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Diurnal feeding strategies of the Ferruginous Duck *(Aythya nyroca)* in Lake Tonga (Northeastern Algeria)

Khalil Draidi[1*], Badis Bakhouche[2], Naouel Lahlah[3], Imed Djemadi[4] & Mourad Bensouilah[5]

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Abstract Although the Ferruginous Duck *(Aythya nyroca)* has thoroughly been studied, the foraging behaviour of this species is still not completely known. In the present paper we studied the diurnal feeding behaviour of ducks. We monitored the annual cycle of birds through two fieldtrips per month. The instantaneous behaviour of birds was recorded in regular 30-minute intervals from 7 a.m. to 4:30 p.m., amounting a total of 456 observation hours. Food searching activity corresponds to a quarter of the total diurnal time budget of the Ferruginous Duck. Foraging behaviour was classified into five categories dominated by the "diving", which is almost 45.61% of the total search time. Foraging activities at the water surface considered to be secondary activities, including feeding by "bill", "neck and head", and "beak and head" in a rate of 19.86%, 14.53%, and 13.98%, respectively. The "toggle" remains a minor activity and represents only 5.99% of foraging time. The feeding behaviour of this species correlated to several environmental parameters (rainfall, temperature and wind velocity), and linked to the group size of ducks visiting the lake. Regarding the food intensity, our results show the highest values for "bill and head" behaviour. "Diving" has the longest feeding interval (16.16±14.1 minutes), while foraging by "bill" has the shortest (0.69 ± 0.48 minutes).

Keywords: El-kala, foraging behaviour, near threatened species, energy budget, Anatidae, wildfowl

Összefoglalás Annak ellenére, hogy a cigányrécével *(Aythya nyroca)* számos tanulmány foglalkozott, táplálkozási szokásai kevésbé ismertek. Jelen tanulmányban a faj nappali táplálékszerzéssel kapcsolatos viselkedését vizsgáltuk. A madarak éves táplálkozási ciklusának monitorozása havonta két terepbejárással történt. Az adott viselkedési mintákat 30 perces időintervallumokban rögzítettük: reggel 7 óra 30 perctől délután 16 óra 30 percig, összesen 456 megfigyeléssel töltött órában. A táplálék keresésével töltött idő hozzávetőlegesen a réce napi aktivitásának negyedét teszi ki. A táplálékszerzéssel kapcsolatos viselkedési mintákat öt kategóriába soroltuk: „merülés" (kereséssel töltött idő 45,61%-a), másodlagos táplálékszerzés a vízfelszínről, a „csőr a felszín alatt" (19,86%), a „nyak és fej a felszín alatt" (14,53%,) „csőr és fej a felszín alatt" (13,98%), valamint a „tótágast állva" történő táplálékszerzés, mely az idő 5,99%-át teszi ki. E faj táplálkozási szokásai számos környezeti paraméterrel (csapadék, hőmérséklet és szélsebesség) függnek össze, és a tavat látogató récék csoportmérete is befolyásoló tényező. A táplálékforrás intenzitásának tekintetében a legmagasabb értékeket a „csőr és fej a felszín alatt" viselkedési mintára kaptuk. A „merülés" mutatta a leghosszabb időintervallumot (16,16±14,1 perc), míg a legrövidebbet (0,69 ± 0,48 perc) a "csőr a felszín alatt" viselkedési minta.

Kulcsszavak: El-kala, táplálékszerzés, mérsékelten fenyegetett fajok, energiaforgalom, Anatidae, vízimadarak

[1] *Laboratory of Ecobiology of Aquatic and Littoral Environments, University of Badji Mokhtar Annaba, 23000, Algeria*
[2] *Laboratory of Dynamics and Biodiversity (USTHB), USTHB, FSB, Bp32 El Alia, Bab Ezzouar, Algies, Algeria*
[3] *Lake Forest College 555 N Sheridan Rd, Lake Forest, IL 60045, USA*

[4] *Laboratory Ecology of Terrestrial and Aquatic Systems, University of Badji Mokhtar Annaba, 23000, Algeria*
[5] *Laboratory of Ecobiology of aquatic and littoral environments University of Badji Mokhtar Annaba, 23000, Algeria*
* *corresponding author: khalildraidi@yahoo.fr*

Introduction

Understanding foraging strategies that animals use when balancing energy budgets can lead to a clearer view of potential constraints to populations, as well as species' behavioral scope, when responding to environmental changes (Pyke 1984). The allocation of time into foraging varies among taxa and individuals and may have important implications for meeting energy requirements (Bautista *et al.* 1998). When facing with food or energetic deficits, the ability to adjust foraging time and strategies allows animals to maintain the necessary rate of energy gaining. For obligate diurnal foragers, day length forces strict limits on available foraging time. The Ferruginous Duck *(Aythya nyroca)* is a shy and cautious diving duck widely distributed in Asia, Africa, and Europe. During the wintering season, this species is a regular visitor in El-Kala wetlands. It is also reported as nesting species in North Africa since the beginning of the 20th century. Its nesting was observed for the first time in 1972 in Algeria (François 1975). During the last decades, nesting populations in this region have suffered serious declines, as well as changes in their distribution (Ali & Ripley 1978, Perennou *et al*. 1994, Callaghan 1997, Lopez & Mundkur 1997, Grimmett *et al*. 1999, Robinson & Hughes 2003).

According to the Red List of Threatened Species (IUCN 2015), the Ferruginous Duck occupies the 'near threatened' status. In Algeria, this species is protected by decrees N°83-509 of 20th August 1983 and N°06-05 of 15th July 2006, relating to the protection and preservation of some critically threatened species. *A. nyroca* has also been presented as a priority species in 4 prominent international conservation treaties: the European Union Bird Directive, the Bern Convention, the Bonn Convention, and the African Eurasian Migratory Waterbird Agreement (Robinson & Hughes 2003).

The Ferruginous Duck is omnivorous. In Uzbekistan, stomach content analysis reveals 78% of sprouts and freshwater plant seeds and 22% of aquatic insects during the nesting period (Kashkarov & Mukhina 1997). In Bulgaria, this duck feeds mostly on seeds and other aquatic plants such as pondweeds (*Potamogeton* spp.), sedges (*Carex* spp.), hornworts (*Ceratophyllum* spp.) and bulrushes (*Scirpus* spp.) (Ayaichia *et al.* 2017). However, animal material can dominate locally or temporarily and includes invertebrates such as chironomids (Chironomidae), snails (gastropods), coleopteran beetles and also small fish and frogs (Phillips 1923, Dementiev & Gladkov 1952, Sterbetz 1967, Cramp & Simmons 1977, Amat & Soriguer 1982, Paspaleva *et al*. 1984, Patrikeev 1996, Green 1998). In addition to the measurement of the total time spent in foraging, which has been rather widely discussed in several studies (Green 1998, Ayaichia *et al*. 2017), understanding feeding methods used by ducks may also enquire on constraints beared by populations. We already know that feeding only with submerged bill may be linked to the choice of feeding in shallower zones, but could also be a response to a need of maintaining activity that requires alertness (remaining eyes above the surface) where predation risks and disturbance are the highest (Guillemain *et al*. 2002). Moreover, the increasing of foraging depth during winter reflects a gradual depletion of resources (Guillemain & Fritz 2002), even a change in consumed prey types (Guillemain *et al.* 2000). In birds, foraging is a limiting process which allows energetic gain. A good wintering season in foraging terms would permit the reconstitution of endogen reserves mobilised during migration and/or to finish moulting (Heitmeyer 1988). Foraging also influences breeding, which is a costly phenomenon on nutritive elements, and can require not only the lepidic reserves but either the stocked tissue proteins (Heitmeyer 1988, Owen & Black 1990). In Anatidae, species often reproduce early, the clutch size and the date of laying depend on the cumulated reserves before arrival on the nesting sites (Ankney & MacInnes 1978, Pattenden & Boga 1989). During the migration journey to the wintering sites, birds forage intensively to reconstitute energetic reserves (Landys *et al.* 2004). Foraging behaviour is determined by foraging niche and depends generally on certain factors of climatic zones and charging capacity (Ankney & MacInnes 1978, Krapu 1981, Drobney 1982, Pattenden & Boag 1989).

In this study, we tried to understand why Ferruginous Duck changes its foraging methods. First, we searched factors, which affect the processes via feeding behaviour. We examined the relation between feeding methods and some environmental factors (temperature, rainfalls, and wind speed). We also considered the relationship between the choice of a foraging method and the ducks' group sizes present at the Lake Tonga (influence of the competition).

Materials and Methods

Field work was conducted over an annual cycle, from January to December in 2013 with two surveys per month. Two classical methods were implemented: The Scan Sampling and Focal Individual Sampling. Scan sampling requires that the behaviour of individuals in the sample is being recorded instantaneously (Altmann 1974). Many waterfowl activity budget studies, utilizing scan sampling, involve surveying the entire local population at the time of sampling, i.e. all birds on a pond (Skead 1977, Norman *et al*. 1979, O'Donoghue & O'Halloran 1994, Adair *et al*. 1996). In some instances, the study site is too large to be sampled from one point (Campbell 1978). A solution to this problem is to divide the site into non-overlapping sections that are observed separately. Then, data needs to be weighted according to the number of birds observed in the different sections (Hepworth & Hamilton 2001). In our case, it took approximately 1 h to sample the entire pond. The different behaviours of the monitored ducks were identified using binoculars, scanning from left to right (Hepworth & Hamilton 2001). To facilitate the sampling, the pond was divided into 5 sections. Antagonistic behaviour was excluded because of its infrequency. All of the different types of feeding behaviour by submersion of the beak, the head, the beak and head, the head and neck or by diving were considered as feeding activities. The aim of this sampling was to estimate the number of individuals in each activity category, on each sampling occasion. These numbers would then be used to estimate the proportion (or percentage) of individuals in each category. Focal observations (10 mins, Altmann 1974) were conducted on feeding individuals chosen at chance; each change in behaviour was recorded. Observations took place in the site twice monthly between 7 a.m. and 4:30 p.m., for a total of 24 study days. Thereby, a total of 456 scans were performed. Data was recorded by the same observers throughout the study. Presumed repetition of observations on the same individual were removed (Altmann 1974). Analyses were restricted to the temporal organization of behaviour during foraging, successions of feeding bouts and interruptions, where birds were standing or swimming in an upright position (head-up vigilance bouts, hereafter scans). We considered foraging to be terminated by any activity other than feeding or scanning (Cézilly & Brun 1989). Foraging methods were classified into five categories: feeding by diving (the whole body was in the water), feeding by bill (only bill was in the water), feeding by bill and head, (bill and head were in the water), feeding by neck and head (diving with head and neck in the water) and feeding by upending (only tail remains out of water). We collected environmental data during each time block. Air temperature (°C, recorded every 10 mins) and wind velocity (km/h, recorded continuously). We were unable to conduct systematic nocturnal surveys due to dense vegetation in the control treatments, distances from blinds to study plots, and logistical constraints.

Study site

Our study area is located in North-eastern Algeria, in the National Park of El-Kala, on the Lake Tonga (in Ramsar since 1983). This lake is ca. 2,500 ha (Belhadj *et al*. 2007) and it is one of the most significant wetlands of North Africa. Lake Tonga provides important habitats of extensive beds of aquatic plants and nesting sites for several rare and globally threatened waterbirds. It is a significant breeding area for such rare waterfowl as Ferruginous Duck, White-headed Duck *(Oxyura leucocephala)*, Common Pochared *(Aythya ferina)* and Marbled Teal *(Marmaronetta angustirostris)*. It attracts a rich and varied population of many birds of prey (Smart & Hollis 1990). The abundant aquatic vegetation of this lake plays a fundamental role in the distribution of waterbirds offering both shelter and food. It is mainly composed by islets of lesser bulrush *(Thypha angustifolia),* yellow iris *(Iris pseudoacorus),* lakeshore bulrush *(Scripus lacustris),* cosmopolitan bulrush *(Bolboschoenus maritimus),* Australian phragmite *(Phragmites australis),* Mediterranean willow *(Salix pedicellate),* and simplestem bur-reed *(Sparganium erectum).* In spring, we witness the immergence and flowering of very invasive hydrophytes of free-water species, white nenuphar *(Nymphaea alba)* (Abbaci 1999).

Statistical analyses

We calculated food intensity of each foraging cycle according to the following formula: IA = A / (A+R), where IA = feeding intensity, A = duration of feeding phase, and R = duration of breathing phase (Allouche & Tamisier 1984, Campredon 1984). We used Pearson's test for correlations, Mann-Whitney's test for comparison between seasons of feeding activities, and packages 'ade4' and 'ade4TkGUI' in the free software R v3.0.3 (R Core Team 2014) for factorial analysis of correspondences (FAC).

Results

Results show that the Ferruginous Duck spends the quarter (25.40%) of the diurnal time with foraging, 30.08% of the time with swimming, and with comfort activities (preening, resting and sleeping) predominated at a rate of 44.52%. Parade activities and flight recorded only a minimal part of diurnal activity rhythms and thus, have been removed from the analyses.

Diurnal feeding activities indicated two important peaks: the first one in February with a value of 44%, followed by another in April with a value of 59.94%. The lowest values of the diurnal foraging are recorded between the months of June and September, less than 30% *(Figure 1)*.

The most frequent foraging method observed is feeding by diving (46.61% of food cycle). Other activities, feeding by "bill" by "neck and head" and by "bill and head" are secondary activities and are represented 19.86%, 14.53% and 13.98%, respectively. Up-ending is a minimal activity and represents only 5.99% of the foraging cycle.

Except feeding by neck and head ($U = 13$, $n = 12$, $p = 0.47$), all other feeding behaviours differ between wintering periods (January-April then November-December) and summer period that spreading between May and October (diving: $U = 0$, $n = 12$, $p < 0.01$; toggle: $U = 3$, $n = 12$, $p < 0.05$; beak: $U = 3$, $n = 12$, $p < 0.05$; beak and head: $U = 3$, $n = 12$, $p < 0.05$) *(Figure 2)*.

FAC demonstrates 78% of information in axe 1 and 2. Toggle, neck and head, and beak and head are grouped in positive side of axe 2 while diving (negative side) and beak (positive side) are positioned separately in axe 1 *(Figure 3)*. The first group is associated with April and September, peak with May to August and October. Diving is associated with

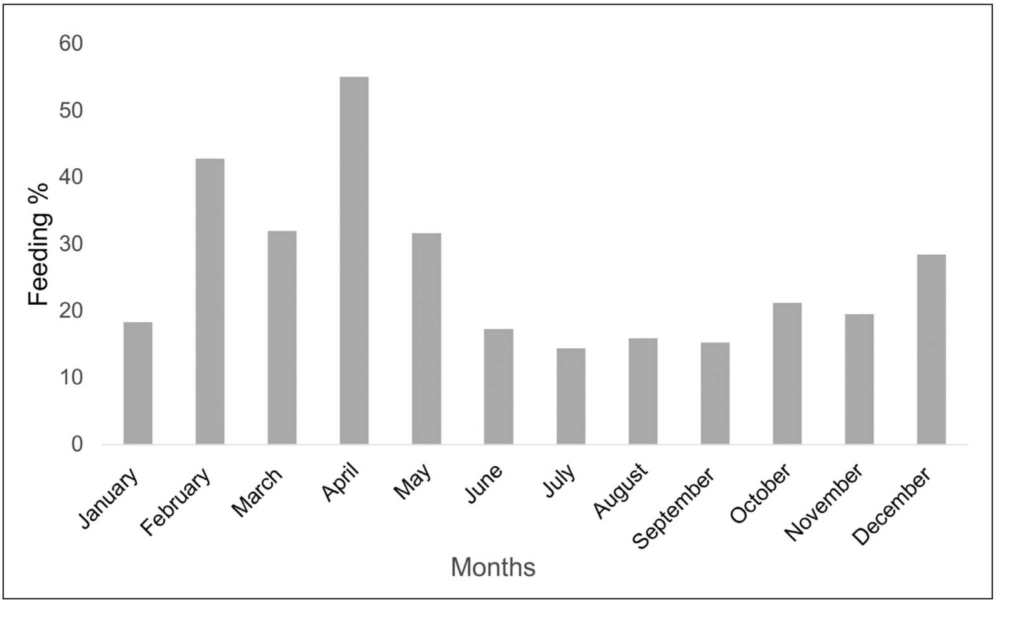

Figure 1. Annual foraging activity of Ferruginous Duck
1. ábra A cigányréce éves táplálkozási aktivitása

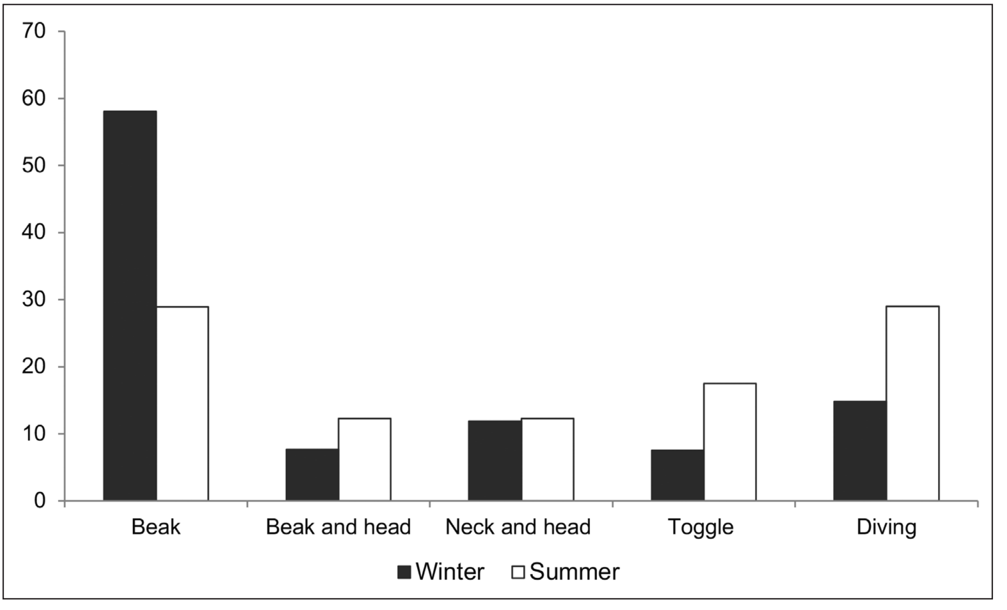

Figure 2. Seasonal differences of foraging activities
2. ábra A táplálkozásmód évszakonkénti változása

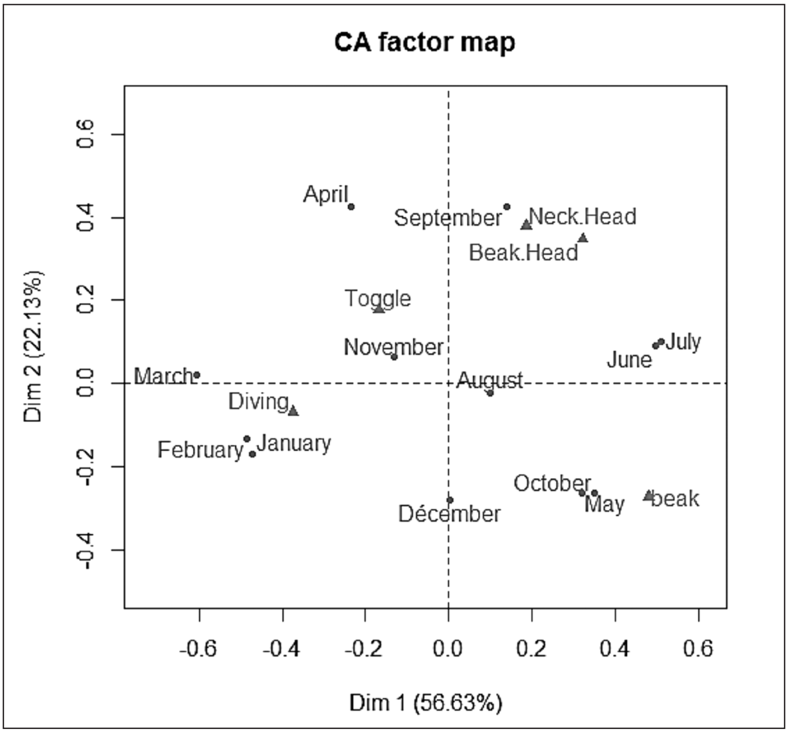

Figure 3. FAC results of *foraging* activities
3. ábra A táplálkozási aktivitás FAC eredményei

months from January to March and November.

Feeding intensity is significantly and negatively correlated with the studied factors: rainfall (test of Pearson, $p < 0.002$, $r = -0.93$), temperature ($p < 0.001$, $r = -0.74$), wind speed ($p < 0.001$, $r = -0.98$).

Feeding activities linked to the surface are significantly and negatively correlated to the number of ducks on the surface and also to the number of diving ducks. However, foraging activity linked to the depth is significantly and positively correlated to the number of ducks on the surface *(Table 1).*

Table 1. Correlation between foraging method and bands' sizes
1. táblázat A táplálkozásmód és a csoportméret összefüggései

Activities	number of diving ducks	number of surface ducks
Surface feeding	$r = -0.002$ $p = 0.99$	$r = -0.096$ $p = 0.019$
Feeding in depth	$r = 0.019$ $p = 0.95$	$r = 0.85$ $p = 0.0004$

Table 2. Feeding intensity by foraging method
2. táblázat A táplálkozás intenzitása az egyes táplálkozásmódok esetében

Feeding type	A (in sec.)	R	IA
Diving	16.16 ± 14.1	15 ± 12.36	0.56 ± 0.28
Up-ending	3.26 ± 1.12	3.63 ± 3.69	0.46 ± 0.24
Bill and Head	5.25 ± 5.2	4.45 ± 3.73	0.47 ± 0.28
Head and Neck	9.97 ± 8.38	9.95 ± 7.01	0.57 ± 0.26
Bill	0.69 ± 0.48	1.82 ± 0.87	0.33 ± 0.12

Table 2 shows that diving is the longest foraging behaviour with also a long breathing phase. The shortest behaviour is feeding by bill with a short breathing phase compared to other behaviours. Concerning food intensity, "head and neck" and diving behaviours recorded the highest values.

Discussion

The results show that the Ferruginous Duck exhibits an important diurnal comfort rate. Our results are supported by other studies. Diurnal resting and other comfort activities in Anatidae represent one of the best ways for rearrangement of energy reserves with a view of migratory for wintering populations (Hill & Ellis 1984, Rave & Baldassare 1989, Hohman & Rave 1990, Green *et al*. 1999, Tamisier & Dehorter 1999), as well as, ensure the reproductive success for nesting populations (Hill & Ellis 1984, Hohman & Rave 1990, Green *et al*. 1999). Swimming is an essential activity for ducks, it is often associated with foraging. Individuals of the studied species fatten up by moving. It takes the second place in the total balance of diurnal activities of this species. Prevalence of this activity is basically observed in the beginning of the day and toward the end of the wintering period. Numerous factors determine importance of diurnal foraging. At northern latitudes, birds allocate 80 to 100% of the diurnal period for feeding (Goss-Custard 1969, 1979), while in more temperate areas, even tropical, this rate is lower, for instance, ranged between 25 and 87% in Africa (Puttick 1984, Fasola & Biddau 1997). This is notably explained by upper energy needs for colder temperature. According to Campredon (1984), granivorous or omnivorous ducks devote 35% of their feeding diurnal time while diving ducks of the genus *Aythya* generally spend less than 30% of their diurnal time with feeding (Nilsson 1970). For example, this proportion is 23% for the Ferruginous Duck in Bulgaria (Petkov 2003), 21% for Tufted Duck *(Aythya fuligula)* in Switzerland (Pedroli 1982), and 17% for the Common Pochard *(Aythya ferina)* (Sabir 2004).

Many ducks, including the Ferruginous, are known to exhibit feeding peak early in the morning and late in the evening (Rodway 1998, Aissaoui *et al.* 2011). Ferruginous Ducks prefer to forage at night and continue feeding diurnally. The diurnal feeding maxima at the beginning and the end of the day is probably the continuation of the night feeding activity that compensates increase of energy needs spent in thermoregulation. One of the most significant decrease in diurnal foraging, recorded in this study, was observed during nesting period. One of the reasons that may explain this pattern, is the continuous monitoring of chicks against predators – mainly the Western Marsh Harrier *(Circus aeruginosus),* requiring a continuous presence of adults close to their nests. This decrease could also be a result of increasing temperatures during the day. In fact, the heat stress is a key factor that influences ducks' health and which enhances during hot seasons and in hot regions (Zhu *et al*. 2014). We believe that the daily heat during summer period forces ducks to decrease their diurnal feeding activity. This loss of time will be compensated by an intensive foraging rate by the end of the day or during the night with temperature decrease This kind of bimodal declining and fluctuating activity pattern, driven by food availability, temperature or the presence of predators, was also recorded by other authors, such as Tanmay (2014), who studied diurnal feeding behaviour of the Ferruginous Duck in Turkey (see also Rodway 1998, Aissaoui *et al*. 2011).

During winter, we observed that individuals search food more actively by decreasing their moves and their vigilance, essentially during cold days. Poor environmental conditions in this period, combined with the increased number of competitors arriving for winter are force this species to spend more time foraging to maintain thermoregulation/energy supplies. Feeding rate increases also before reproduction period translating the need to accumulate more fat as well as other nutrients essential to female's breeding.

Food resources are generally distributed heterogeneously, both in time and space, and foraging animals show flexible responses to this heterogeneity. This flexibility is expressed at different levels: animals can occupy a new habitat, select a different patch within the same habitat, and select different items within a patch (reviews in Stephens & Krebs 1986, Hughes 1993, Sutherland 1996). Another kind of behavioral adjustment involves switching search methods (Stephens & Krebs 1986). Short-term switches or the short-term changes in food searching methods were observed and analysed in numerous animal groups as a rapid and reversible adaptation response to different conditions of food availability (Thomas 1974, Davies 1977, Recher *et al*. 1983, Formanowicz & Bradley 1987, Grant & Noakes 1987, Village 1990, Bell 1991, Nakano *et al*. 1999). The Ferruginous Duck is an excellent diver, but we have also highlighted other feeding methods less frequent than diving, but have crucial importance in the subventions of nutritional needs. For the Ferruginous Duck, diving remains the most efficient feeding technique because by this method it gathers the most rentable preys in term of energy, which are generally animal materials (benthic macro-invertebrates) (Phillips 1923, Dementiev & Gladkov 1952, Sterbetz 1969, Cramp & Simmons 1977, Amat & Soriguer 1982) or certain plants such as sago pondweed *(Potamogeton* *peetinatus),* small pondweed *(P. panormitanus),* and bulrush *(Schoenoplectus litoralis),* abundant in the benthos. Alternative feeding techniques are dominated by the usage of bill. This technique occurs essentially in shallow waters where vegetation is available at water surface. We believe that this technique also allows ducks to maintain a certain level of vigilance while foraging. This capacity in combination between vigilance and food seeking might be a crucial importance for species whose type and/or energy needs necessitate daily, long foraging. Effectively, individuals may be unable to compensate the loss of the feeding time if vigilance is reached only by "head up", in a time period where feeding is impossible (Martin & Katzir 1999). Feeding by bill and so other feeding behaviour linked to the surface are generally used to collect insects such as chironomids or submerged seeds (Cramp & Simmons 1977).

According to Poysa (1983), two reasons may explain the choice of ducks' feeding method; 1) water depth; 2) distribution of prey. In winter, diving ducks are mostly feeding on benthic macro-invertebrates (Nilsson 1972, Stott & Olson 1973, Bellrose 1980, Jones & Drobney 1986, Poulton *et al*. 2002). This kind of prey with high energy can only be obtained by "diving". Depletion of surface resources, presence of great number of several wintering duck species also force the studied species to look for food in the depth. Increase in the rate of foraging activities linked to the surface in summer time may be explained by the abundance of sufficient food resources on the surface to supply energy needs, and also by the need to maintain more vigilance due to presence of chicks during this period (see previous section).

Numerous authors linked foraging behaviour to environmental factors. For instance, Paulus (1984) has studied the Gadwall *(Mareca strepera)* in Louisiana in October 1977 and in April 1978, and found a negative relationship between ducks' feeding rate and temperature fluctuation. Gaston and Nasci (1989) report that temperature decrease provokes an increase of food seeking. Thompson *et al.* (1991) found negative correlations between wind speed and foraging rate of four duck species: Blue-winged Teal *(Anas discors)*, Northern Shoveler *(A. clypeata)*, Northern Pintail *(A. acuta)*, and the American Wigeon *(A. americana)*. Results of the present study show a clear decrease in foraging during rainy days. We assumed that ducks have difficulties to reach submerged vegetation because of the increase of water depth, but also of their incapability to locate surface preys due to water turbulence by rains. Our study also shows the negative influence of wind speed on feeding activity. Thompson *et al*. (1991) emphasizes that wind speed would have more influence on duck's foraging than may have any other climatic parameters. In fact, we noticed that formation of waves on water surface disturbs feeding activity and sometimes completely interrupts it, since wind also disturbs the movements of insects (such as chironomids), which generally depend on the surface vegetation. Furthermore, the influence of temperature, especially thermal stress in hottest or coldest periods, forces ducks to limit their feeding and increase comfort behaviour in order to reduce energy use.

At Lake Tonga, the Ferruginous Duck cohabits with several bird species, especially the Common Pochard, the Northern Shoveler, the Eurasian Teal *(Anas crecca),* and the Eurasian Coot *(Fulica atra)*. Various studies on habitat use by community of ducks showed separation of niches between species in horizontal dimensions, such as size of wetlands, vegetation characteristics, and chemical characteristics of water (Bengston 1971, Weller 1975, Toft *et al*. 1982, Anderson & Ohmart 1988, Monda & Ratti 1988, Bergan & Smith 1989, Nummi & Poysa 1993, Nudds *et al.* 1994). Ferruginous Duck is belonging to the omnivore diving ducks according to diet composition and feeding methods (Pecsics *et al.* 2017). Some studies demonstrate the presence of vertical partitioning in foraging methods in the depths of water column. Amat (1984) suggested that the Red-crested Pochard *(Netta rufina)* and the Common Pochard use different habitats with the same foraging strategy in winter, however, they share the same habitat but use different feeding methods in spring. In the present case, results demonstrated clearly that feeding behaviour of Ferruginous Ducks is highly modulated by presence of competitors. In order to optimize its food supply, this species adopts different food-seeking strategies to be able to face the competitiveness. When group size of surface ducks become a constraint, either for consumption intensity of the surface preys or because of prey's disturbance which generate an increase foraging time, it forces this species to dive as the most efficient strategy. Competitiveness with other diving ducks obliges certain individuals to choose surface feeding as a mean to face this constraint. We also noticed interferences between ducks on the same supply spot, which can be manifested in aggressive behaviour of dominant ducks, forcing some individuals to change the foraging site.

Behaviour linked to surface foraging are the shortest in terms of time; this may be explained by the fact that these postures put ducks in position of weakness facing predators, while having eyes under water and the rest of the body exposed. Shortening or fragmenting those phases of foraging seems to be a way to face this constraint. Kramer (1988) discussed that the optimal diving duration are relatively short. Deep, long dives, therefore, will be feasible only with a large reserve in O_2. For this, regeneration time would allow fulfilling reserves in O_2, which corroborates our results where breathing phases are the longest after diving. During these resting phases, ducks also recover from body heat loss of diving (de Leeuw *et al.* 1998). As it has already been discussed in the previous chapter; diving is a very efficient foraging method during wintering season, diminution of resources (scarce and change of prays distribution) may explain in part the long dives.

Future perspectives

Unfortunately, data collected in this study are too limited to explain variation of ducks' feeding behaviour in response to the differences in sex and age of individuals but also in response to productivity fluctuation of the study sites. Study of diet of this species and its eventual seasonal variation, different kinds of disturbance (e.g. predators, human presence) can also help the understanding of certain aspects of the foraging behaviour, where more detailed studies of this species at Lake Tonga, and in other sites of its nesting area in Algeria are needed.

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