the bulk. The bulk of seeds (n=29) contained *Naias marina*, *Potamogeton pusillus*, *P. pectinatus*, *P. lucens*, *Chara spp.* and *Nitella spp.* Like Tufted Duck, *Naias marina* showed higher IRI values for Common Pochard. Vegetative parts, mollusks and crustaceans were recorded in single sample respectively. Stones were frequently distributed in 22 individuals for crushed food items (Fig. 10; Table 9).

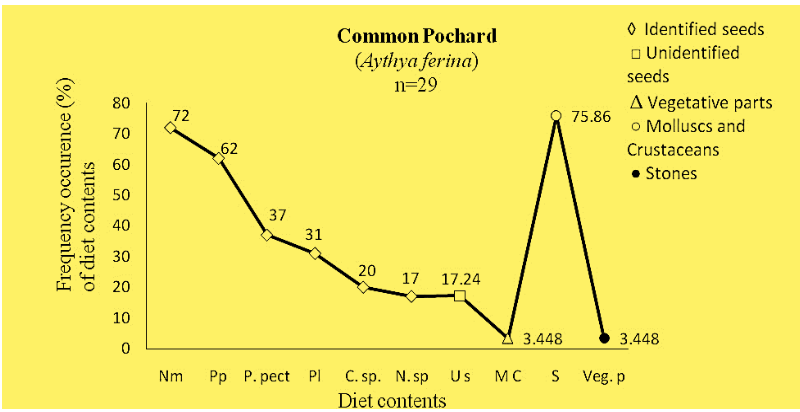

Fig. 10: The frequency occurrence (%) of various diet contents. Diet contents are abbreviated (e.g. "Nm" for *Naias marina*, "Pp" for *Potamogeton pusillus*, "P.pect" for *Potamogeton pectinatus*, "Pp" for *Potamogeton lucens*, "C.sp" for *Chara species*, "N.sp" for *Nitella species*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 9: Frequency of occurrence (%), relative abundance and IRI for food items of Common Pochard (*Aythya ferina*)

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Naias marina	72.0(21)	0.1822±0.1077	0.02352	0.166
	Potamogeton pusillus	62.0(18)	0.1825±0.0760	0.01792	0.1189
	Potamogeton pectinatus	37.0(11)	0.1180±0.0486	0.01464	0.0706
	Potamogeton lucens	31.0(09)	0.1222±0.549	0.18300	0.0562
	Chara spp.	20.0(06)	0.1582±0.879	0.35870	0.0283
	Nitella spp.	17.0(05)	0.0776±0.0353	0.01576	0.0205
	Unidentified seed species **(04)**	17.24(05)	0.0782±0.0331	0.01465	0.0211
2.	Vegetative parts	03.448(01)	0.411±0.182	0.09060	0.0134
3.	Molluscs and Crustaceans	03.448(01)	0.411±0.182	0.09060	0.0134
4.	Stones or Sand	75.860(22)	0.1185±0.1077	0.02296	0.176

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

3.10. Ferruginous Pochard (Aythya nyroca)

A total of thirty-four gizzard samples were analyzed for their food contents and no one was empty. Seed diversity was consisted of eleven species including four unidentified ones. The bulk of seeds (n=34) contained Poligonum spp., Nitella spp., Potamogeton lucens, P. pectinatus, P. pusillus and Najas marina. Poligonum spp. possessed higher IRI values than any other seed species. Vegetations, mollusks and crustaceans were recorded from two two samples respectively. Stone were discovered in seventeen samples, had 50% frequency occurrence (Fig. 11; Table 10).

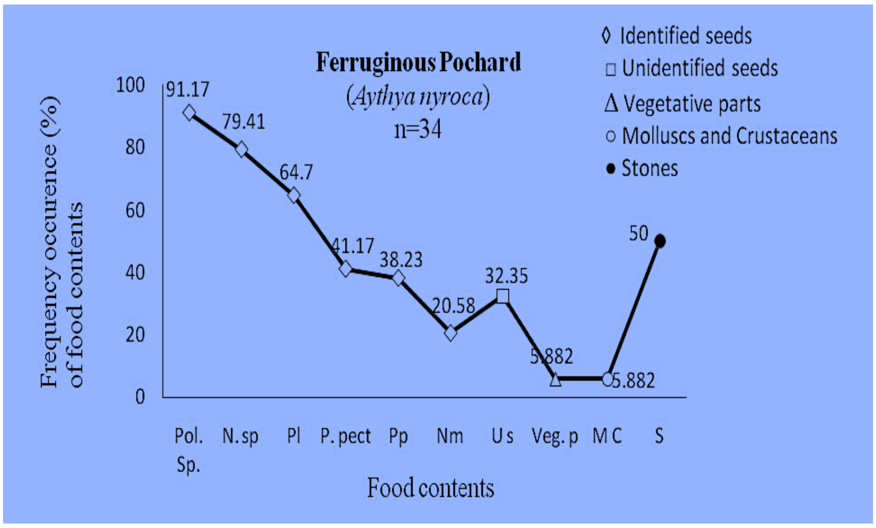

Fig.11: The frequency occurrence (%) of different food contents. Food material is abbreviated (e.g. "Pol.sp" for *Poligonum species*, "N.sp" for *Nitella species*, "Pl" for *Potamogeton lucens*, "P. pect" for *Potamogeton pectinatus*, "Pp" for *Potamogeton pusillus*, "Nm" for *Najas marina*, "U s" for Unidentified seeds, "Veg. p" for Vegetative parts, "M C" for Molluscs and Crustaceans, and "S" for Stones).

Table 10: Frequency of occurrence (%), relative abundance and IRI for food items of Ferruginous Pochard (*Aythya nyroca*)

No.	Food Contents	Frequency Occurrence (%)	*Relative Abundance	SE	IRI
1.	Seeds belonging to				
	Poligonum spp.	91.17(31)	0.1654±0.1124	0.02018	0.188
	Nitella spp.	79.41(27)	0.0953±0.0707	0.01362	0.143
	Potamogeton lucens	64.70(22)	0.1178±0.0596	0.01271	0.090
	Potamogeton pectinatus	41.17(14)	0.0929±0.0570	0.01524	0.086
	Potamogeton pusillus	38.23(13)	0.0929±0.0803	0.02224	0.0345
	Najas marina	20.58(07)	0.1004±0.0726	0.02739	0.0140
	Unidentified seed species **(04)**	32.35(11)	0.0909±0.0763	0.01223	0.0247
2.	Vegetative parts	05.882(02)	0.0835±0.0751	0.05311	0.0187
3.	Molluscs and Crustaceans	05.882(02)	0.0654±0.0541	0.03826	0.0153
4.	Stones or Sand	50.000(17)	0.1672±0.1285	0.03119	0.0943

*Mean±SD; SE=Standard Error; IRI=Index of Relative Importance.

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4. DISCUSSION

The contribution of different food contents to bird's diet has been analyzed. The gross diet for each duck species therefore can be described only as the frequency (%) with which each food type occurred in the all-gizzard samples. It should also be noted that the analysis considered the gizzards, which highlights the proportion of the hard items (especially seeds) in the diet (Nie et al. 2022). Teals (n=122) and Pintails (n=56) were exclusively ≥90% granivorous, having greater seed diversity in their gizzards (Table 1; Table 6). Like Teal and Pintail, gizzards of Common Pochard (n=29) and Ferruginous duck (n=34) contained mainly seeds (occurrence=100%), though molluscs (occurrence≥3.448%) and vegetative parts (occurence≥3.5%) of plants were found in few individuals (Table 9; Table 10). However, Eurasian Wigeon's (n=17) diet was chiefly composed of seeds (occurrence=100%), molluscs and crustaceans (occurrence=17.64%) but no vegetative part of any plant species were recorded at all (Table 2). But gizzards of Gadwalls (n=143) and Tufted Duck (n=04) were partially filled with a large amount of sand (occurrence=100%) with less quantity and greater occurrence (≥80%) of seeds. The presence of molluscs, crustaceans (occurrence ≥ 7%) and vegetative parts (occurence≥8%) of plant species was scarcely observed in their diet (Table 7; 8). Other studies have shown that Zebra Mussels *Driessena polymorpha* form an important part of Tufted duck's diet (Tableau et al. 2022; Królaczyk et al. 2022), but these molluscs were not encountered in our study area. Like Wigeon, seeds (occurrence=100%) were also recorded in all seven Garganey's gizzards, but no molluscs, crustaceans and vegetative parts were located at all (Table 3). Only two Mallard's gizzards were collected from study area with no vegetative parts but having majority of seeds (occurrence=100%) with little molluscs (occurrence=50%) (Table 4). Norther Shoveler (n=22) showed higher proportions of crushed molluscs and crustacean shells (occurrence=36.36%) than any other waterfowl species. Large amounts of seeds (occurrence=72.72%) were also recorded as major diet of Northern Shoveler with little vegetations (occurrence=9.09%) (Table 5).

The food contents for ten waterfowl species were recorded in study area thus generally correspond with earlier reports on waterfowl feeding at inland wetlands (Klimas et al. 2022). However, Pochards, Northern Pintails, Common Teals were more specialist granivores in our study area than others, where a non-negligible proportion of the diet consisted of crushed molluscs and crustacean shells. Indeed, it is known that when inland waterbodies lack macrophytes, they feed almost exclusively on macro invertebrates (Green et al. 2023).

Although, the seeds (major food item) of many plant species were identified, few contributed substantially to the diet of ducks. Seeds of *Potamogeton pusillus* and *Naias marina* were both important and had six highest IRIs in six (Eurasian Wigeon, Garganey, Mallard, Gadwall, Tufted duck, Common Pochard) of ten waterfowl species. *Naias marina* is cited by Agami and Waisel (1986) as being used by waterbirds. The analysis of wintering duck diet in Brenne and at the Dombes fishponds (Curtet et al. 2004), in France, also highlighted the importance of this seed species for Mallard, Pochard and Tufted duck. *Potamogeton pusillus* being an important food for waterbirds, yet it was frequently found in the bird's diet (Liang et al. 2022; van Leeuwen et al. 2023).

Potamogeton pectinatus and *Poligonum* species accounted highest IRIs for four (Northern Pintail, Northern Shoveler, Common Teal, Ferruginous Duck) of ten waterfowl species. A few seed species were prevalent to the diet of ducks: *Eleocharis palustris*, *Nupher vriegatum*, *Echinochloa crusgalli*, *Cyperus sp*, *Ruppia maritime*, *Holeochloa schoenoides*, *Chara sp*, *Nitella sp*, *Spyragnum emersum*, *Myriophyllum spicatum*, *Scirpus maritimus*, *Bidens sp*, *Persiceria persiceria* and *Ceratophyllum demursum* (Tables 1-10). These were already known to be an important food for Gadwalls, Teals, Shovelers, Pintails, and Mallards, as well as for Pochards (Curtet et al. 2004; Ayaichia et al. 2017).

Despite having much in common, the composition of the seeds in the diet differed markedly in waterfowl species. The most commonly observed vegetative parts of those plants in the diet of typical herbivores (Northern Pintail, Northern Shoveler, Common Teal, Gadwall, Tufted Duck, Common Pochard, Ferruginous Duck) were, logically, those that retain green parts in Autumn and Winter. For Gadwall and other herbivore waterfowl, the results support those of earlier studies, which describe the importance of vegetation as food for these species (Urgyán et al. 2023). A sum of nine benthivores duck's species (Northern Pintail, Eurasian Wigeon, Mallard, Northern Shoveler, Common Teal, Gadwall, Tufted Duck, Common Pochard, Ferruginous duck) was collected, having crushed molluscs and crustacean shells in their gizzards, except Garganey. The frequency occurrence (%) of crushed crustacean and molluscs shells in Shoveler's gizzards was much greater than any other waterfowl species. Previously, it was observed that Shoveler's diet consisted mainly of zooplankton prey, molluscs and crustaceans. Little frequency (%) of molluscs and crustaceans in other waterfowl species was recorded during winter migration, as noted in previous results (Nagarajan et al. 2022).

5. CONCLUSION

It is concluded by study that waterfowl species preferred to consume plants over animals as food during winter migration, while passing at Taunsa in South Punjab of Pakistan. Food analysis exhibited mainly that all bird species ingested seeds in abundant. *Naias marina* and *Potamogeton pusillus* were consistent for ingestion among the six species of ducks including out of ten species. Whereas seeds of *Potamogeton pectinatus* and *poligonum spp.* were found excessively in diet of Northern Pintail, Northern Shoveler, Common Teal, and Ferruginous Duck. In animals, mollusks and crustaceans were well represented in gizzard samples. Importance of vegetation in wetland ecosystem is also revealed in the study.

Authors Contribution

Ghulam Ali Raza and Aleem Ahmed Khan conceived and designed the study. Ghulam Ali Raza performed the study. Ghulam Ali Raza, Syed Ali Akbar Hussain and Aleem Ahmed Khan performed statistical analysis of experimental data. Ghulam Ali Raza and Syed Ali Akbar Hussain prepared the draft of the manuscript. Ghulam Ali Raza and Aleem Ahmed Khan edited the manuscript. All authors critically revised the manuscript and approved the final version.

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