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Seasonal Occurrence and Daytime Behaviour of Eurasian Spoonbills *Platalea leucorodia leucorodia* in Senegal's Atlantic Coastal Areas

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Abstract.—Senegal hosts hundreds of wintering Eurasian Spoonbills *Platalea leucorodia* every year. To contribute to the paucity of knowledge on their distribution and ecology, this study aimed to compare the occurrence and behaviour of spoonbills at the three most important sites in Senegal: Djoudj National Park, Technopôle of Dakar and Palmarin Reserve. Based on monthly counts in 2017 and 2018, Djoudj reached peak numbers of more than 2500 birds in April. The number in Palmarin peaked at 500 birds in October. In both cases this well exceeds the 1% threshold for the East Atlantic Flyway population, but Djoudj can hold up to a sixth of the population. Technopôle is an intermediate site that rarely hosts more than 50 individuals. Based on the scanning of behaviours throughout the day, we show that foraging activity was high early in the morning and decreased towards noon. At Palmarin, Spoonbills spent more time resting (68%) than at Djoudj (50%), allocating less time to foraging (16%) compared with Djoudj (29%). If this indicates favourable wintering habitat at Palmarin, the growing population of Eurasian Spoonbills from Europe may increasingly rely on the Palmarin site during the coming decade. *Received 25 Apr 2022, accepted 21 Sept 2022.*

Key words.— Diurnal behaviour, Djoudj, Migration, Niayes, Palmarin, Time budget

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Senegal is located on the East Atlantic Flyway and almost a sixth of the flyway population of Eurasian Spoonbills *Platalea leucorodia leucorodia* (henceforth 'spoonbills') is known to occur here winter (BirdLife International 2013). This population breeds in Europe, migrates along the Atlantic coast to Morocco, and winters in Mauritania and Senegal, where the birds mix with individuals of the Mauritanian subspecies *Platalea leucorodia balsaci* and the African Spoonbill *Platalea alba* (Triplet *et al.* 2008). According to Lok *et al.* (2011), in the period 1990-2010 more than 50% of the northwest Europe-breeding spoonbills migrated to the coast of West Africa in Mauritania and Senegal during their first migration, thereby establishing individual life-long routines. Post-breeding migration begins in September and birds arrive on their wintering grounds in November and December (Triplet *et al.* 2008). Northward migration from West Africa begins in early

February and birds arrive on their breeding grounds in late February (southern Spain) or in March-April in north-western Europe (Triplet *et al.* 2008).

Most spoonbill breeding colonies on the East Atlantic Flyway are protected. Colonies are currently established in Morocco, Portugal, Spain, France, Belgium, The Netherlands, Germany, Denmark, and Great Britain (Triplet *et al.* 2008). The most important breeding areas for the Atlantic population are in The Netherlands, France, and southern Spain. The Eurasian Spoonbill is classified as Least Concern (LC) on the IUCN Red List (BirdLife International 2019) and its global conservation situation is better than ten years ago, with an estimate of 8,886–10,211 breeding pairs in 2007 vs. 10,872–11,134 breeding pairs in 2018 (Champagnon *et al.* 2019). The population size of the subspecies *P. l. leucorodia* is 19,000–24,000 individuals, with an increasing trend (2013–2018; BirdLife International 2021)

In contrast to the well-studied wintering areas of the Eurasian Spoonbills in the Iberian Peninsula and Mauritania, there is less information on the winter distribution south of Mauritania (El-Hacen *et al.* 2013, Oudman *et al.* 2020). In this paper we assess the distribution of wintering spoonbills in Senegal between October–February of 2017–2019, focusing on the three sites that are known by the authors to be important: (1) Djoudj National Bird Park, (2) Niayes de Dakar urban wetland (Technopôle), and (3) Palmarin Community Nature Reserve, which is part of the Saloum Delta Biosphere Reserve (Fig. 1, Fig. 2). In addition to counts, we carried out time budget observations in Djoudj National Bird Park and Palmarin to examine possible differences between the quality of the two sites. These time budgets can reveal how individuals cope with the quality of habitats and energy demands (e.g., Ménard *et al.* 2013). Habitats yielding more available food resources should result in behavioural time budgets with more time for comfort behaviours and less time foraging (Piersma 2012).

METHODS

Study Area

All three study sites are found along Senegal's Atlantic coast. Djoudj Park was created in 1971 to safeguard a representative sample of the ecosystem of the Senegal River Delta and is situated 60 kilometres north-east of Saint-Louis (16°23'59" N, 16°14'25" W). Within its current boundaries it extends over an area

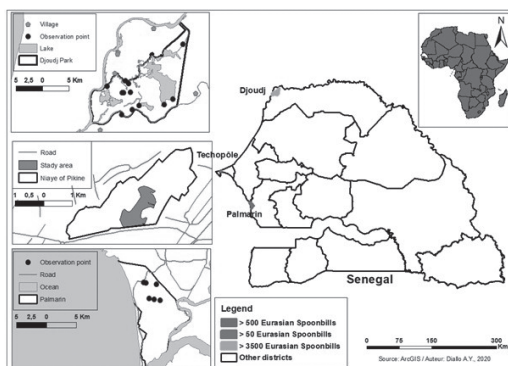


Figure 1. Location of the study sites in Senegal and approximate maximum number of Eurasian Spoonbills recorded at the different sites.

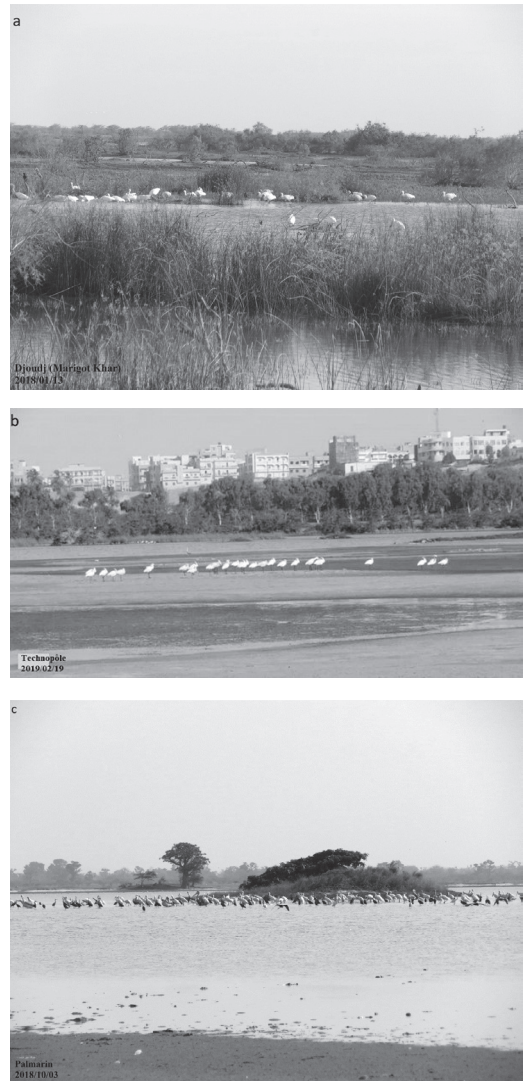


Figure 2. Illustration of the different monitoring sites. (a) Eurasian Spoonbills foraging at the Khar marigot in Djoudj. This marigot often dries up during the dry season. (b) Eurasian Spoonbills resting at the Technopôle on the banks of a brackish water lake. (c) Eurasian Spoonbills resting in Palmarin in a temporary pond.

of approximately 16,000 ha (Fig. 1). The Senegal Delta has direct access to the Atlantic Ocean. In the past, salt water entered the delta during the dry season creating a variety of habitats. However, the construction of dykes and dams has altered this dynamic system (Zwarts *et al.* 2009). The Djoudj has been flooded artificially since 1971 to simulate natural flooding. These artificial floods occur mostly in July and August, causing the basins being fed from the Diama dam. The inlets are closed during the rest of the year (Zwarts *et al.* 2009).

The Niayes system is an area of inter-dune depressions that extends along the Senegalese coast to the Cape Verde peninsula. The great Niaye of Pikine, commonly called “Technopôle”, is part of this ecosystem located on the periphery of the Dakar region. It is a resting and feeding site for many migratory and resident birds. Many areas once occupied by the great Niaye of Pikine have now disappeared due to rapid urbanization. The Technopôle (14°45'16"N, 17°24'48"W) is an area of about 200 ha. At this site about 200 bird species have been observed (Hopkins and Diop 2011, Diallo *et al.* 2019).

The Palmarin Community Nature Reserve (14°01'00" N, and 16°46'00" W) covers an area of 10,340 ha. The reserve is crossed by the Joal-Djifer Road which divides it into two parts: a continental part that follows the contours of the rural community and a maritime fringe that extends from Palmarin to Joal. This combination of the Atlantic coastline, intercoastal mangrove channels and areas with low salt concentration gives it a rich and varied heritage (Ndouye 2011). Belonging to the Saloum Delta Biosphere Reserve, the Palmarin Reserve remains a place of reception and reproduction of many birds, represented by more than 60 species of waterbirds (Fig. 1).

From January 2017 to December 2019, between and October–January, we conducted monthly counts of each site. In the Djoudj Park, monthly waterbird counts form a core activity of the park. The counts are made in seven sectors of the park (the Great Lake, the Miradors, the Djoudj Marigot, the Nguinth Lake, the Thieugueul Marigot, Djeuss and Crocodile) (Fig. 1). To avoid double counts, in the seven sectors all teams started the counting at 08:00 hr. Depending on the area, the counts were carried out using binoculars and telescopes, on foot or from a canoe. At Technopôle, the counts of spoonbills over approximately 200 ha generally took two people with the same equipment as in the Djoudj two hours to complete (Fig. 1). In Palmarin, two people counted the spoonbills partly from a car and partly on foot, sometimes using a canoe too to access the spoonbills. At this site spoonbills were generally found in 2–3 groups in three different sectors. Counts started at about 7:00 hr in the coastal part of the reserve and ended in the Niassam sector where spoonbills roost in mangroves during the hottest part of the day.

At Djoudj and Palmarin we measured time budgets by scoring the behaviour of individuals during the morning. We monitored several birds for 30 minutes for 4 hours. This is an overview of a group of 10 individuals in one minute or more. That is, everyone is observed for 10 to 15 seconds as it progressed from No. 1 to No. 10 and their first behaviour seen was noted down. We distinguished between four different behaviours: feeding, flying, preening and resting. Since the observations are made during every 30 minutes, then we used the time gaps to see if there are interactions with other bird species. Therefore, there was no bias in the data collection (e.g., missing birds feeding elsewhere) over the course of the day.

Habitat mapping was done using software such as ArcGIS 10.4.1 (Geographic Information System) and

Google Earth. We analysed the behaviour data using a Bayesian multinomial categorical regression model in brms (Bürkner 2019), in Rstudio (R core team 2020). We choose Bayesian models to handle multinomial models easily and the Bayesian framework allows flexibility and provides for clear interpretations. We used weakly informative priors ($\mu = 0$, $\sigma = 5$). All results are summarised by their posterior means accompanied with their 95% HDI (Highest Density Interval), indicating the 95% highest probability for the posterior mean calculated from the posterior distribution. This can be viewed as an analogue of a frequentist confidence interval of the mean. To test if proportions of time spent on a certain behaviour differed between the two areas, we subtracted the full posterior means from each other. This results in a posterior distribution of the difference. If the behaviours are equally displayed in the two areas, the posterior distribution of the difference would be centred around 0. Therefore, if 95% of the HDI excludes 0 we identify the difference as significant.

RESULTS

Monthly counts in Djoudj, Palmarin and Technopôle showed a variety of seasonal patterns (Fig. 3). At Djoudj, the highest number of individuals were recorded in April, with more than 2,000 in 2017 and 2018; in 2019 the peak number at Djoudj was lower and one month earlier. Autumn and winter spatial distributions of spoonbills were more spread out over the three areas. During October, the highest number of individuals were recorded at Palmarin with an average of more than 600 individuals (Fig. 3).

Overall, spoonbills spent on average 59% (HDI = [57.7, 60.8]) of their time during the morning on resting, followed by 24% (HDI = [22.3, 25.0]) on foraging, 14% (HDI = [15.0, 13.8]) on preening and 2% (HDI = [1.6, 2.5]) on flying (Fig. 4). Over the course of the morning time allocated to forage decreased from 49% (HDI = [45.7%, 52.8%]) at 07:30H to 4% (HDI = [3.2, 5.3]) at 12:30H. Time allocated to rest increased from 36% (HDI = [33.0, 39.2]) at 07:30hr to 79% (HDI = [76.2, 82.6]) at 12:30hr. Both areas showed a similar pattern in behavioural distribution over the course of the day (Fig. 4). When comparing time budgets, birds in Djoudj allocated 29% (HDI = [26.8, 31.7]) of their time to foraging compared with 16% (HDI = [14.5, 17.7]) in Palmarin birds (a significant difference of 12% (HDI = [3.2, 20.0]). In ad-

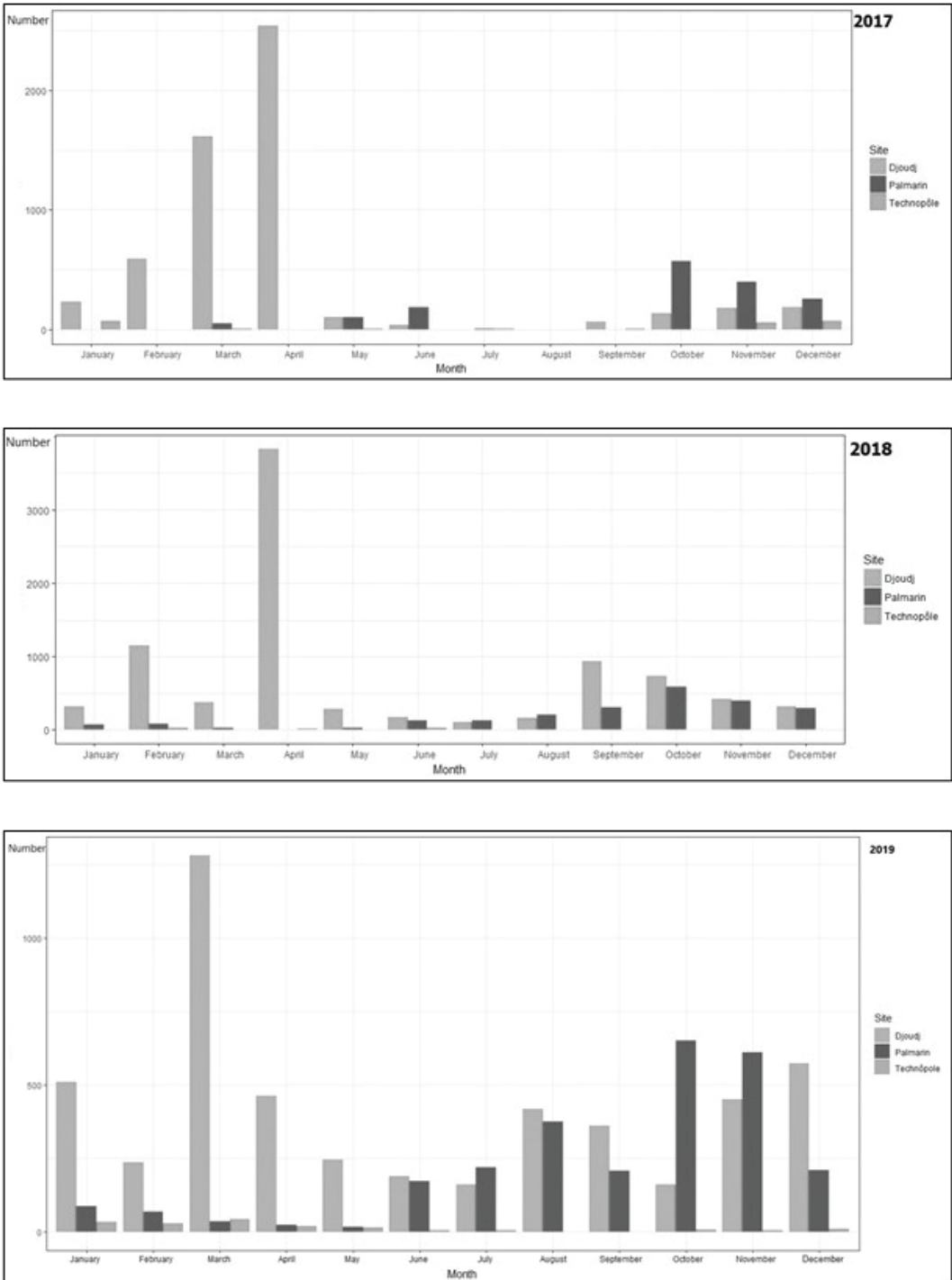


Figure 3. Spoonbill numbers in the different study areas from 2017 to 2019.

dition, the Djoudj birds allocated less time (50%, HDI = [47.4, 52.8]) to rest compared to those at Palmarin (68%, HDI = [65.7, 69.8]), a significant difference of 16% (HDI

= [10.3, 21.7]). No differences were found in allocation of the times spent preening (difference = 3%, HDI = [-0.8, 7.2]) and flying (difference = 2%, HDI = [-0.3, 3.6]).

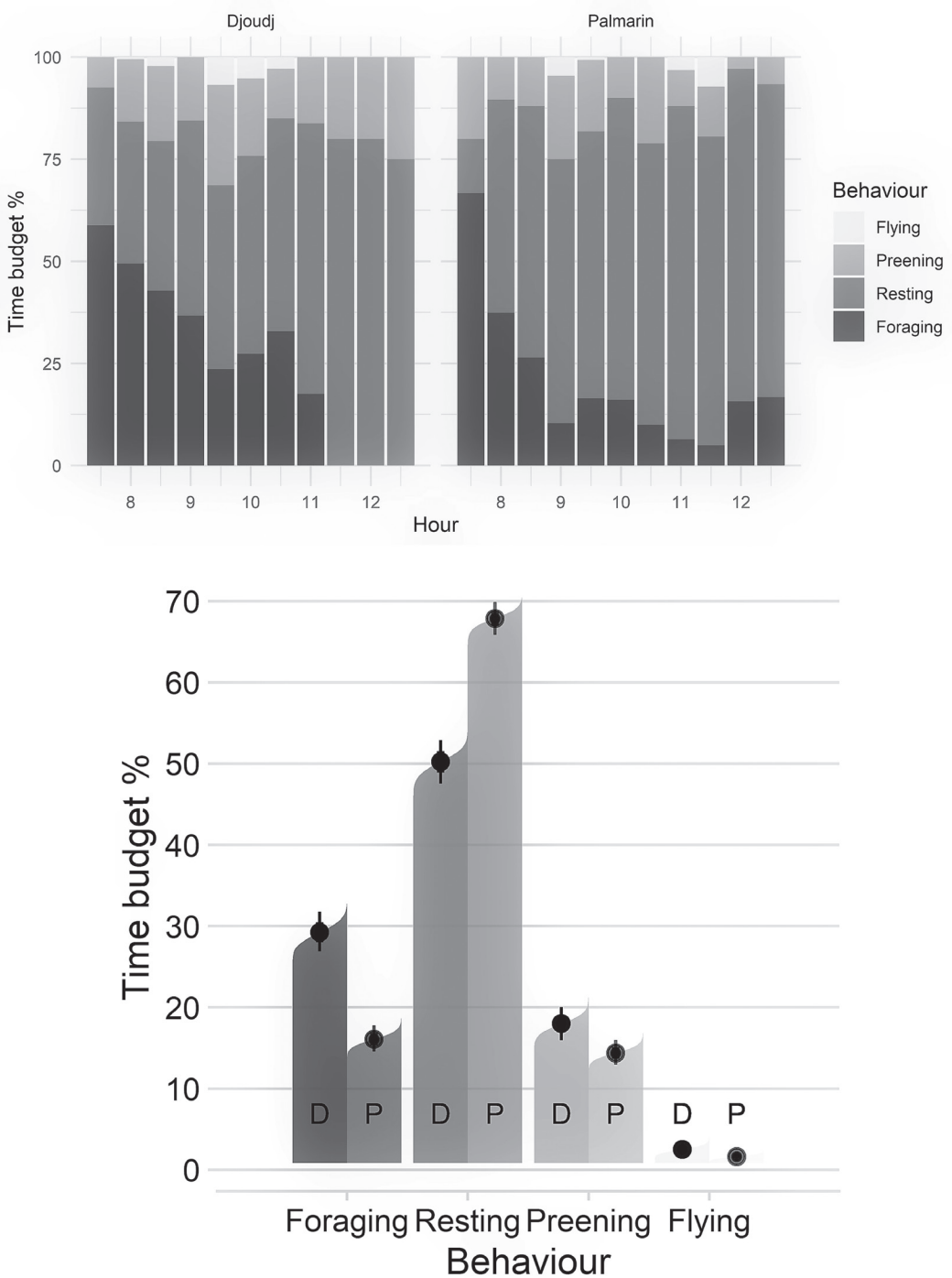


Figure 4. Figure A (left) shows the time budgets of spoonbills over time for the areas of Djoudj and Palmarin between 2017 and 2019. These results were obtained from scanning groups of spoonbills over the course of the morning. Both Djoudj and Palmarin show similar trends over time. The proportion foraging is high during early morning and decreases as the day goes on, whereas the proportion of resting increases over the same period. Figure B (right) The overall time budgets of spoonbills split according to the four scored behaviours (D = Djoudj and P = Palmarin). The bars and black dots indicate the medians, the thin black lines indicate the 95% HDI. The complementary cumulative distribution function (CCDF) is shown at the end of the bars to express the full uncertainty of the mean percentage spent on a behaviour.

DISCUSSION

This study indicates that the wintering distribution of Eurasian Spoonbills ranges south to Dakar and Palmarin in Senegal. During August–September a new influx of migrating individuals was observed in our study sites. Overall, Palmarin was mostly visited by spoonbills between August and December. From January to April the number of individuals in Djoudj rose steeply and after April this cohort seems to have migrated northwards. Reflecting a lack of adequate investigation of spoonbills in Senegal prior to this study, this contradicts Lok *et al.*'s (2011) statement that the migration range of Eurasian Spoonbills stops in northern Senegal. However, as the Eurasian Spoonbill population has increased in recent years (Champagnon *et al.* 2019), it also seems likely that population growth has led to more individuals wintering south of the Senegal river. It is noted that ringed spoonbills return regularly to Senegal (2017 and 2018) even though they are more likely to die there than in Europe. According to Lok *et al.* 2011, survival is higher in France and in the Iberian Peninsula. Despite this fact, the spoonbills remain faithful to their wintering sites. From August onwards, migrating individuals moved into Senegal, especially in 2019. From December to April there was a steep increase in the number of individuals visiting Djoudj, with a decline in Palmarin. Numbers were highest in Djoudj during April with 2,543 individuals in 2017 and 3,830 individuals in 2018, at times that there were no more spoonbills in Palmarin and Technopôle. This gives us reason to believe that Djoudj is used as a meeting place where wintering spoonbills from all over Senegal gather prior to the challenging northward Sahara crossing (Lok *et al.* 2015). During the preparation of the spring migration that more individuals are observed in Djoudj, and they are almost absent in the other monitoring sites. Why Palmarin is used mainly during August–December and seems to be neglected afterwards raises intriguing questions. Are the food resources depleted or does the migration pattern of the spoonbills force them to move to Djoudj?

Our results on time budgets show that foraging occurs most frequently early in the morning and decreases during the morning, with having lowest proportions of time spent on foraging around noon. According to Kersten *et al.* (1991) this may be due to low oxygen levels in the morning water (after a night of oxygen uptake rather than production by the water plants) driving fish to the surface. The increase in solar heat in the course of the day may also explain why spoonbills foraged mostly in the early mornings. Birds at rest can minimize the heat load and do not produce heat themselves, thus avoiding hypothermia.

Whilst the spoonbills at Djoudj and Palmarin showed the same temporal trends in foraging and resting behaviour, spoonbills in Djoudj allocated 12% more time to forage and 16% less time resting than spoonbills at Palmarin. Further studies could illuminate whether these differences may be explained by the following factors and combinations thereof: (1) prey species differing in their daily rhythms among the two sites (e.g. prey species are better available at night in Palmarin they are at Djoudj), (2) density and size of prey differing among the two sites (e.g. more prey are present at Palmarin, making foraging more efficient), and (3) competition for food resources being highest in Djoudj.

In the welcome case that the international conservation organizations, in tandem with local governments, would become serious about a positive management regime for Eurasian Spoonbills along the East Atlantic Flyway, the data presented provide a first basis for conservation action in Senegal.

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