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Wintering Diurnal Behavior of the Aquatic Bird: The Northern Shoveler *Spatula clypeata* (Anatidae) at Lac Ayata (El-Méghair, Algerian Sahara)

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ABSTRACT

An eco-ethological study on the northern shovelers (*Spatula clypeata*) was conducted from September 2022 to April 2023. The results indicate that this zooplanktivorous species functions as a quintessential wintering species in the study water body. The highest recorded count was approximately 375 individuals, observed in the first half of December 2022. In contrast, the lowest numbers occurred in the first half of September, marking the onset of the wintering season, when only six individuals formed the initial early group to occupy the wetland. Analysis of diurnal activity patterns showed that feeding behavior dominated, accounting for 46% of the total activity budget. Feeding occurred 52% of the time at the water surface, 31% through dabbling (body tilting into the water), and 17% by diving. This activity was primarily observed in December, January, and March, toward the end of the wintering season. Feeding was followed by sleeping (27%), swimming (17%), preening (7%), and display, antagonistic, and flight behaviors, each representing roughly 1% of the activity budget. These findings emphasize the ecological importance of Lac Ayata as a diurnal feeding area for this Anatidae species. Furthermore, multivariate statistical analysis using Correspondence Factor Analysis (CFA) revealed that the wintering season can be subdivided into four interdependent sub-periods.

INTRODUCTION

Algeria is renowned for its biological, ecological, and genetic diversity due to its location in the Western Palearctic. The country encompasses nearly every type of ecological habitat and possesses a rich ecosystem heritage, including wetlands, grasslands, and forests **(Houhamdi, 2002; Boulekhssaim *et al*., 2006, 2009; Saheb *et al*., 2006; Samraoui *et al*., 2006; Houhamdi *et al*., 2008; Mayache *et al*., 2008; Metallaoui & Houhamdi, 2008, 2010; Maazi, 2009; Metallaoui *et al*., 2009; Loucif *et al*., 2021)**. The Oued Righ Valley, situated in the arid bioclimatic zone with warm winters

in the northern Algerian Sahara, is a site of both national and international importance for birds. It is particularly known as a wintering and stopover site for numerous waterbirds, especially members of the Anatidae family (dabbling and diving ducks) **(Nouidjem, 2008; Nouidjem *et al*., 2012, 2014, 2015, 2016)**. The area also supports a rich diversity of shorebirds (waders) and serves as a natural nesting site for greater flamingos (*Phoenicopterus roseus*) **(Bensaci *et al*., 2011, 2013, 2015)**.

Anatidae are a key component of Algeria's wetland ecosystems **(Metallaoui & Houhamdi, 2008; Houhamdi *et al*., 2009; Maazi, 2009; Baaziz *et al*., 2011; Boukrouma *et al*., 2011; Guergueb *et al*., 2014; Merzoug *et al*., 2014; Amor Abda *et al*., 2015; Halassi *et al*., 2016; Atoussi *et al*., 2017)**. Their distribution is closely linked to the ecological conditions of aquatic habitats, particularly predator protection **(Metallaoui *et al*., 2009; Bensizrara *et al*., 2013; Bendahmane *et al*., 2014; Talai-harbi *et al*., 2016)**. Commonly found in coastal wetlands, these waterbirds are important ecological indicators **(Metallaoui & Houhamdi, 2010; Chettibi *et al*., 2013; Aberkane *et al*., 2014; Boudraa *et al*., 2014; Guergueb *et al*., 2014; Merzoug *et al*., 2014)**.

This study focuses on one of the most abundant members of this group, the northern shoveler (*Spatula clypeata*), a species classified as Least Concern on the IUCN Red List. The choice of this species is motivated by its socio-economic importance to resource managers, particularly in relation to wetland conservation and sustainable development **(BirdLife International, 2004, 2008)**. In Algeria, this Anatidae species—regularly recorded in large numbers—belongs primarily to breeding populations originating from Central Europe **(Ruger *et al*., 1987)**. It is a consistent wintering species across the country's aquatic ecosystems, especially in the northeast **(Ledant *et al*., 1981; Isenmann & Moali, 2000; Bouzegag *et al*., 2013; Metallaoui *et al*., 2014; Khemis *et al*., 2016, 2017a, b; Tabouche, 2017)**, as well as in northeastern Algeria and Tunisia **(Isenmann *et al*., 2005)** and Morocco **(Thévenot *et al*., 2005)**.

The aim of this study was to enhance ecological and eco-ethological understanding of the wintering behavior of the northern shoveler, one of the most significant waterbird species in Algerian wetlands. To achieve this, the phenology and diurnal behavior of a surface-feeding duck population wintering at Lac Ayata were monitored throughout the 2022–2023 wintering season.

MATERIALS AND METHODS

Study area

The Oued Righ Valley (Fig. 1, Photo 1) is a vast oasis stretching from the city of Touggourt in the south to the southern foothills of the Saharan Atlas in the north. Two bioclimatic types predominate in this Saharan region: the Saharan type, which covers most of the valley, and the arid, hot, and dry type, which characterizes the entire northern portion **(Bouzegag, 2008, 2015; Bouzegag *et al*., 2013)**. This extended basin contains depressions that reach 41 meters below Mediterranean Sea level and comprises roughly

ten bodies of water (Table 1). The palm groves of the oases, extending from the city of Touggourt, provide drainage and wastewater to these water bodies, which serve as a controlled outlet.

Table 1. Main wetlands in the Oued Righ Valley

Site	GPS coordinates	Area	Conservation status	Breeding waterbirds	Vegetation
Chott Merouane	34°02.433'N 5°58.748'E	337 000 ha	Ramsar site **(**2004**)**	*Phoenicopterus roseus, Tadorna tadorna, Tadorna ferruginea* and *Recurvirostra avosetta, Himantopus himantopus*.	Often based on chenopodiaceae- *Salsola fruticosa,* *- Salicornia fruticosa,* *- Atriplex halimus* *- Zygophylum s*p and in some lakes*. *Phragmites australis*
Lac de Oued Khrouf*	33°53.332'N 06°01.125'E	1 200 ha	Ramsar site **(**2004**)**	*Recurvirostra avosetta*, *Himantopus himantopus*, *Anarhynchus alexandrinus*, *Ayhtya nyroca* and *Tadorna ferruginea*	
Chott Melghir	34°10.631'N 06°17.322'E	552 000 ha	Ramsar site **(**2004**)**	*Recurvirostra avosetta*, *Himantopus himantopus*, *Anarhynchus alexandrinus* and *Tadorna ferruginea*.	
Lac El-Hamraia*	33°39.787'N 06°02.815'E	75 ha	None	*Anarhynchus alexandrinus, Himantopus himantopus* and *Tadorna ferruginea*.	
Lac Ayata * «**Sidi Amrane»**	33°29.867'N 05°59.403'E	40 ha	None	*Recurvirostra avosetta*, *Himantopus himantopus*, *Anarhynchus alexandrinus* and *Tadorna ferruginea*.	
Lac Merara	33°03.432'N, 06°03.967'E	65 ha	None	*Recurvirostra avosetta*, *Himantopus himantopus*, *Anarhynchus alexandrinus, Pterocles alchata* and *Pterocles orientalis*	
Chott Tighdidine	33°31.366'N 06°02.181'E	200 ha	None	*Anarhynchus alexandrinus, Himantopus himantopus* and *Tadorna ferruginea*.	
Lac Merdjadja	33°03.086'N 06°03.565'E	22 ha	None	*Anarhynchus alexandrinus* and *Tadorna ferruginea*.	
Chott Lgoug	32°53.576'N 05°59.330'E	78 ha	None	*Anarhynchus alexandrinus* and *Tadorna ferruginea*.	

Lac Ayata (33°29′867″ N, 5°59′403″ E) is one of the most important wetlands in the Oued Righ Valley **(Bouzegag, 2008)**. During the flood season, the water body covers an area of approximately 40 hectares **(Nouidjem, 2008)** (Fig. 1, Photo 1). The wetland is divided into two distinct sections. The northern portion, spanning 20 hectares, is an open body of water with a maximum depth of 60cm and no vegetation. The southern portion consists of a reed bed dominated by *Phragmites australis* **(Bouzegag, 2015)**, providing excellent shelter and cover for wildlife seeking refuge from the heat of the day.

Mammals recorded in this reed bed include the wolf (*Canis lupus*), fennec fox (*Vulpes zerda*), wild boar (*Sus scrofa*), and Cape hare (*Lepus capensis*) **(Bouzegag, 2015)**. The site also hosts numerous waterbirds, including the greater flamingo (*Phœnicopterus roseus*), a regular breeder in the valley **(Bensaci *et al.*, 2011, 2013)**, as well as the northern shoveler (*Spatula clypeata*), the mallard (*Anas platyrhynchos*), the white stork (*Ciconia ciconia*), and various shorebird (wader) species **(Bouzegag, 2015)**.

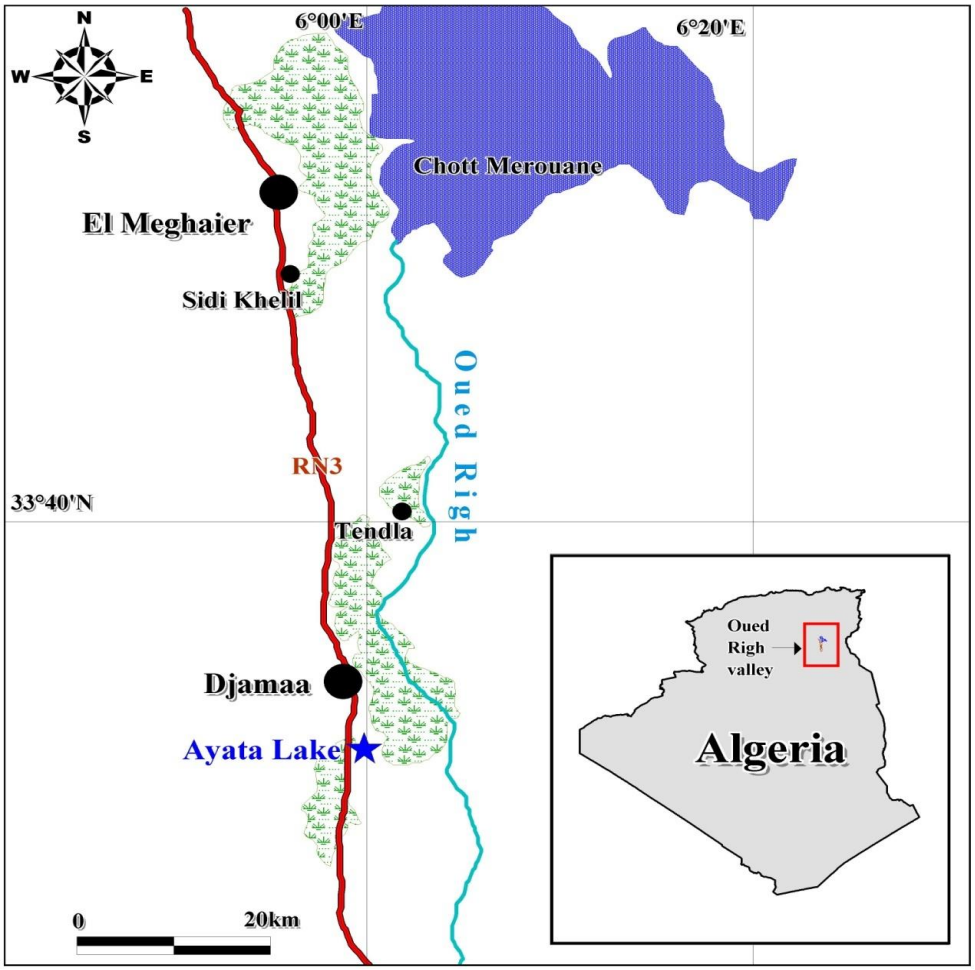

Fig. 1. Geographical location of Lac Ayata

Photo 1. View of the southern sector of Lac Ayata (Taken by Ines Houhamdi 14th January 2023)

Sampling

Counts of northern shoveler (*Spatula clypeata*) were conducted at Lac Ayata in the Oued Righ Valley (northern Algerian Sahara) throughout the wintering season, from September 2023 to mid-April 2024. The wintering season—defined as the period between two breeding events—generally extends from September to late March or early April. Field surveys were carried out every two months. When bird groups were within 200 meters and contained no more than 200 individuals, counts were made individually. In contrast, visual estimates of population size were used for larger and more distant flocks **(Lamotte & Bourlière, 1969; Blondel, 1975; Tamisier & Dehorter, 1999; Houhamdi, 2002)**. This widely used method for counting waterbirds in wetlands has an estimated margin of error of 5–10% among experts **(Blondel, 1975; Houhamdi, 2002)**. To improve accuracy, several counts were made from different observation points, and the average value was retained as the sample size for analysis.

The second phase of the study focused on tracking daily activity patterns of these surface-feeding ducks. The scan sampling technique (Instantaneous Scan Sampling) was selected because it is well suited to large, open habitats with minimal disturbance **(Altman, 1974; Baldassare *et al*., 1988; Losito *et al*., 1989; Tamisier & Dehorter, 1999; Houhamdi, 2002)**. During the wintering season, 80–90% of individuals present in the wetland were regularly scanned, with observations targeting behaviors that were readily visible. The study ran twice a month from the species' first arrival in September 2023 until their complete departure in mid-April 2024.

The recorded activities included sleeping, swimming, preening, flying, courtship and antagonistic behaviors, and feeding (at the surface, by head-dipping, or by body-tipping). Observations were made hourly from 08:00 to 16:00, and an average of the

recorded proportions was calculated. This approach provides valuable ecological insight into the role of this Saharan wetland in meeting the species' needs—such as feeding and roosting—which remain poorly documented in Algeria. It also contributes to understanding the wintering strategy of this Anatidae species.

The wintering strategy of the Northern Shoveler at Lac Ayata was further described by applying multivariate statistical analysis (Correspondence Factor Analysis, CFA) to the diurnal time budget data **(Chessel & Doledec, 1992)**.

RESULTS AND DISCUSSION

Structure and phenology

The Northern Shoveler (*Spatula clypeata*) is the quintessential wintering species at Lac Ayata, as confirmed by its continuous presence throughout the study period (Fig. 2). Similar patterns have been reported elsewhere in the Oued Righ Valley **(Bouzegag, 2008, 2015)**. The first individuals—six birds—were recorded in the central open-water area during the first half of September. From there, the population followed a generally Gaussian trend, increasing steadily and peaking at 375 individuals in the first half of December, the highest number ever recorded for this species at the site during winter. This peak coincided with the massive influx of post-nuptial migratory groups moving south toward larger Saharan water bodies.

Following the peak, a gradual decline was observed, with 53 individuals recorded in the first half of April. By mid-April, no northern shovelers remained at the site. This zooplanktivorous species is highly sensitive to water depth **(Pirot, 1981; Pirot *et al.*, 1984; Metallaoui *et al.*, 2014; Amor Abda *et al.*, 2015; Khemis *et al.*, 2016, 2017a, b; Tabouche *et al.*, 2016; Bendjedid *et al.*, 2020)** and was most frequently observed in the deeper, central parts of the lake, where it appeared more gregarious and active.

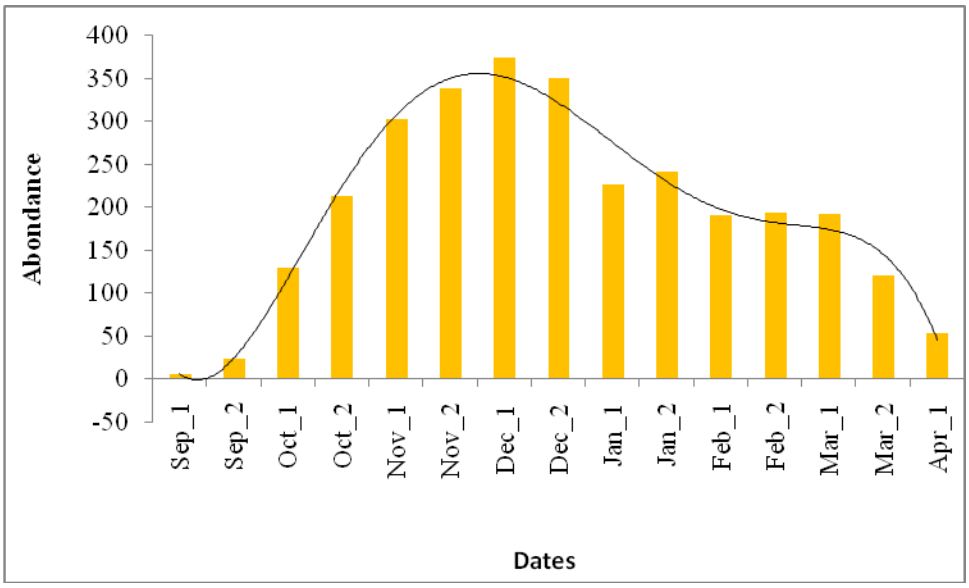

Fig. 2. Evolution of abundance of northern shoveler wintering in Lac Ayata

Study of diurnal activity rhythms

Feeding behavior dominated the overall diurnal activity budget of northern shovelers wintering at Lac Ayata (September 2023 to mid-April 2024), accounting for 46% of the daily time budget (Fig. 3). Sleeping ranked second at 26%, followed by swimming at 17%, preening and feather maintenance at 7%, and flight, courtship displays, and agonistic behaviors at 1% each. These results are consistent with previous findings from several wetlands along the High Plateau and Algerian coast **(Metallaoui *et al*., 2014; Abda *et al*., 2015; Khemis *et al*., 2016, 2017a, 2017b; Tabouche *et al*., 2016; Bendjedid *et al*., 2020)**.

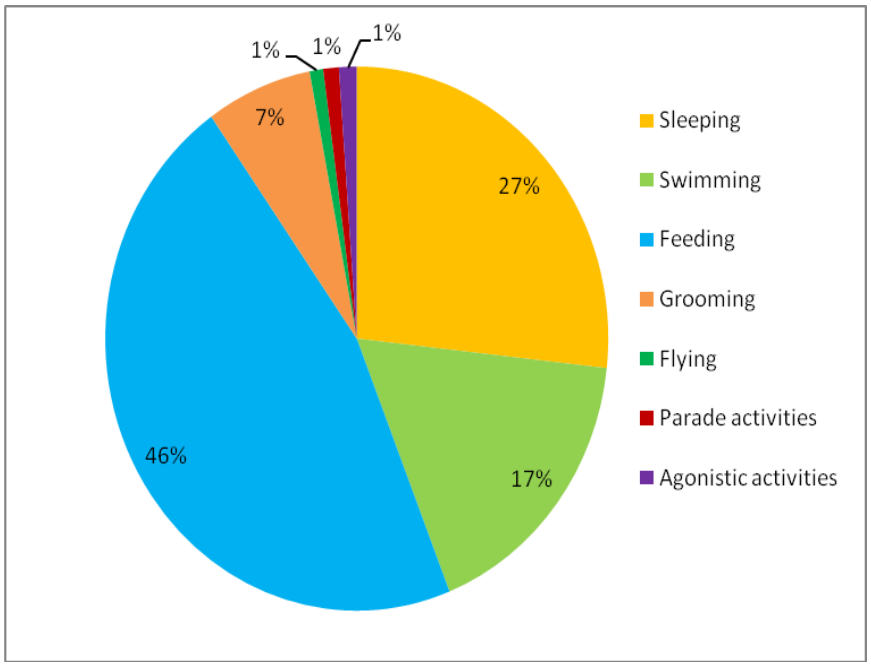

Fig. 3. Diurnal time budgets of northern shoveler wintering in Lac Ayata

Surface feeding accounted for the largest share of the diurnal feeding budget in northern shovelers, representing 52% of total feeding activity. This was followed by head-immersion feeding (31%) and diving, which made up 7% of the total budget (Fig. 4). In the central portion of the water body, surface feeding was most commonly observed in the early morning and late afternoon, often in proximity to other overwintering Anatidae species such as the mallard (*Anas platyrhynchos*) and the Eurasian teal (*Anas crecca crecca*). Swimming activity showed a strong correlation with this behavior.

Toward the end of the day, shovelers increasingly engaged in head-immersion feeding. These zooplanktivorous ducks benefit from greater prey availability at this time, as poikilothermic aquatic insects become more active **(Houhamdi, 2002; Metallaoui *et al.*, 2014; Tabouche *et al.*, 2016; Khemis *et al.*, 2017b)**. Diving was most frequently observed during midday hours as temperatures rose, when the birds dispersed across the entire water body. Surface feeding was often associated with swimming, during which the birds selectively chose food items. However, head-immersion feeding typically indicated reduced food availability at the surface, often due to competition with other waterbirds that fed at depth without selection. As food demands increased, shovelers resorted more to diving, swallowing whatever prey they encountered at depth **(Baldassare *et al.*, 1988; Losito *et al.*, 1989; Tamisier & Dehorter, 1999; Houhamdi, 2002)**.

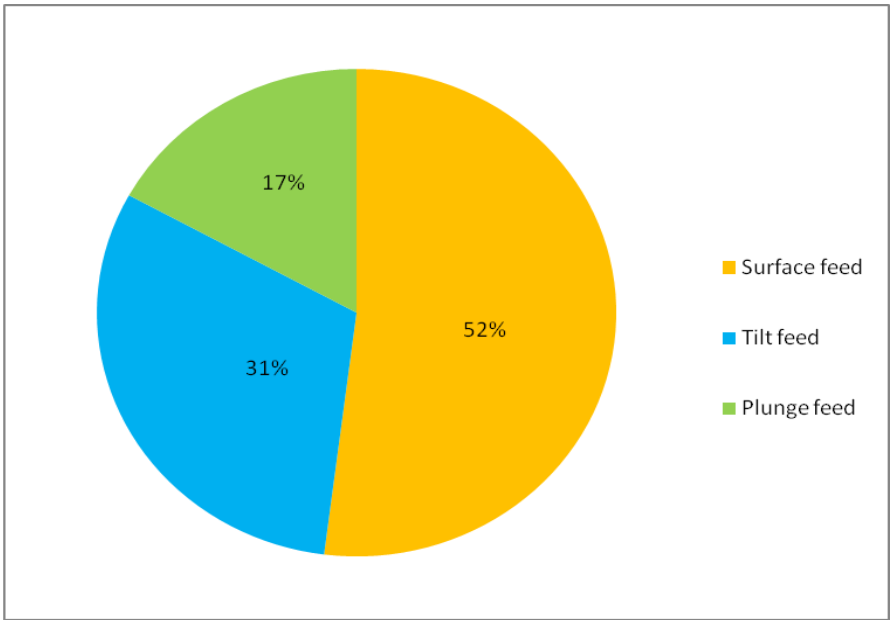

Fig. 4. Mode of feeding of northern shoveler wintering in Lac Ayata

For this zooplanktivorous species, feeding occurs exclusively in the water, with rates ranging from 32% in September to 53% at the end of February (Fig. 5). Although recorded throughout the entire wintering season (Fig. 6), feeding activity fluctuated between periods, showing a sawtooth pattern with the lowest rates generally observed at the beginning of the season. Similar patterns have been reported in other Algerian wetlands **(Metallaoui *et al*., 2014; Abda *et al*., 2015; Tabouche *et al*., 2016; Khemis *et al*., 2017a, b; Bendjedid *et al*., 2020)**. Feeding activity typically peaked in February, March, and April—the pre-nuptial migration preparation period **(Houhamdi, 2002; Metallaoui *et al*., 2014)**.

Toward the end of the season, northern shovelers became more active in preparation for migration, employing diving, body-tipping, and surface feeding to accumulate the lipid reserves needed for their trans-Mediterranean journey to breeding grounds **(Pirot, 1981; Pirot *et al*., 1984; Thomas, 1976; Metallaoui *et al*., 2014)**. The consistently high feeding activity rates indicate that Lac Ayata serves as an important diurnal foraging ground for this species.

Sleeping ranked second in the daily activity budget (Fig. 5) and is considered an effective energy-conservation strategy **(Tamisier, 1972a, 1972b; Houhamdi *et al*., 2001, 2003, 2008)**. Sleep was most prominent in the early morning, although observed throughout the day. At the start of the wintering season, sleeping rates reached 44%, then steadily declined to 11% by April 2024. This behavior was observed almost exclusively in the morning, with afternoons typically devoted to increased feeding. For migratory individuals, daytime rest is an important way to conserve energy in cold weather **(Tamisier & Dehorter, 1999; Houhamdi & Samraoui, 2001, 2003, 2008)**. Among

settled individuals, it is primarily associated with post-migratory recovery during the initial months of occupation of the wetland.

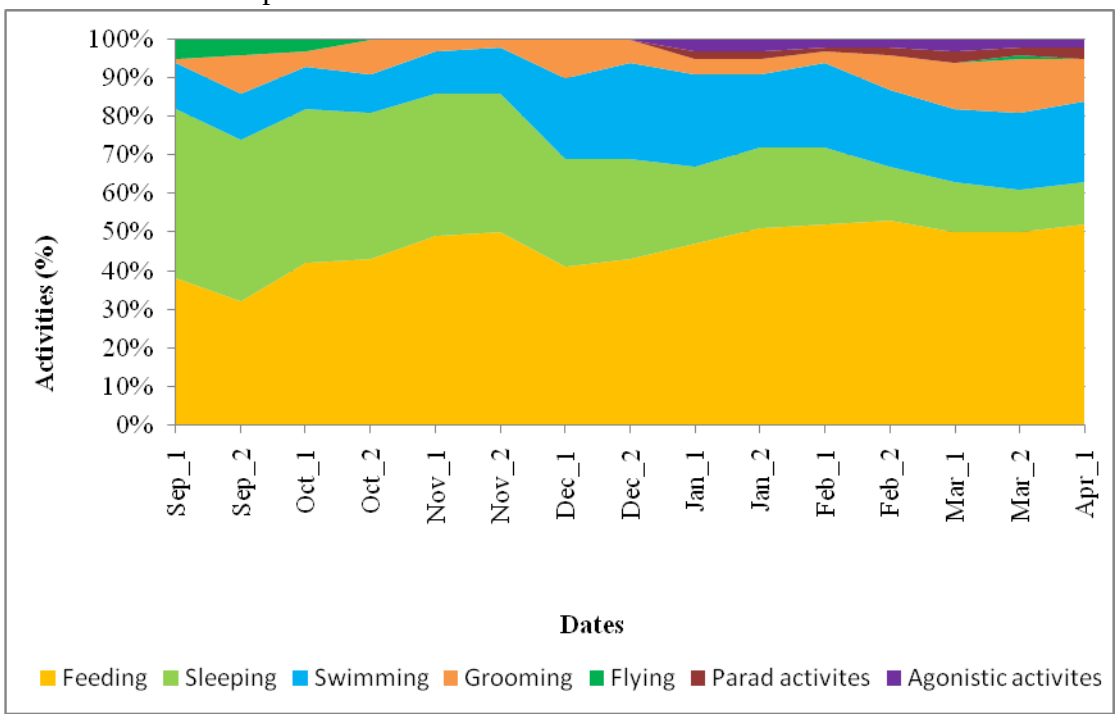

Fig. 5. Evolution of the diurnal activities of the northern shoveler wintering in Lac Ayata

Swimming is a key activity for these zooplanktivorous ducks **(Metallaoui *et al.*, 2014; Abda *et al.*, 2015; Tabouche *et al.*, 2016; Khemis *et al.*, 2017b)**, serving both as a means of locomotion and as part of feeding behavior. Northern shovelers often feed while swimming, particularly at the water's surface **(Tamisier, 1972b, 1972c)**. At the start of the wintering season, swimming activity was low, ranging from 10 to 12%. From December 2022 onward, levels doubled, remaining high until the end of the season, with rates between 20 and 25% (Fig. 6). Swimming was most often observed around midday, when temperatures were high and the water body was shared with other waterbird species.

Feather maintenance (preening) was recorded at rates fluctuating between 2 and 15% (Fig. 6). This activity becomes particularly important in the late wintering season, during the pre-nuptial migration preparation period. Observed both in the water and along the shores of Lac Ayata, preening plays a crucial role in the development of new plumage and the replacement of damaged feathers **(Houhamdi & Samraoui, 2002)**.

In the diurnal activity budget, flight was classified as a secondary behavior, along with courtship displays and antagonistic interactions, each accounting for roughly 1% of daily activity (Fig. 4). Flight behavior is often contagious: when a small group takes off, it frequently prompts the entire flock, as well as other species on the lake, to follow. Usually triggered by disturbances, flights often serve to help northern shovelers regroup **(Houhamdi, 2002; Houhamdi & Samraoui, 2002)**. At the start of the wintering season

(September–October), flight activity was more frequent, representing 3–5% of the daily budget (Fig. 7). By the end of the season, the rate had dropped to around 1%, after which it was rarely observed.

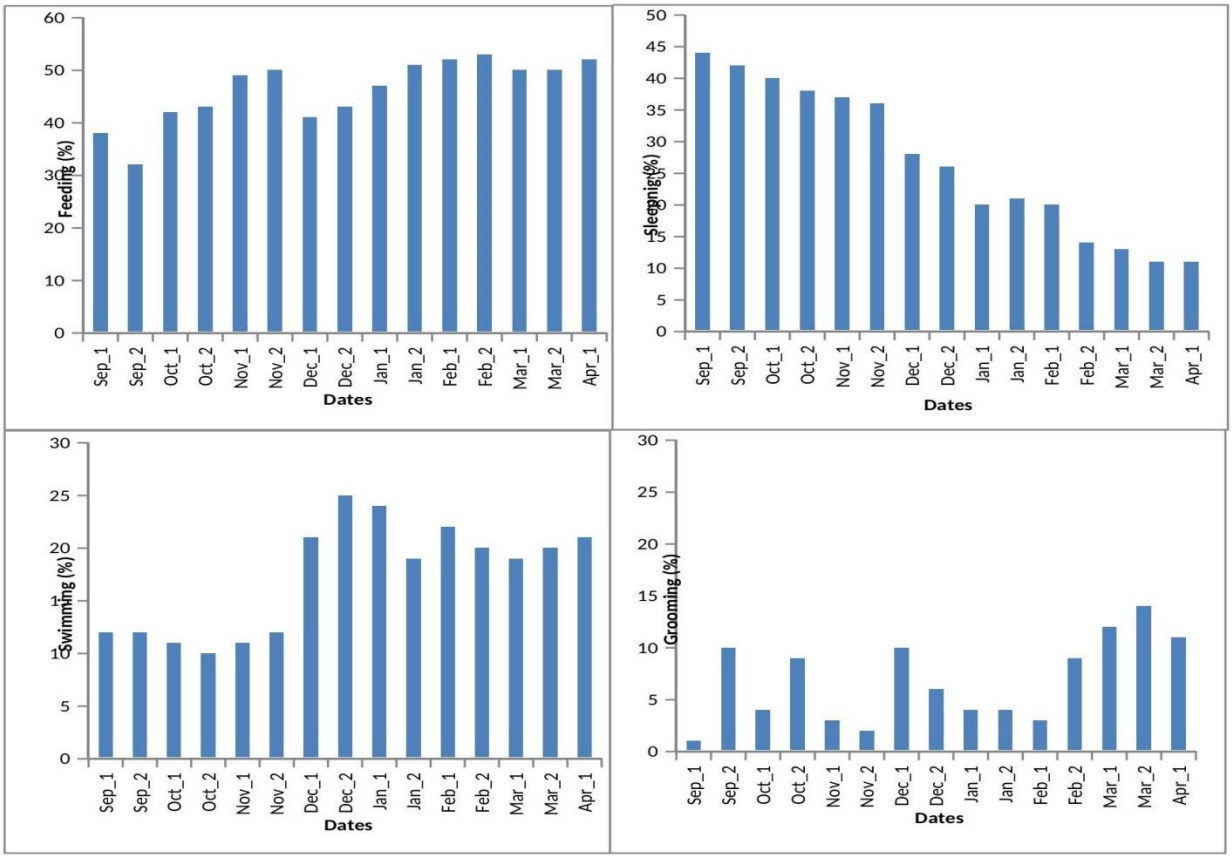

Fig. 6. Evolution of the feeding, swimming, sleeping and grooming activities of northern shoveler wintering in Lac Ayata

In this diurnal time budget study, courtship displays and antagonistic behaviors—often signaling the onset of the breeding season—were recorded at very low rates **(Tamisier & Dehorter, 1999; Houhamdi, 2002)**, each accounting for approximately 1% of the daily activity budget (Fig. 4). These behaviors in northern shovelers were first observed in January 2023, with rates typically ranging from 1 to 3% (Fig. 7). Courtship displays occurred exclusively in the water, where males actively pursued females or performed displays such as wing- and head-bobbing. Antagonistic behaviors—encounters or challenges between males—were usually triggered when a male entered another pair's territory or when two males competed for the same female **(Houhamdi, 2002)**.

Both courtship and antagonistic behaviors are far more frequent during the breeding season **(Tamisier & Dehorter, 1999)**. In Anatidae, these activities, often observed together, take place toward the end of the wintering season during pair formation, particularly among experienced individuals. Early pair formation during

wintering is generally associated with higher reproductive success **(Tamisier & Dehorter, 1999; Houhamdi, 2002)**.

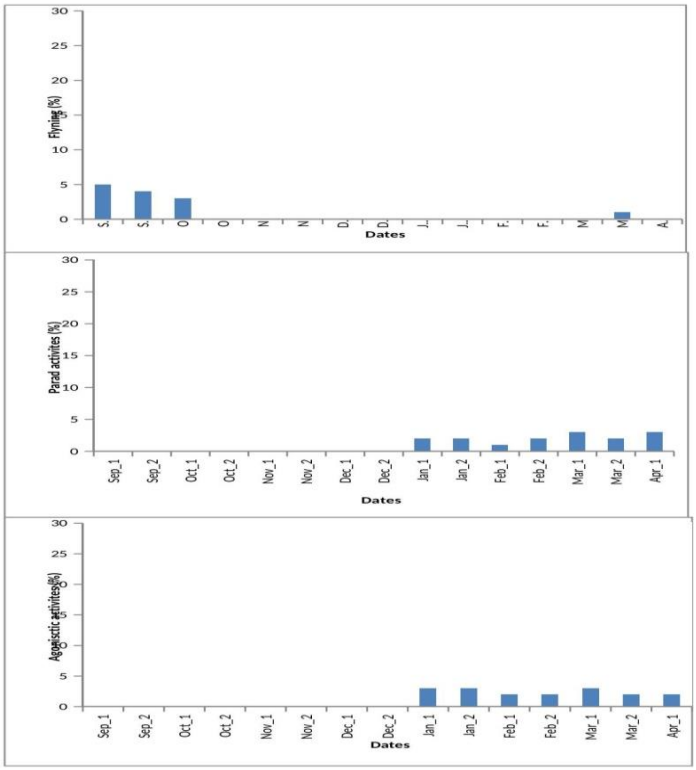

Fig. 7. Evolution of the flight activities, parades and agonistic activities of the northern shoveler wintering in Lac Ayata

Based on multivariate analysis of the data collected throughout the wintering season, the behavioral cycle of the northern shovelers at Lac Ayata can be divided into four distinct yet interdependent phases. Correspondence Analysis (CA) was performed on seven recorded activities across fifteen observation sessions, with results plotted on the factorial plane 1 × 2. The first two axes explained 46 and 7% of the variance, respectively, for a cumulative total of 53%. This factorial map (Fig. 8) provides a temporal occupancy profile of Lac Ayata, illustrating how wintering northern shovelers engage in a genuine spatio-temporal partitioning of the wetland.

The first sub-period extends from early September to mid-October and is characterized by flight activity. During this phase, the birds—still wary—frequently take short flights over the water before regrouping.

The second sub-period spans mid-October to mid-December and is dominated by sleeping behavior. This phase coincides with the arrival of post-nuptial migrants, when rest is essential for conserving energy, particularly in individuals fatigued or weakened from migration.

The third sub-period, from late December to the end of February, is marked by a strong association between swimming and feeding activities. After diurnal rest, the

northern shovelers typically feed while swimming, a pattern that reflects their dependence on aquatic prey.

The fourth sub-period encompasses March to mid-April and signals the end of the wintering season. During this phase, courtship displays and antagonistic interactions are frequently observed alongside preening and plumage maintenance. These comfort behaviors are critical for birds preparing for pre-nuptial migration, enabling them to arrive at breeding grounds in optimal condition, with well-maintained plumage and established pair bonds.

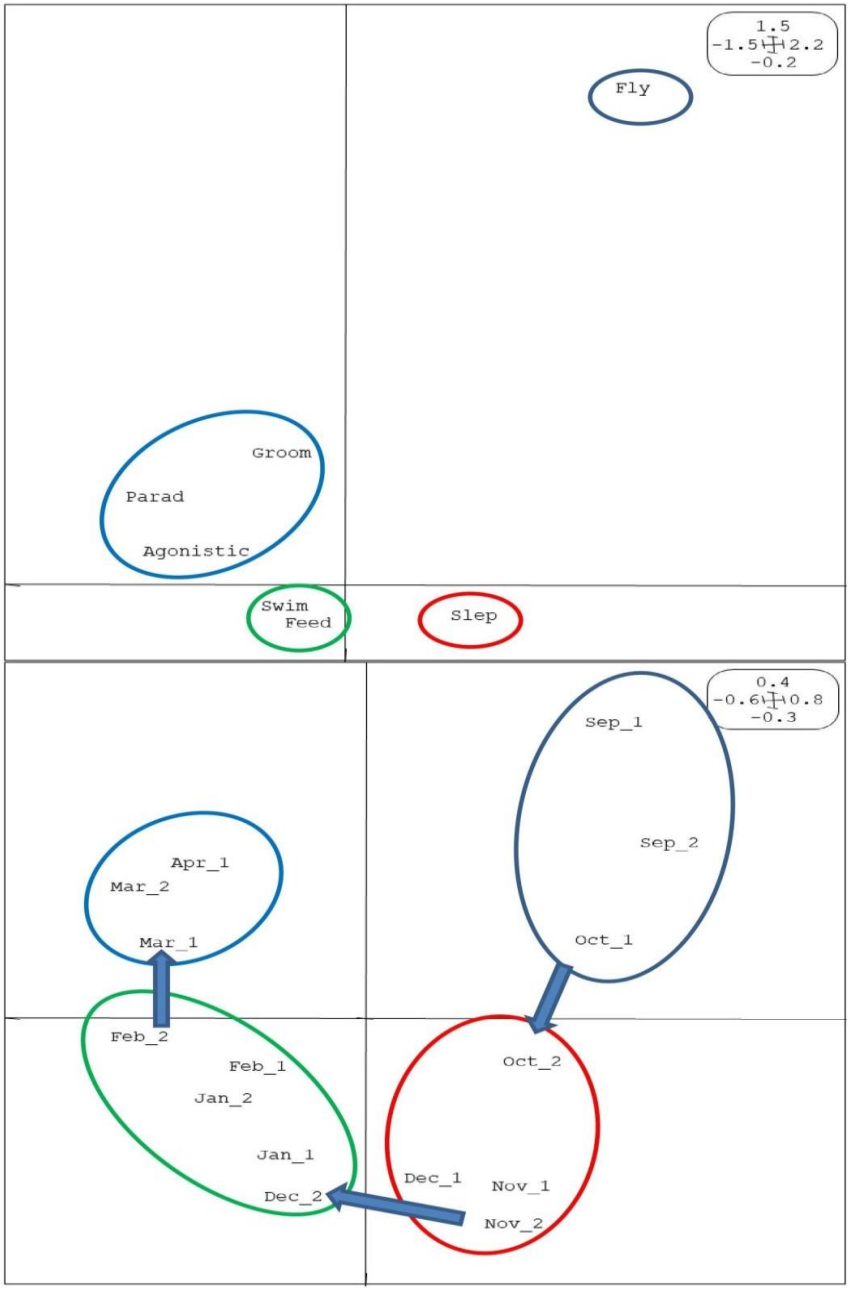

Fig. 8. Factorial plan (1x2) of the AFC of the diurnal activities of the northern shoveler wintering in Lake Ayata

Overall, the wintering season of northern shovelers at Lac Ayata can be described in several sequential stages. Flight activity dominates among the earliest arrivals, which are often inexperienced and highly cautious, taking off at the slightest disturbance. As the season advances, sleep behavior becomes increasingly important for replenishing energy lost during migration, and it is widely recognized as the most effective energy-conservation strategy **(Tamisier & Dehorter, 1999; Houhamdi, 2002)**.

Following sleep, feeding emerges as the next major activity, providing a reliable means of restoring energy reserves. By consuming zooplankton, the northern shovelers improve their body condition in preparation for pre-nuptial migration to their traditional breeding grounds **(Houhamdi & Samraoui, 2001, 2002, 2003, 2008; Houhamdi, 2002; Metallaoui *et al*., 2009; Metallaoui *et al*., 2014; Abda *et al*., 2015; Khemis *et al*., 2016; Tabouche, 2017)**. This aquatic foraging, which occurs exclusively in the water, is closely associated with swimming **(Metallaoui *et al*., 2014; Amor Abda *et al*., 2015; Khemis *et al*., 2017a, b)**.

Toward the end of the wintering period, the birds devote an increasing time to plumage maintenance, courtship, and antagonistic interactions—behaviors that often occur together. These activities facilitate pair formation and signal the approach of the breeding season, marking the conclusion of the wintering cycle.

CONCLUSION

In Algeria, during the 2022–2023 wintering season, the behavior of the northern shoveler—a species previously studied extensively in coastal and High Plateau wetlands—was observed at Lac Ayata (Wilaya of El-Méghair, Oued Righ Valley), a Saharan wetland. This small water body, which retains water year-round, supported a substantial number of these surface-feeding, zooplanktivorous ducks throughout the season. The highest count was recorded in mid-winter, with 375 individuals observed in the first half of December 2022. The ducks were predominantly seen in open-water areas, exhibiting the gregarious behavior typical of Anatidae during winter. These observations confirm that the species is a regular and abundant visitor to this site.

The diurnal behavior of the species in the same wetland was also investigated. Seven activities were recorded: sleeping, swimming, preening, flying, courtship displays, antagonistic interactions, and feeding (at the surface, by body-tipping, and by diving). The activity budget was dominated by feeding, which accounted for 46% of total daytime activity—nearly half of the observed behavior. As an aquatic zooplanktivore, the northern shoveler feeds exclusively in the water. Sleeping ranked second at 27%, followed by swimming at 17%, preening at 7%, and courtship, antagonism, and flying at low rates of about 1% each. Early in the season, flying and sleeping predominated among the first arrivals; as the season progressed, feeding and swimming became the main activities.

Comfort behaviors (courtship and antagonism) and plumage maintenance became more frequent toward the end of the wintering period, particularly during sunny hours.

Feeding, which is always associated with swimming, was observed in three forms: surface feeding, body-tipping with head submersion, and full diving. Diurnal observations indicate that Lac Ayata serves as a significant daytime feeding area for the northern shoveler. These unprotected oases hold both national and international importance as feeding grounds and may also provide potential nesting sites for this and other Anatidae species. To preserve their ecological integrity during both wintering and breeding periods, close monitoring is essential. Developing a national conservation strategy and action plan to safeguard these ecosystems and their habitats is therefore a priority.

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