

A comparative study of the diurnal behaviour of the Northern Shoveller (*Anas clypeata*) during the wintering season at Garaet Hadj-Tahar (North-East Algeria) and Garaet Timerganine (Algerian highlands)

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Abstract: The rhythms of the Northern Shoveller's (*Anas clypeata* Linnaeus, 1758) activities during its wintering period in 2 wetlands, Garaet Hadj-Tahar (North-East Algeria) and Garaet Timerganine (Oum El-Bouaghi, Algerian highlands), were studied during 2 wintering seasons in Garaet Hadj-Tahar from November 2007 to March 2008 and November 2008 to March 2009, and in the Timerganine wetland from November 2007 to March 2008. They were linked to certain spatiotemporal variables, i.e. daytime activities and 2 different wetlands. During the wintering season, the main activity at Garaet Hadj-Tahar was sleeping (70%), followed by swimming (12%). By contrast, feeding was the dominant activity at Garaet Timerganine, occurring 45% of the total monitoring time, followed by sleeping (35%). The frequency of the behaviours did not differ significantly between the sites as a function of the date ($P > 0.05$). The choice of the site was made according to either the feeding resources or the resting place. These factors are therefore essential and highlight the importance of the protection of the sites where the species is concentrated outside of the breeding period.

Key words: Northern Shoveller, wetlands, wintering, season activity budget, behaviour

1. Introduction

The ecological importance of Algerian wetland complexes lies primarily in the role they fill for migrating birds during the winter quarter. However, they face growing human activities that affect the entire region (Hollis, 1992; Tamsier and Grillas, 1994), including hunting in some wetlands, human disturbance due to children and water pumping, climate change, and severe weather, which makes it necessary to develop a management plan that will allow effective and strong protection (Dehorter and Tamsier, 1996). Therefore, information on population estimates and trends, identification of imperilled species, and factors affecting them are of immense importance for conservation practitioners (Salafsky et al., 2002; Battisti et al., 2008).

The Guerbes-Sanhadja wetlands in North-East Algeria and the extensive brackish wetlands of the highlands in the north have been the subject of scientific study for only a few years. Lake Tonga (El-Kala National Park) in the north-east of Guerbes-Sanhadja and Garaet Hadj-Tahar

currently host the largest populations of White-headed Duck *Oxyura leucocephala* Scopoli, 1769 (Metallaoui et al., 2009); Ferruginous Duck *Aythya nyroca* Gùldenstàdt, 1770 (Aissaoui et al., 2009); and other ducks (family Anatidae), such as the Eurasian Wigeon *Anas Penelope* Linnaeus, 1758; the Gadwall *Anas strepera* Linnaeus, 1758; the Common Teal *Anas crecca* Linnaeus, 1758; and the Common Pochard *Aythya ferina* Linnaeus, 1758 (Houhamdi and Samraoui, 2001, 2003, 2008; Metallaoui and Houhamdi, 2008; Metallaoui, 2010; Metallaoui and Houhamdi, 2011), in Algeria and North Africa. Following the discovery of the Greater Flamingo *Phoenicopterus roseus* Pallas, 1811 nesting in Garaet Ezzemoul (Boulekhssaim et al., 2006a; Saheb et al., 2006; Samraoui et al., 2006), the wetlands of the highlands have been shown to be important for the wintering of numerous species of migratory birds, such as the Common Shelduck *Tadorna tadorna* Linnaeus, 1758 (Boulekhssaim et al., 2006b); the Common Crane *Grus grus* Linnaeus, 1758 (Houhamdi et al., 2008); the White-headed Duck (Houhamdi et al., 2009); some species of

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Anatidae, such as the Eurasian Wigeon, the Gadwall, the Common Teal, the Ferruginous Duck, and the Common Pochard (Maazi, 2009); and flocks of shorebirds and waders (Seddik et al., 2010).

As the predominant member of Anatidae in Algeria, the Shoveller has the status of wintering migrant. During the winter period, the Western Palearctic region hosts 3 large populations (Rose and Scott, 1994) of Shovellers. The most important is in the Black Sea/Mediterranean region, estimated to host 220,000 individuals, followed by the West Mediterranean region (175,000 individuals) and North-West Europe (40,000 individuals). In Garaet Timerganine, the largest number of Shovellers was observed during the 2007–2008 wintering period, with a maximum of 380 individuals. Garaet Hadj-Tahar has hosted larger numbers of individuals, e.g., 2500 in January 2007 (Metallaoui and Houhamdi, 2010).

Although the reproduction of the Shoveller has been well studied (McKinney, 1970; Poston, 1974; Seymour, 1974), as well as the place it occupies in summer in the waterfowl community (Bellrose, 1976; Pöysä, 1983), studies of daytime activity rhythms during the winter at single or multiple sites have been rare. These rhythms can, however, affect the physical conditions, breeding (Paulus, 1980; Krapu, 1981), and survival of the ducks (Fretwell, 1972). Moreover, activity budgets are basic yet powerful general tools in the study of wild populations, since an understanding of species' behavioural requirements is a prerequisite for proper management (Sutherland and Gosling, 2000).

The daytime activity budget plays a major role in determining an animal's adaptations to seasonal and diurnal variations in environmental factors. During some periods of the year, individuals may have to increase their energy intake to meet particular needs, such as those linked to migration and reproduction (King, 1974; Ricklefs, 1974). Knowledge of the time activity budget can therefore provide useful information on the survival strategy it is adopting and help in Shoveller conservation and management.

The aim of this study was to compare the daytime activity budget of wintering Shovellers on 2 sites during 1 wintering season. Daytime activity budget was compared at Garaet Hadj-Tahar (located on the northern coast of Algeria) and Garaet Timerganine (a body of water in the East Algerian highlands). The comparison of the activity rhythms from these 2 inland aquatic ecosystems allows us to identify the similarities and differences of these Shoveller wintering grounds, and the comparison between 2 consecutive years at the same site (Site A) allows us to assess the repeatability of the behaviours.

2. Materials and methods

2.1. Description of the study areas

2.1.1. Garaet Hadj-Tahar

In the province of Skikda on the eastern coast of Algeria, the Guerbes-Sanhadja complex has been classified as a Ramsar Site since 2 February 2001. It comprises salt lagoons, lakes, and freshwater marshes and is bordered on the west by the coastal hills of Skikda and on the east by the coastal Chetaibi Mountains (Figure 1). Garaet Hadj-Tahar is a part of this complex (Figure 1; 36°51'N, 07°15'E); it is a freshwater pond (Figure 2) covering 112 ha located 20 km from the Mediterranean Sea, with an average altitude of 16 m. Its average depth is 0.8 m (maximum: 2 m). The north-west shores are characterised by shallow depth and abundant food. The lake is fed by the runoff of rainwater from the surrounding mountains and by the tributaries of the river Oued El Kébir. The vegetation of the Garaet is abundant and diversified and includes some rare species. Masses of *Nymphaea alba* Linnaeus, 1753; *Typha angustifolia* Linnaeus, 1753; *Phragmites australis* Adans, 1763; *Scirpus maritimus* Linnaeus, 1753; *S. lacustris* Linnaeus, 1753; and *Iris pseudacaurus* Linnaeus, 1753 occupy 60% to 70% of the total area of the water. The pond is bordered by a bed of vegetation composed mainly of *Juncus acutus* Linnaeus, 1753; *J. maritimus* Linnaeus, 1753; *Olea europaea* Linnaeus, 1753; *Rubus ulmifolius* Schott, 1818; and grassy areas dominated by *Cynodon dactylon* Linnaeus, 1805 and *Paspalum distichum* Linnaeus, 1760. The land surrounding Garaet Hadj-Tahar is bordered exclusively by vegetable crops.

2.1.2. Garaet Timerganine

The brackish wetlands of the eastern Algerian highlands (plateaus of South Constantine), located in valleys that have semiarid climates, are one of the most extensive and diversified wetlands complexes in Algeria. Garaet Timerganine (Figure 1; 35°39.241'N, 06°57.468'E), which has been listed as a Ramsar Site since 18 December 2009, covers an area of 250 ha and has an average altitude of 850 m. The region is mainly marked by endorheism, which is reflected by the existence of a multitude of potholes, some of which flood occasionally and others frequently (Figure 3), concurrent with the flooding of the river Oued Boulefraiss. The waters of Timerganine are derived from storm and flood waters conveyed by the main tributary, Oued Boulefraiss, which begins in the Aurès Mountains. As a result, the majority of sites whose water supply depends on rainfall dry up in June (Houhamdi et al., 2008).

In 2006, 2007, and 2008, the water level in the Garaet underwent many fluctuations. Two dry periods occurred: the first on 27 February 2007, and the second from the beginning of September 2007 to the end of October 2007. The dominant soil substrate is rich in magnesium chloride

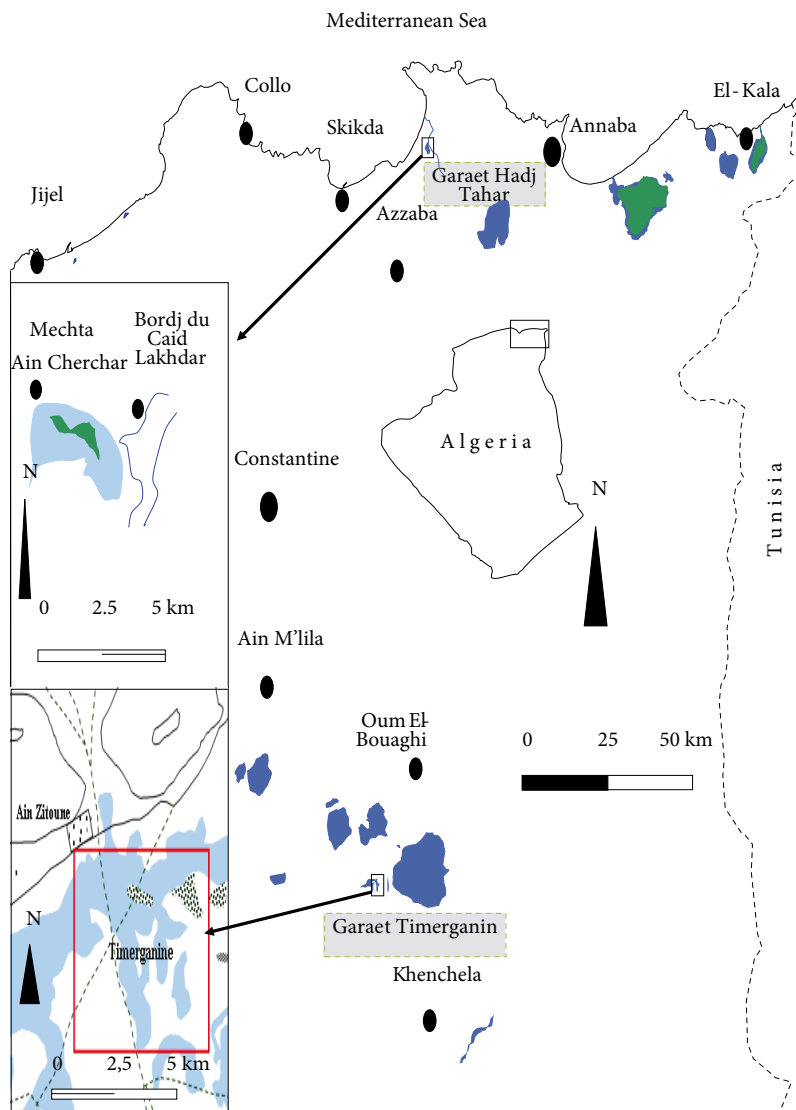


Figure 1. Map of the geographical positions of the 2 study sites: Garaet Hadj-Tahar (North-East Algeria) and Garaet Timerganine (North Algerian highlands).



Figure 2. Photograph of general view of Garaet Hadj-Tahar, Skikda (January 2008).



Figure 3. Photograph of general view of Garaet Timerganine, Oum El-Bouaghi (January 2008).

and allows for the development of only highly adapted halophyte flora, mainly species of the Chenopodiaceae family such as *Atriplex halimus* Linnaeus 1753, *Atriplex patula* Linnaeus 1753, and *Salicornia fruticosa* Linnaeus 1753; crucifers *Moricandia arvensis* Linnaeus (DC.) 1821, *Matthiola fruticosa* Rouy & Foucaud, 1893, *Diplotaxis muralis* Linnaeus (DC) 1821, and *Carex divisa* Huds 1762; and *Scirpus maritimus* Linnaeus 1753, *S. triquetus* Linnaeus 1767, and *Phragmites australis* Linnaeus 1753 (Zemouchi and Ounissi, 2004).

The time–activity budget has been recognised as an important tool for understanding habitat use and niche separation (Rave and Baldassarre, 1989), and consequently it is an invaluable aid for managing waterfowl communities and habitats. Fieldwork was carried out between the months of November and March each winter from 2007–2008 to 2008–2009 in Garaet Hadj Tahar (site A) and during 1 wintering season (from November 2007 to March 2008 only, because it underwent a dry period until December) in Garaet Timerganine, and consisted of behavioural monitoring. The observations were made by a single observer from the same observation points from early November until the end of March, every hour from 0900 to 1500 hours (Tamisier and Dehorter, 1999), twice a month. Days of inclement weather (persistent rain, high winds, poor visibility) were avoided. Hepworth and Hamilton (2001) undertook sampling at approximately monthly intervals.

The transect method with direct count (Bibby et al., 2000) was used to study the abundance of the Northern Shoveller. Scan sampling requires that the behaviour of individuals in the sample be recorded instantaneously (Altmann, 1974). Many waterfowl activity budget studies utilising scan sampling involve surveying the entire local population at the time of sampling, e.g., all birds on a pond (Skead, 1977; Norman et al., 1979; O'Donoghue and 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 nonoverlapping sections that are observed separately. The data then need to be weighted according to the numbers of birds observed in the different sections (Hepworth and Hamilton, 2001). It took approximately 1 h to sample the entire pond. The different behaviours of the monitored ducks were identified using binoculars (Konus 20 × 70 by Konus Italia Group SpA., Italy). To facilitate sampling, the pond was divided into 5 sections. The purpose of these sections was only to aid surveying. Each of the 5 sections was scanned from left to right (Hepworth and Hamilton, 2001). One of the following activity classes was assigned to each individual without distinction of sex: feeding, sleeping, swimming, grooming, flying, and courtship. Antagonistic behaviour was not taken into

account because of its infrequency. All of the different types of feeding behaviours by submersion of the beak, the head, the beak and head, or the head and neck or by flyover or on foot were considered feeding activities

The aim of the sampling described above was to obtain sound estimates of the numbers 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.

A total of 60 h were devoted to monitoring diurnal activities during the wintering season 2007–2008 in the 2 sites and 120 h in Garaet Hadj-Tahar during the seasons 2007–2008 and 2008–2009.

The behavioural data were analysed using multivariate analysis of variance (MANOVA) (Morrison, 1967). The main purpose of this analysis was to test the effects of sites, years, dates, and hours on the percentage of individuals engaged in a particular activity. The homogeneity of variances was systematically tested using Levene's test (Levene, 1960).

In this way, a diurnal data matrix (15 days/6 activities, hours/6 activities, 2 sites/6 activities, and 2 years/6 activities) was assembled and analysed using MANOVA.

3. Results

The monitoring of the diurnal time budget during 1 wintering period, a total of 60 h, indicated that at Garaet Hadj-Tahar sleeping was the main activity (70%) where the birds found refuge in the western sector covered by water lilies, followed by swimming (12%), feeding (8%), grooming (5%), and flying (5%) (Figure 4A). At Garaet Timerganine, feeding was the main activity (45%) (Figure 4B), during which the Shovellers occupied the centre of the wetland near the north-west shores, which are characterised by low depth and abundant food, followed by sleeping (35%), and preening (9%). Time devoted to swimming and flying was relatively minor, with the respective values of 8% and 3%.

Swimming was relatively uncommon at the 2 sites (12% at site A and 8% at site B); it was due to the repositioning of the birds when the wind caused them to drift, or was related to the activities of courtship. Flight also occupied a small proportion of the Shovellers' time at the 2 sites and was due mainly to disturbance caused by the Marsh Harrier *Circus aeruginosus* Linnaeus, 1758 and the Yellow-legged Gull *Larus cachinnans* J.F. Naumann, 1840.

The frequency of some of the behaviours (grooming, swimming, flying, courting, sleeping, and feeding) differed significantly between the sites but not the dates (MANOVA; site $F_{5,6} = 15.48$, $P = 0.002$; 15 days $F_{20,20} = 1.53$, $P = 0.169$; site × 15 days $F_{20,20} = 1.47$, $P = 0.196$) (Table 1). Analyses show that the time spent sleeping and courting was more important at Garaet Hadj-Tahar, and

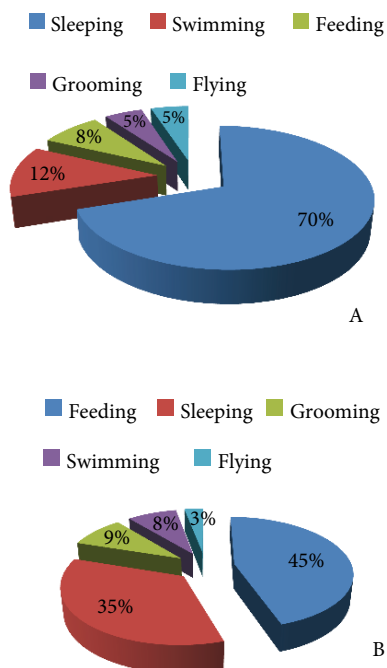


Figure 4. Percentage of time allocated by the Shoveller for diurnal activities at (A) Garaet Hadj-Tahar and (B) Garaet Timerganine.

that the time spent feeding was more important at Garaet Timerganine. The highest values for feeding (81.35%) were recorded at the end of the wintering season and displayed an inverse relationship to sleeping (Figure 5). Grooming also occupied a small proportion of the Shovellers' time. The highest values were recorded at the end of the wintering period at Garaet Hadj-Tahar (12.84%) and at the start of the season at Garaet Timerganine (25.17%) (Figure 5). Swimming is a part of the Shoveller's behaviour. At Garaet Hadj-Tahar, this activity increased gradually from 4.8% at the beginning of the wintering season to around 30.25% at the end of this period. At Garaet Timerganine, the peak was also observed at the end of the wintering period (approximately 26%). Time devoted to courting was relatively minor, with values rarely exceeding 1% at the 2 sites (Figure 5).

The behaviour frequencies varied significantly between the 2 sites but not among the hours of the day (MANOVA, site $F_{5,2} = 14.98$, $P = 0.064$; hour $F_{30,10} = 0.89$, $P = 0.623$; Table 2). Analyses suggest that the time spent feeding was significantly higher at Garaet Timerganine, whereas the time devoted to sleeping was lower at this site (Figure 5).

Feeding and sleeping were the 2 most common behaviours observed during fieldwork. At Garaet Hadj-Tahar, Shovellers spent a higher proportion of the day sleeping (76.14%) (Figure 5). However, a lower proportion of birds feed at this time (14.45%). At Garaet Timerganine, Shovellers feed for most of the day (35.23%).

Table 1. Results of MANOVA tests for differences between sites and periods for the behaviour frequencies of Northern Shoveller in 2007–2008. Period corresponds to 15-day periods during which observations were carried out and behaviour frequencies averaged.

	F	Effect df	Error df	P
Intercept	52.91	5	6.00	0.001
Site	15.48	5	6.00	0.002
Period	1.53	20	20.85	0.169
Site × period	1.47	20	20.85	0.196
	Adjusted R ²	df	F	P
Grooming	0.27	9, 10	1.80	0.187
Swimming	0.39	9, 10	2.36	0.099
Flying	0.03	9, 10	1.06	0.459
Courting	0.64	9, 10	4.76	0.011
Sleeping	0.65	9, 10	5.00	0.010
Feeding	0.75	9, 10	7.25	0.002

At Garaet Hadj-Tahar, we did not find a significant difference in the behaviour frequencies between years regardless of the time of the day (MANOVA; year $F_{5,2} = 0.800$, $P = 0.619$; hour $F_{30,10} = 0.500$, $P = 0.938$) (Table 3), but behaviour frequencies differed between sites according to 15-day periods (MANOVA; year $F_{5,6} = 4.708$, $P = 0.043$; 15 days $F_{20,20} = 1.816$, $P = 0.092$; year × 15 days $F_{20,20} = 1.871$, $P = 0.082$) (Table 4). Analyses suggest that the time spent sleeping and courting was higher in 2008 than in 2009 (Figure 6).

4. Discussion

The Northern Shoveller is present during the wintering season in a wide range of habitats including Numidia in North-East Algeria, the Hauts Plateaux, and the salt lakes of the Sahara (Bensaci et al., 2013), and there are generally more obvious differences in the use of these different sites. The physical differences between sites are largely a consequence of their function and current usage.

Dabbling ducks in colder areas (which hence have higher energy needs) compensate by increasing foraging time during daylight hours (Tamisier and Dehorter, 1999; Guillemain et al., 2002). At Garaet Timerganine, Shovellers use a sizeable part of their diurnal behaviour in feeding. This activity is affected by time period. The recorded peaks in diurnal feeding activity in the day between 1300 and 1500 hours and between February and March (Figure 5) could represent higher temperatures. This result adds weight to the evidence for a Shoveller seasonal foraging strategy, whereby birds feed more heavily in the winter when zooplankton are more abundant and use endogenous fat reserves later on (Briggs, 2007).

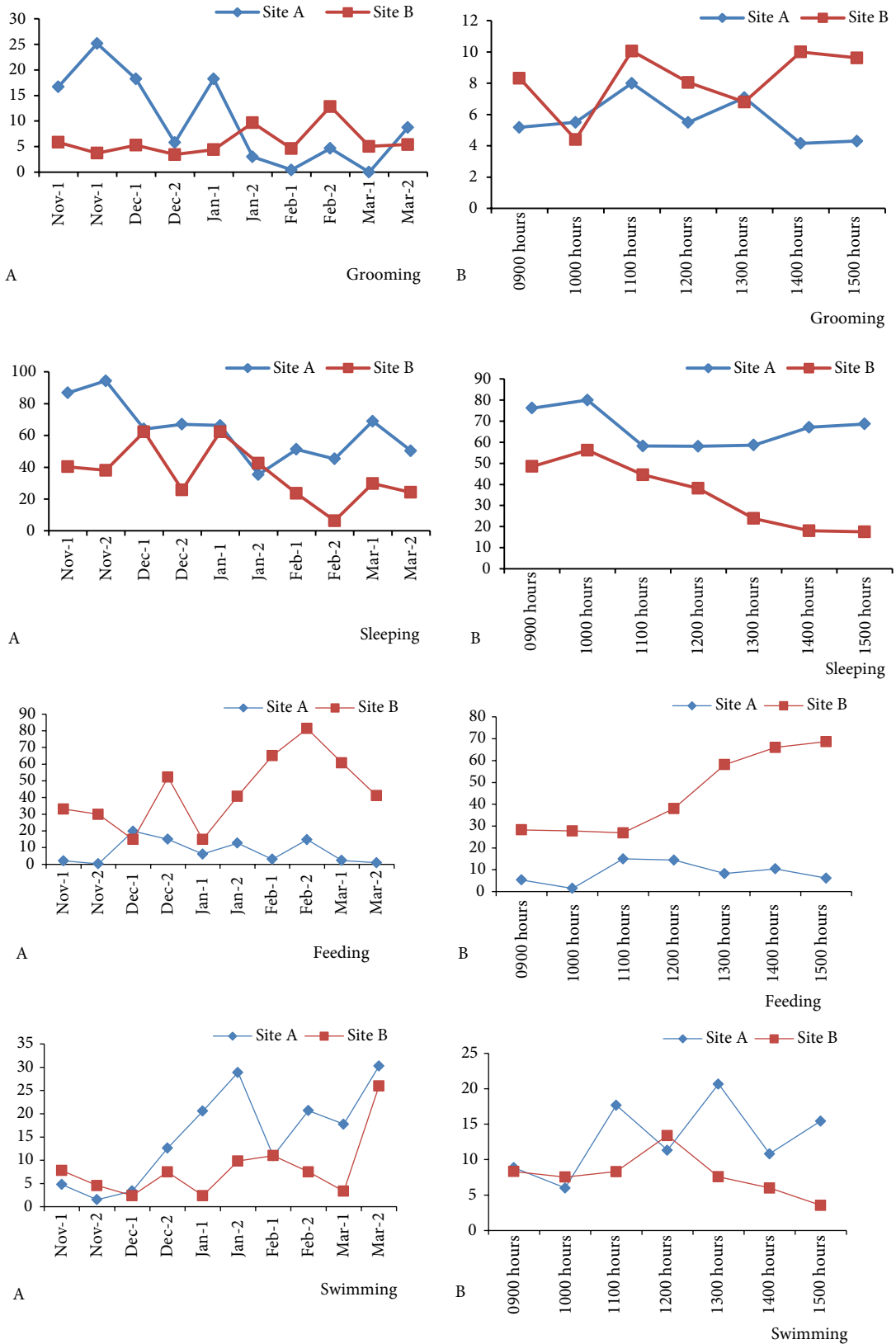


Figure 5. Evolution of daytime activities of the Shovellers during the 2007–2008 wintering season at (A) Garaet Hadj-Tahar and (B) Garaet Timerganine.

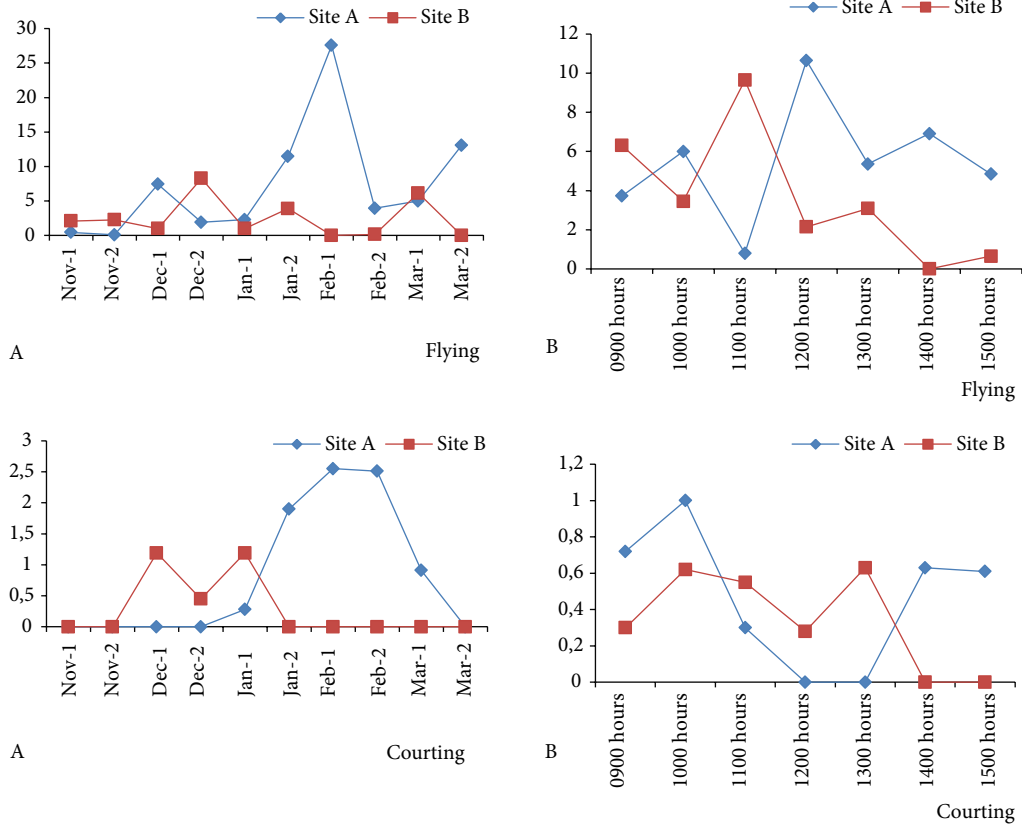


Figure 5. (continued).

Our results showed that a number of factors influence habitat choice by the Shoveller. This species prefers undisturbed sites with open shorelines for sleeping during the day. In a review by McNeil et al. (1992), the Shoveller was recorded as a species that feeds more at night than

during the day. In Garaet Hadj-Tahar this was found to be true, because sleeping proved to be the main diurnal activity (Figure 5). Tamisier and Dehorter (1999) suggested that communal roosting during the day is primarily an antipredator strategy at sites with low disturbance levels

Table 2. Results of MANOVA tests for differences between sites and hours for the behaviour frequencies of Northern Shoveller in 2007–2008.

	F	Effect df	Error df	P
Intercept	144.73	5	2	0.006
Site	14.98	5	2	0.064
Hour	0.89	30	10	0.623
	Adjusted R ²	df	F	P
Grooming	0.258139	7, 6	1.64	0.280
Swimming	0.136124	7, 6	1.29	0.385
Flying	-0.692694	7, 6	0.24	0.958
Courting	-0.210610	7, 6	0.67	0.691
Sleeping	0.752592	7, 6	6.64	0.017
Feeding	0.637936	7, 6	4.27	0.048

Table 3. Results of MANOVA tests for differences between hours and year for the behaviour frequencies of Northern Shoveller in 2007–2008.

	F	Effect df	Error df	P
Intercept	215,943.1	5	2	0.000
Hour	0.5	30	10	0.938
Year	0.8	5	2	0.618
	Adjusted R ²	df	F	P
Grooming	-0.144388	7, 6	0.76	0.635
Swimming	0.102379	7, 6	1.21	0.415
Feeding	-0.142648	7, 6	0.76	0.634
Sleeping	-0.499432	7, 6	0.38	0.883
Flying	-0.264747	7, 6	0.61	0.733
Courting	0.375430	7, 6	2.11	0.189

Table 4. Results of MANOVA tests for differences between years and periods for the behaviour frequencies of Northern Shoveller in 2007–2008 and 2008–2009.

	Adjusted R ²	df	F	P
Grooming	-0.106107	9, 10	0.80	0.628
Swimming	0.244659	9, 10	1.68	0.214
Sleeping	0.525952	9, 10	3.34	0.036
Flying	-0.214530	9, 10	0.63	0.752
Courting	0.744856	9, 10	7.16	0.002
Feeding	0.286658	9, 10	1.84	0.176

	F	Effect df	Error df	P
Intercept	1856.290	5	6.00	0.000
Year	4.708	5	6.00	0.043
Period	1.816	20	20.84	0.092
Year × period	1.871	20	20.84	0.082

and with other areas of water nearby. The value of nearby sites is likely to stem from the provision of alternative refuge areas (Briggs, 2007). Garaet Hadj-Tahar, which is a part of a large and varied wetland complex, would appear to offer good protection from predation.

Waterfowls and waders comprise a large set of water-related species with differing phenology and are strictly linked to specific water regimes (Battisti et al., 2006; Boertmann and Ricet, 2006; Holm and Clausen, 2006; Causarano and Battisti, 2009; Causarano et al., 2009). Among waterfowl, ducks (Anseriformes, Anatidae) are a group of species that are particularly sensitive to water level changes (Nummy and Pöysä, 1995; Austin, 2002; Krapu et al., 2006). Dabbling ducks can generally only feed at depths of up to 40 cm (Andrews, 1995). The Shoveller occurs more frequently in flooded pastures (Rizzo and Battisti, 2009) and is less restricted by the depth of water, although zooplankton are more likely to be highly concentrated in shallow waters with low fish populations (Briggs, 2007). Garaet Timerganine is a rarely flooded wetland that is a

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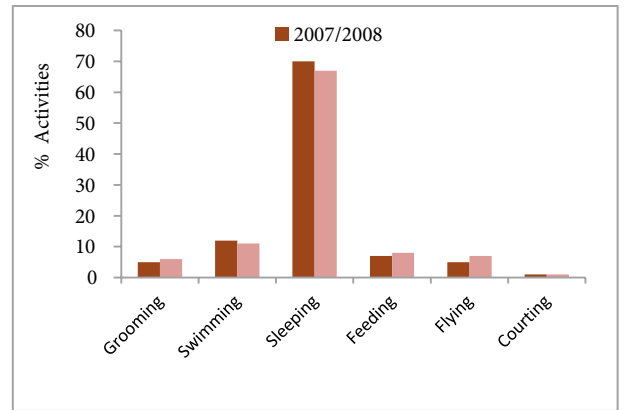


Figure 6. Balance of the rhythms of daytime activities of the Shovellers in Garaet Hadj-Tahar during the 2 wintering seasons of 2007 and 2009.

good source of food, especially zooplankton (Takeshi et al., 1994).

If swimming is taken as a surrogate for courtship activities, its increase and highest values in spring (February and March) are consistent with observed patterns of dabbling ducks, which generally “pair” earlier than diving ducks.

Managing sites effectively for this species therefore requires an understanding of its behaviour patterns, since water bodies will often not provide suitable conditions for both sleeping and feeding.

It would be most interesting to know the importance of stopover availability and suitability along their flyway, especially given the need for sites with high food availability and low disturbance, to show the impact on levels of zooplankton, wildfowl numbers, and daytime activities, and to monitor disturbance levels in the long term to look for any noticeable changes.

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