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Breeding biology of Eleonora's Falcon, *Falco eleonorae* Gené, 1839 (Accipitriformes Falconidae), in Northeast Algeria at Sérigina Island

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ABSTRACT The Eleonora's Falcon, *Falco eleonorae* Gené, 1839 (Accipitriformes Falconidae), is a long migrant and a seabird of conservation concern. After discovering the Sérigina colony in Northeast Algeria, data on laying period, reproductive success, and nestling growth were collected. A total of 18 nests were located and surveyed during the breeding season of 2006. The species started to lay eggs in late July and the majority of nests contained 3 eggs. There was no variation in the mean eggs volume and weight between different clutches. The mean clutch size was 2.39 ± 0.78 eggs and the hatching success was 53.5%. Productivity per nest was 0.39 ± 0.40 chick, lower than previous published works. Inclement weather and avian predation was thought to be the main sources of chicks' mortality. Nestling growth for both body mass and wing span fitted a linear fashion during the first 25 days in nestling life. The accelerated chick growth suggested food availability and high parental provisioning. Finally, we think that Algerian's coast could support other large colonies that should be discovered, surveyed, and conserved.

KEY WORDS Breeding biology; breeding success; Eleonora's Falcon; marine bird; nestling.

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INTRODUCTION

The global breeding population of the Eleonora's Falcon, *Falco eleonorae* Gené, 1839 (Accipitriformes Falconidae),was recently updated by Dimalexis et al. (2008) giving a number of more than 13,500 pairs over the Mediterranean region, Atlantic Morocco, and the Canary Islands. This long migrant raptor covers a distance of more than 9,000 km from its breeding areas to its wintering ground mainly in Madagascar by crossing the whole African continent including the Sahara (Delgado & Quilis, 1990; Gschweng et al., 2008; López-López et al., 2009; López-López et al., 2010). Although the main global breeding population occurs in Greece (Dimalexis et al., 2008), substantial and probably underestimated proportion also nests in North Africa.

In Tunisia, most breeding pairs reproduce in the Galite Archipelago, North of the country off coast (Hamrouni, 2007). Breeding records in Algerian colonies have been started in the mid twentieth century (Laferrère & Mayaud, 1960), followed by subsequent counts made mainly in islands near Skikda (East coast) and the Habibas Islands (West coast) but the numbers recorded have never excee-

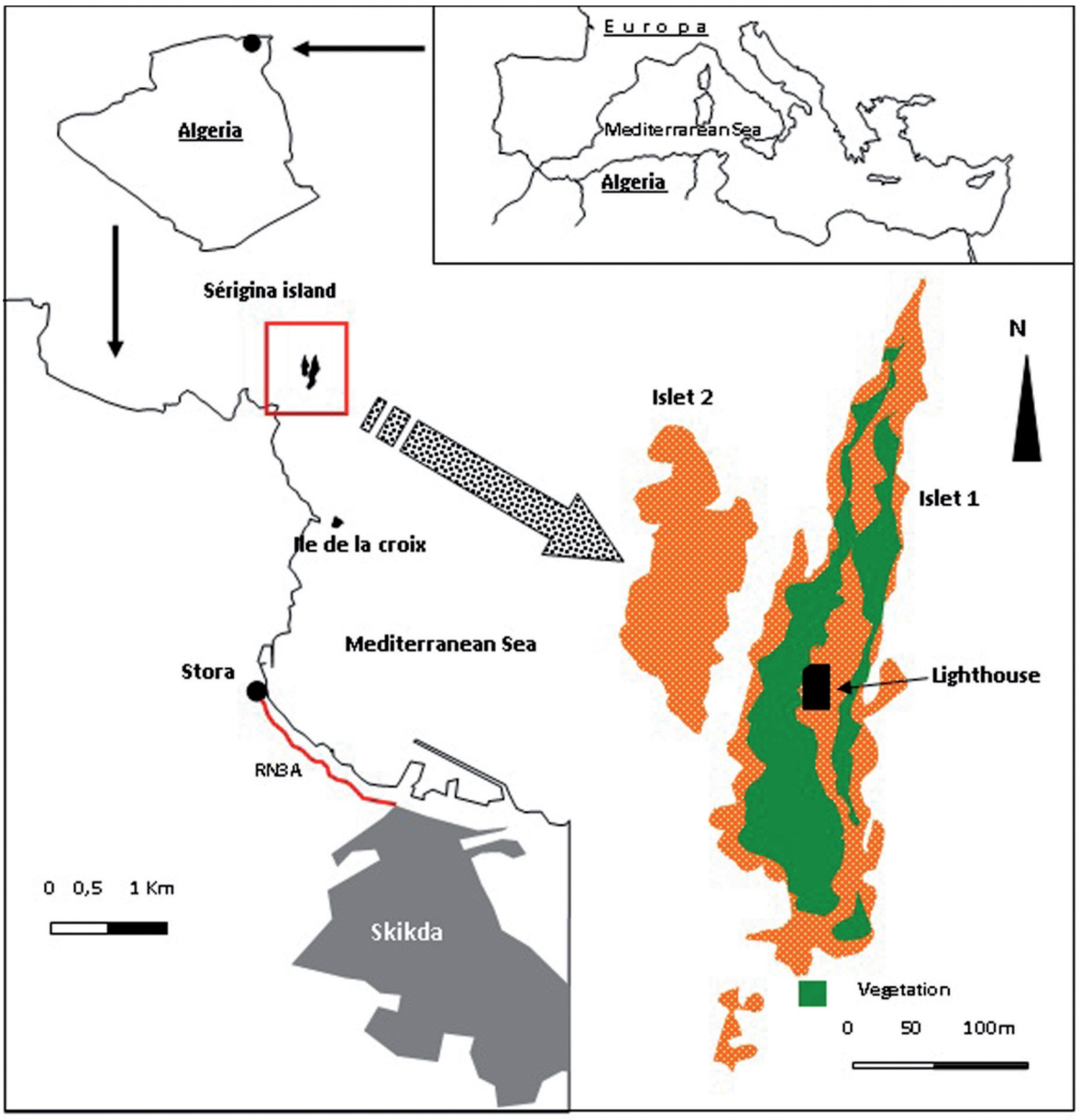


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Figure 1. Map presenting the study site: Sérigina island, Northeast Algeria.
Figures 2-4. Sérigina island

ded 50 breeding pairs (Le Fur, 1975; Michelot & Laurent, 1988; Michelot & Laurent, 1993; Rguibi et al., 2012). In Morocco, the breeding range is restricted to two colonies (Essaouira's islands and Salé's sea cliff) situated on the Atlantic coast (Walter, 1979; Bergier, 1987; Thévenot et al., 2003). However, several coastal islands of the three countries hosting eventual suitable breeding habitats remain still unexplored. Most works have focused on the diet and migration of the species (Walter, 1979; Delgado & Quilis, 1990; Gschweng et al., 2008; Lopez-Lopez et al., 2009; Diaz-Portero et al., 2009). Breeding biology and ecology were also well studied in different geographic areas within the species breeding range; however, reproductive parameters of Algerian colonies have never been investigated.

This study was conducted on an Eleonora's Falcon colony in the Algerian East coast (Figs. 1-4) and provides the first contribution on its breeding biology in the country.

MATERIALS AND METHODS

Study area

Sérigina is a 2.4 ha island situated in Northeast Algeria (36°56' N, 6°53' E), 700 m from the coast of Skikda. Sparse vegetation dominated by shrubs *Chamaerops humilis* L., *Opuntia ficus-indica* (L.) Mill., 1768 and grasses *Malva veneta* (Mill.) Soldano, Banfi et Galasso, 2005, *Melilotus* sp., *Carpobrotus acinaciformis* (L.) L. Bolus, 1927 covers its southern half while is absent in the north. A lighthouse of 20 m height occupies the center of the island. In addition to the Eleonora's Falcon, Yellow-legged Gull, *Larus michahellis* Naumann, 1840, and Cory's Shearwater, *Calonectris diomedea* (Scopoli, 1769), were also nesting at the island.

Data collection and analysis

We started to visit weekly the island in early July 2006 and checked for potential egg laying. In the breeding season we also collected weekly data from each Eleonora's falcon nest encountered in the Sérigina Island. Nests were marked by fixing small numbered flags on the ground near the nest.

After being individually marked using permanent markers, eggs lengths and breadths were measured with a Vernier calliper to the nearest 0.1 mm and their weights were measured using a Pesola spring balance to the nearest 1 g. Chicks were also marked by non-toxic permanent markers (Kaihongyu model KH8012) using coloration codes. Nests

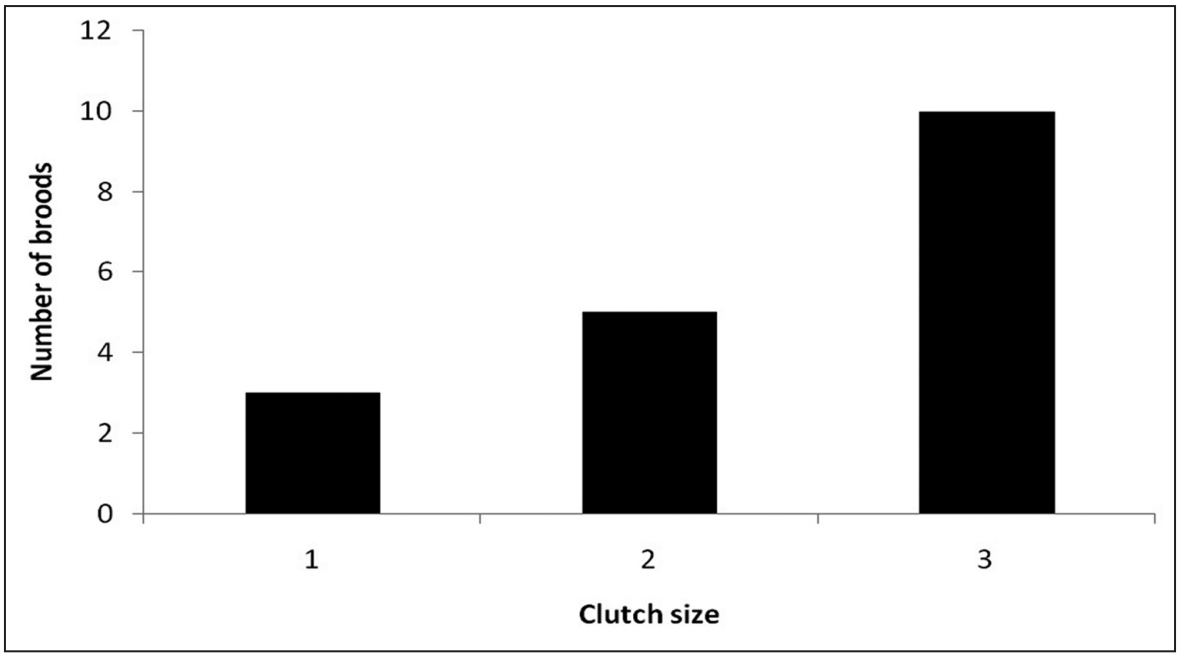

Figure 5. Frequency distribution of clutch sizes of the Eleonora's Falcon in the Sérigina island.

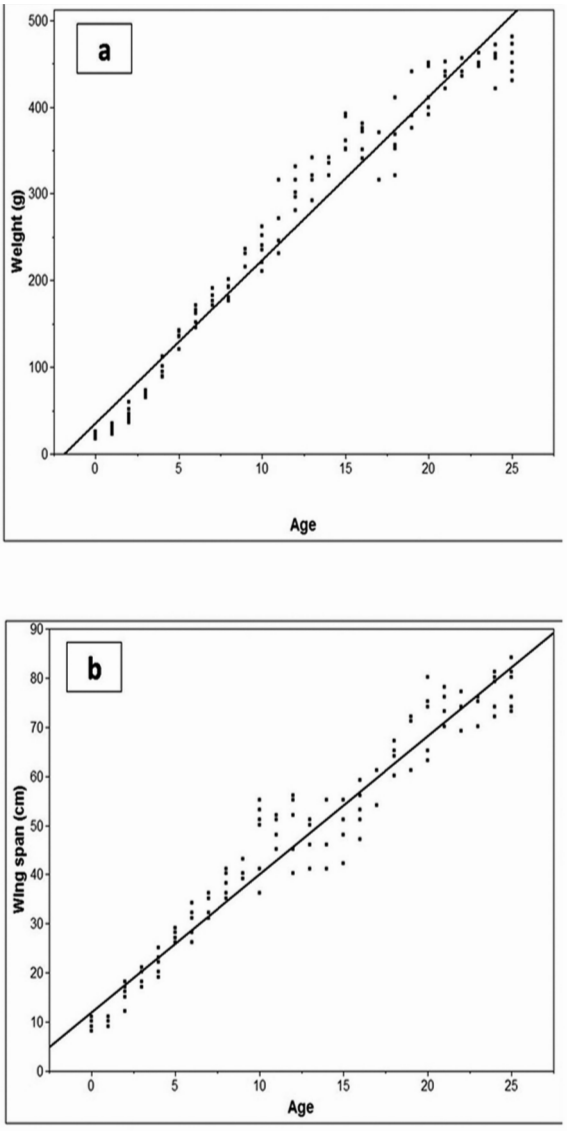

Figure 6. Growth of (a) body weight and (b) wing span of Eleonora's Falcon nestlings.

	Mean ± S.D	N
Egg length (mm)	42.57 ± 1.62	43
Egg breath (mm)	33.48 ± 1.12	43
Egg volume (cm^3)	24.38 ± 2.14	43
Egg weight (g)	25.67 ± 2.37	43

Table 1. Egg dimensions of Eleonora's Falcon breeding at Sérigina island.

	N	Success (%)
Eggs laid	43	/
Eggs hatched	23	53.5
Chicks that survived to 25 days	17	39.5

Table 2. Reproductive success parameters of Eleonora's Falcon breeding at Sérigina island.

	Mean	Intercept	r^2	p	N
Body mass (g)	18.82	35.41	0.96	<0.0001	17
Wing span length (cm)	2.80	12.00	0.94	<0.0001	17

Table 3. Growth rate of Eleonora's Falcon in Sérigina island.

were checked weekly and the number of eggs was counted and surveyed for hatching and fledging in order to calculate the clutch size, hatching success (the proportion of eggs that hatched to chicks) and the number of chicks surviving to 15 days. Mortality and losses of eggs and chicks were also recorded. From hatching, we measured the wing span length and weight of nestlings weekly until the age of 25 days.

At this age, chicks became usually very mobile and aggressive which made their capture difficult. We estimated chick age based on their appearance. Growth curves were developed for the two morphometrics recorded for nestling Eleonora's Falcon. All growth data were modeled with the linear function by Kuusela & Solonen (1984):

$$Y = at + b$$

where Y is a morphometric trait (body mass or wing span length), t the nestling's age in days, and a and b the linear growth parameters. The latter coefficients were calculated using least squares linear regressions of body measurements.

We put values of 350 g as the adult body mass (Newton, 2009) to determine the age when did nestlings reach adult size. In contrast, young ne-

stlings do not have fully developed feathers as adults, thus a comparison between them could be highly biased. Statistical analyses were carried out using SPSS (2009) with values reported as mean ± S.D. and $p < 0.05$ used as significance level. When data did not conform to a normal distribution, we used non-parametric tests.

RESULTS

Breeding parameters

Table 1 summarizes data of eggs measurements at the Sérigina island. After the calculation of the mean egg volume and weight for each nest containing more than one egg, we found that there was no significant difference between the mean eggs volume and mean eggs weight of different clutches (Kruskal-Wallis: $\chi^2 = 1.598$, df = 2, P = 0.45; ANOVA: F = 0.882, df = 2, P = 0.417 respectively).

The laying period of Eleonora's Falco was quite long and it lasted 34 days from July 24 (the first egg laid) to August 27. The mean and median egg-laying time was August 7 and 15, respectively. Egg hatching started on 21st August and ended on October 8. Two thirds (67%) of clutches hatched in the three first weeks of the hatching period showing a peak on September 4. The frequency distribution of clutch sizes is showed in Figure 5. The mean clutch size was 2.39 ± 0.78 eggs (N = 18 nests). More than half (53.5%) of clutches contained 3 eggs, all clutches ranging from 1 to 3 eggs. A substantial proportion of nests (38.8%) have failed to hatch a single egg and 4 cases of nest desertion were found during the study period. Eggs hatched asynchronously within a clutch and the total hatching success was 53.5% (Table 2). The percentage survivorship (to 15 days) from eggs was 39.5% while percentage survivorship from hatch was 74 % (n = 18 clutches). The mean net productivity per nest (up to fifteen days of age) was 0.39 ± 0.40 (n = 18 clutches).

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Figure 7. Sérigina island: a nest of Eleonora's Falcon containing 3 eggs. Figure 8. Young chicks of Eleonora's Falcon (7 days). Figure 9. A feathered chick of Eleonora's Falcon (28 days).

Growth of nestlings

We obtained growth curves of 17 nestlings from 11 broods for the body mass and wing span length respectively (Figs. 6 a, b). Linear growth parameters of both traits are presented in Table 3.

Mean body mass of Eleonora's Falcon nestlings at day 0 was 22.9 ± 4.25 g (n = 8) corresponding to 6.5% of the adult mass, while mean wing span length was 10.1 ± 0.33 cm (n = 4) which represents 8.4% of the adult wing span. Usually, chicks became very mobile and hard to capture when they reached the age of 20 days and the older nestling captured had an age of 25 days.

Nestlings reached 50% of the adult wing span length at the age of 16 days and half of adult body mass at 4 days of age. Also, chicks have never reached 100% of wing span length before fledging but they exceeded 100% of adult mass at the age of 15 days and attained 143% at 22 days of age.

DISCUSSION

Little is known about the breeding biology and distribution of Eleonora's Falcon in North Africa, and new data on egg laying phenology, growth rates and breeding success are important to shed light on the life-history strategies and conservation needs of this long migrant bird. The Sérigina island carried about 20 breeding pairs which is more or less similar to others yet reported in Algeria (Laferrère & Mayaud, 1960; Le Fur, 1975; Michelot & Laurent, 1988; Michelot & Laurent, 1993). We suppose that this is not consistent with an actual population growth but rather with an early underestimation of the actual breeding population due to the lack of monitoring scheme. This work constitutes the first contribution on the breeding biology of the Eleonora's Falcon in Algeria (Figs. 7-9).

Eleonora's Falcon is known to be one of the latest breeder birds in the Mediterranean region. In late June, Eleonora's Falcon has started to arrive and displayed courtship behaviors. The laying period of the Sérigina colony initiated on July 24 and lasted until August 27. Considering previous works on the species, our study showed a slightly later first laying date and a quite longer laying period as observed by Wink & Ristow (2000).

Vaughan (1961) made a synthesis on the egg-laying of different colonies in the species breeding range and concluded that the laying period begins at July 15-20 and continues to early August. Moreover, Badami (1998) observed a similar laying date (July 22) in South West Sardinia in the breeding seasons of 1993 and 1994 but the laying ended in early August. In the same way, hatching period was similar to that observed by Badami (1998). However, we believe that comparisons should consider population density and island occupancy phenology when dealing with laying and hatching periods.

Our data of egg dimensions were very similar to those given by Wink et al. (1985). We found that there was no significant difference in egg size between eggs of different clutches which also was the case for the Common Kestrel, *Falco tinnunculus* Linnaeus 1758, breeding in Finland (Valkama et al., 2002). Since the colony was situated next to one of the main flyways of passerine migration (birds that cross the Mediterranean through Sardinia) which is the principal prey during the species breeding season, the absence of egg size variation could be explained by food availability.

In addition, we could expect that there were small variations in the females' age in the study colony or also that the laying period was quite short (compared to other Falcon species) to produce a significant effect on eggs' dimensions. Both of these factors are known to be correlated with egg size in many species of birds (Shanawany, 1987; Williams, 1994; Göth & Evans, 2004).

The mean clutch size was similar to that reported by Badami (1998) in South-west Sardinia, Mayol (1977) in Balearic Islands, and Wink & Ristow (2000) in South Aegean Sea. The majority of nests contained 3 eggs as observed in Morocco (Walter, 1979) and South-west Sardinia (Badami, 1998). We did not observe any nest containing more than 3 eggs during this study but the species was recorded to lay 4 or even 5 eggs per clutch in other colonies (Vaughan, 1961; Walter, 1979; Badami, 1998). The breeding success was very low, less than 1 chick per nest, such as has been observed in South-west Sardinia colony during the breeding season of 1994 (Badami, 1998). We think that mortality of young resulted primarily from climatic factors (exposition to sun and heavy winds) but, most likely, it might be due to sibling aggression and cannibalism of the oldest chick towards younger ones.

Regarding nestling growth, both body mass and wing span showed a linear growth from hatching to the age of 25 days. Similarly, Walter (1979) found the same curve fashion for body mass during the same period of nestling life, but leveled off and reached the asymptote just after. We did not find this trend because we were only able to survey nestlings until the age of 25 days but we may expect the same result for the Sérigina chicks. The rapid growth in the first month of nestlings' life probably reflects a high performance of parental care regarding food provisioning. When we regularly checked the Eleonora's Falcon nests, we noted, from dead birds or pieces of bodies like feathers and wings near nests, that the Robin, *Erithacus rubecula* (Linnaeus, 1758), was the principal prey of the species.

Sérigina island represents an interesting breeding site carrying a substantial number of Eleonora's Falcon breeding pairs and and is one of the most important in Algeria. Improvement in monitoring scheme is necessary to reveal the exact status of the species and set an effective national conservation plan.

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