SOME POPULATION ASPECTS OF COMMON TERN *Sterna hirundo* BREEDING IN ALGERIA AT A SMALL MEDITERRANEAN ISLAND (EAST COAST OF ALGERIA)

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Abstract

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We present the first detailed study of population dynamics, breeding biology and egg measurement of Common Terns. During six years (from 2004 to 2009) of monitoring, from mid-May to mid-August, 74 Common Terns individual were recorded at Laouinet small island, El Tarf, northeast of Algeria, with a finite population growth rate that indicated an alarming population decline ($\lambda = -0.62$: *Lambda*). *Sterna hirundo* build its nests ($n = 37$) in the northeast at a mean distance of 7.58 m from the closest edge of rocks. The nests were closed and ovoid, constituted mainly of mussel shells Sandpit, stems and leaves. Incubation was performed by pairs of common tern and lasted 25.5 ± 3.4 days. We recorded a clutch size of 1 to 3 eggs with mean clutch size of 2.45 ± 0.65 ($41.24 \pm 0.83 \times 30.46 \pm 0.62$ mm). The egg parameters (volume, mass, shape index) varied between the six years of the study. The egg volume (19.24 ± 0.87) depended more on egg width (30.46 ± 0.62), however the egg shape (0.73 ± 0.20) depended negatively on the egg length (41.24 ± 0.83) but not on the egg width. Our results also showed a stabilized hatching success and a best estimation of breeding success. The hatching success did not vary between years: 70.5% in 2004, 68.75% in 2005, 71.42% in 2006, 71.42% in 2007, 69.23% in 2008 and 69.23% in 2009.

Key words: unique population, *Sterna hirundo*, egg parameters, little rocky, marine environment.

Introduction

Seabird's taxa were the precursor to invasion of marine habitats (Kildaw et al., 2005); they breed in large colonies (Belopol'skii, 1957; Pearson, 1968; Croxall, Prince, 1980; Hunt et al., 1981). Seabirds are an integral part of marine ecosystems. Because they are top predators and are connected closely to the marine environment, they are often used as indicators of marine ecosystem health, and can be very useful in monitoring marine environmental changes: as levels of pollution; changes in fish stocks or water productivity (Diamond, Devlin, 2003; Weimerskirch et al., 2003). Seabird's species are highly affected by the decline especially in the last few decades (Croxall et al., 2012). This makes their protection and conservation a priority need, for those species and the management of their marine habitats (Croxall et al., 2012; Šúr et al., 2013; Page, 2014). In the Mediterranean Sea, marine locations – mainly small Islands – are a hotspot for Mediterranean biodiversity, they shelter a high number of species, and represent a real stake for the protection of the Medi-

terranean biodiversity (Blondel, Aronson, 1999; Monbailliu, 2013). Also, these closed localities represent a nesting place for numerous emblematic birds like shearwaters, Eleonora's falcons or ospreys; they shelter, for example, the largest population of Scopoli's Shearwater *Calonectris diomedea* on Zembra Island, Tunisia (Defos du Rau et al., 2012), the island of Tavolara in Sardinia for the Yelkouan Shearwater (Baccetti et al., 2009), and the island from Filfla to Malta for the Storm Petrel (LoValvo, Massa, 2000). Brief, small islands can be the barometers of the world, a double recognition that implies to protect them. On these habitats, sea birds spend a major part of their offshore life and find refuge on islands to insure their breeding requirements, far away from human disturbances and predation. Therefore, breeding parameters (reproductive success) are one of the most important ecological requirements of determining population dynamics in seabird, and they contribute considerably to the abandonment or the occupancy of such small islands (Martínez-Abraín, 2003). Lies between 1 and 2 km from the Algerian coast, small islands and little rocks have attracted little field work by ornithologists

and land managers. Only three significant efforts have been conducted regarding this topic: at Srigina and Saint Piastre, the breeding biology of Cory's Shearwater (*Calonectris diomedea*) (Telailia et al., 2014), at the Rachgoun Island, the breeding biology of Cory's shearwater (Taïbi et al., 2014), and at a small Rocky Islet offshore of the "Plage des Goélands" near El Kala, the breeding of Common Terns (Michelot, Laurent, 1992, 1993; Baaloudj et al., 2018).

The Common Tern (*Sterna hirundo*) is a migratory (del Hoyo et al., 1996; Snow, Perrins, 1998) colonial seabird, widespread over its large breeding range (Nisbet et al., 2017; Becker, Ludwigs, 2004; Yésou et al., 2005); with a global population estimated between 1,600,000 and 4,600,000 individuals (Wetlands International, 2006) however, the decrease in these figures was reported by several authors in the world (Scarton, 2010; Erwin et al., 2011; Morris et al., 2012; Szostek, Becker, 2012; Nisbet et al., 2013) despite its current status (Least Concern) (IUCN, 2018). However, the Common Tern seems to be well studied by many authors (Scarton, 2010; Erwin et al., 2011; Morris et al., 2012; Szostek, Becker, 2012; Nisbet et al., 2013, 2017; Becker, Ludwigs, 2004; Yésou et al., 2005; Chokri et al., 2010) through its range, except in North Africa where only two studies were conducted in (a) Algeria (Baaloudj et al., 2018) and in (b) Tunisia (Chokri et al., 2010).

In order to develop a spirit of marine and coastal environmental protection, mainly regarding several small and ignored islets, in this research paper, we highlight the ecological value of a single breeding small island for the unique population of Common Terns in Algeria (Laouinet, east coast of Algeria), through a regular surveys of six breeding seasons, and by monitoring several aspects of the species reproduction patterns such as: (1) population dynamics, (2) nests characteristics, (3) clutch and eggs measurements, (4) incubation and hatching, and (5) relationship between the clutch size and egg measurement to latitude.

Material and methods

This work was carried out for six consecutive breeding seasons (2004–2009) from mid of May to mid of August by (Salah Telailia), we performed a phenological monitoring and counting of Common Tern individuals, and pairs, twice per week in the little rocky of Laouinet north east of Algeria, using binoculars (90 * 90) and a telescope (60 * 80) to locate nests. Once the nest is located, we recorded the date of its discovery, its geo location using a GPS (Garmin) and its distance from the edge on rocks, the nest dimensions (internal diameter and external diameter). We also measured the clutch size (number of eggs per nest), the eggs' weight using an electronic scale (0.01g of accuracy) and their length (A) and width (B) using an electronic vernier caliper. We estimated, eggs volume with Hoyet's formula (1979) ($V = 0.51 \times A \times B^2$), fresh mass (fresh mass = $0.542 \times A \times B^2$), and Egg shape with Panda formula (1996): Egg shape = $(\text{egg B} / \text{egg A}) \times 100$. The two visits per week allowed us to estimate the incubation period (Del Hoyto et al., 1994); also to monitor the hatching success (the ratio between the number of eggs laid and the number of hatched eggs).

Study area

The little rocky of Laouinet is situated in the central Mediterranean basin, northeast of Algeria exactly in the east of El Kala golf ($36^\circ 54'24.85''\text{N}$, $8^\circ 29'16.95''\text{E}$), with a surface area of 50 m².

Fig. 1. Map showing the location of the little rocky of Laouinet wetland in northeast of Algeria.

This s land is constituted of sand stone dome, in the presence of cells dug in the eroded rock (Fig.1). The land dominates these a about 5 m maximum. The vegetation is rare, composed mostly of salicornia (Michelot, Laurent, 1992, 1993).

Statistical analysis

Prior to statistical analysis, we checked all the variables' normality (Kolmogorov–Smirnov test) and variance homogeneity (Levene's test). Variables, whose parametric tests cannot be applied, were log-transformed to meet the assumptions of the analysis.

Based on the observed number of pairs between 2004 to 2009, the population growth rate was estimated for the whole study period as $\lambda = (N_t / N_0)^{1/t}$, where N_0 is the initial population size, N_t the final population size and t the number of years between the start and the end of the study period.

We performed the one-way ANOVA parametric test to determine whether there is a year effect (six-year of monitoring) on the different parameters (nests measurement, egg traits and incubation period); in the case of a significant effect, analysis will be complemented with LSD tests. We also used Pearson correlation to explore the relationships between egg breadth and egg volume, egg length and egg shape index, clutch size and egg measurement with latitude at different parts of the world.

Fig. 2. Maximum abundance of *Sterna hirundo* between 2004 and 2009 at Laouinet small island, El Tarf, Algeria.

Fig. 3. Temporal patterns of the Common Tern population's establishment.

Table 1. Nest measurements.

Nests characteristics		Mean	Min.	Max.
North africa (n=37)	internal diameter (cm)	11,78	8,5	13
	external diameter (cm)	17,61	11,6	24
Bocheński (1966)	internal diameter (cm)	10	8	13
	external diameter (cm)	15	11.5	24

A multivariate analysis of variance (MANOVA) with the GLM procedure was carried out by taking morphological parameters (egg volume, fresh mass, egg shape index) and hatching success as dependent variables and the six years of monitoring, the number of eggs by nests (2 vs. 3 egg) as independent variables (Wilk's lambda was the test criterion), in the case of a significant effect, analysis will be complemented with LSD tests. Significant effects were further explored by Kruskal–Wallis non-parametric test; this allowed us to evaluate the distribution of the clutch size according to the six years of monitoring. All statistical analyses were carried out using SPSS 17 (SPSS, Inc., Chicago, USA).

Results

Population size

In six seasons, we recorded 74 Common Terns individual at Laouinet small island, El-Tarf, Algeria. The greatest abundance of breeders have been observed at the first year of the study (2004), followed by a negative linear decrease until 2009 (Fig.2). The proportional change in population size during this period is a very worrisome ($\lambda = -0.62$: *Lambda* is called the finite population growth rate) indicated an alarming population declining.

Arrival and departure dates

During these study years (six year of survey), mid-May was the period over which the first Common Tern individuals have occupied the place, the low number of the arrived individuals was recorded around mid-May (12.33 ± 2.33 SD). Then, the maximum Tern's population abundance was reached (25.33 ± 5.64 SD)

after three months, by mid-August period in which all the birds leave the site (Fig. 3).

Nest placement and measurement

Almost all nests were located at the center of this small island with an average distance of 7.58 m from the island edge. Nests were mainly made with dead vegetation (stems and leaves) that had washed onshore, shell fragments, bones, stones, and sometimes plastic (Fig. 4). During the six years of the study, nests have been made uniformly, with a mean external diameter of (17.61 ± 2.26 SD), and a mean internal diameter of (11.78 ± 1.07 SD). So, no significant variation among nests' measurements have been detected (external diameter: Anova; $F = 1.562$; $df=5$; $P=0.200$, internal diameter: Anova; $F = 1.327$; $ddl=5$; $P=0.279$) (Table 1).

Nesting facts

The monitoring of 87 eggs from 37 nests during six breeding seasons enables us to obtain an interesting description of the Common Tern nesting facts (Table 2). Three eggs by nest have been counted for more than half of all the surveyed nests (54%), two eggs for 38%, and one egg for the rest of nests (8%). The aforementioned clutch sizes have not been varied significantly ($X^2 = 5.044$, $P = 0.88$) across years (Fig. 4) (Table 2). Egg length ranged from 40 mm to 43.6 mm, egg width from 29 to 31.6 mm, and egg weight from 19 to 21 grams, All mean egg traits did not differ between the six years of monitoring (egg weight Anova; $F = 3.224$; $df = 6$; $P = 0.010$ and egg length Anova; $F = 1.77$; $df = 5$; $P = 0.128$), only egg breadth (Anova; $F = 2.53$; $df = 5$; $p = 0.035$) increased with time and showed its maximum during the last

Table 2. Nesting facts summary (87 eggs from 37 nests).

Clutch size	1-3Eggs
Egg traits	
Egg length	40-43.6mm
Egg breadth	29-31.6 mm
Egg weight	19-21 grams
Morphological Parameters	
Egg volume	17.85-20.4 cm ³
Egg mass	19-22 grams
Egg shape index	0.68-0.76
Incubation Period	22-31 day

year of the study (2009 to 2008 LSD = 0.20, $P = 0.391$, 2009 to 2007 LSD = 0.47, $P = 0.04$; 2009 to 2006 LSD = 0.54, $P = 0.02$, 2009 to 2005 LSD = 0.63, $P = 0.00$, 2009 to 2004 LSD = 0.58, $P = 0.00$) (Fig. 5).

Concerning the morphological parameters, the egg volume array from 17.85 to 20.0 cm³, egg mass from 19 to 22 grams, and finally, the egg shape index varied between 0.68–0.76. Over the six years, the morphological parameters (volume, mass, shape index) varied between the six years of the study (MANOVA: Wilks' $\lambda = 0.762$, $F = 1.312$; $P = 0.049$), but does not vary with eggs number (MANOVA: Wilks' $\lambda = 0.980$, $F = 0.473$; $P = 0.702$), and their interaction (MANOVA: Wilks' $\lambda = 0.839$, $F = 0.833$; $P = 0.640$).

The egg volume varied between the years (GLM df = 5, $F = 1.87$; $P = 0.030$) was more important year after year (2009 to 2008 LSD = 0.22, $P = 0.49$; 2009 to 2007 LSD = 0.92, $P = 0.00$; 2009 to 2006 LSD = 0.69, $P = 0.03$; 2009 to 2005 LSD = 0.31, $P = 0.01$; 2009 to 2004 LSD = 0.31, $P = 0.00$) (Fig. 6) but does not vary with the number of eggs and their interaction (GLM df = 1, $F = 0.663$; $P = 0.418$, GLM df = 5, $F = 1.099$; $P = 0.369$).

The egg shape index does not vary from year to year, neither with the number of eggs or their interaction (GLM df = 5, $F = 1.75$, $P = 0.134$; GLM df = 1, $F = 0.613$, $P = 0.436$; GLM df = 5, $F = 1.16$, $P = 0.335$).

The egg mass also does not vary in years or the number of eggs and their interaction (GLM df = 5, $F = 0.578$, $P = 0.717$; GLM df = 1, $F = 0.421$, $P = 0.519$; GLM df = 5, $F = 0.600$, $P = 0.700$). The egg volume depended more on the egg breadth ($r = 0.753$, $P = 0.03$); however, the egg shape depended negatively on the egg length ($r = -0.645$, $P = 0.028$).

The mean incubation period of Common Tern is 25.5 (± 3.4) and varies between the range of 22 to 31 days. The incubation period varies between the six year of monitoring (Anova; $F = 31.28$; df = 5; $P = 0.00$) and showed an increase from year to year (2009 to 2008 LSD = 0.91, $P = 0.25$, 2009 to 2007 LSD = 0.87, $P = 0.01$; 2009 to 2006 LSD = 0.87, $P = 0.00$; 2009 to 2005 LSD = 0.83, $P = 0.00$; 2009 to 2004 LSD = 0.81, $P = 0.00$) (Fig. 7).

Breeding success

The hatching success was 70.5% in 2004, 68.75% in 2005, 71.42% in 2006, 71.42% in 2007, 69.23% in 2008 and 69.23% in 2009. The hatching success does not vary between years, eggs' number and their interaction (GLM df = 5, $F = 0.963$, $P = 0.337$; GLM df = 5,

Clutch size

Fig. 4. Clutch size variation. **Fig. 5.** Yearly eggs breadth variation. **Fig. 6.** Yearly egg volume trend. **Fig. 7.** Yearly variation of the Common Tern incubation period.

Table 3. International egg measurements variation.

Country	Egg length	Egg breadth	Egg volume	Egg shape	Author
Present study	41.8mm	30.3mm	19.12cm ³	0.72	
Switzerland	41.8mm	30.4mm	20.22cm ³	-	(Noll, 1943)
Germany, Oberrhein	41.84 mm	30.56mm	20.46cm ³	-	Glutz von Blotzheim, Bauer, 1982
Slovakia	41.9mm	30.3mm	20.14cm ³	-	Glutz von Blotzheim, Bauer, 1982
Austria	41.03mm	30.2mm	19.59cm ³	-	Glutz von Blotzheim, Bauer, 1982
Bulgaria	41.4mm	30.4mm	20.03cm ³	-	(Konigstedt et al., 1991)
Poland	41.5mm	30.6mm	20.43cm ³	-	(Becker et al., 1997)
Germany, Wadden Sea	41.8mm	30.3mm	20.09cm ³	-	(Becker et al., 1997)
Netherlands	-	-	19.72cm ³	-	(Brenninkmeijer et al., 1997)
Slovenia	41.23mm	30.07mm	19.52cm ³	0.73	(Vorgin, 1998)
Romania	41.28mm	31.02mm	-	-	(Shurulinkov et al, 2016)

$F = 0.145$, $P = 0.980$; GLM $df = 5$, $F = 0.855$, $P = 0.526$). Our results showed a stabilized hatching success and a best estimation of breeding success.

Discussion

In the object to develop conservation prescriptions of the unique population of Common Tern in the Mediterranean North West, we aimed to investigate the breeding biology and habitat of the majority of Common Tern in winters on the western seaboard of Africa, principally west and south Africa; while the minority appear to winter off Portugal (Muselet, 1982; Becker, Ludwigs, 2004), in Central Europe, the Common Tern starts breeding in May (Glutz von Blotzheim, Bauer, 1982). Yésou et al. (2005) recorded the presence of the Common Tern in Europe during the breeding period (mid-May to mid-August), which is consistent with our results. We also reported its presence in the study area during the same period in the breeding season; the Common Tern occupied several types of habitat, such as, roofs used by several hundreds of nesting pairs in Netherlands and Latvia (Stienen, 2002; Strazds, 2002), artificial sites such as gravel pits, peat pits, bog ponds, patches of dumped soil from dredging, small concrete structures in freshwater lakes, fish farms, or other artificial islands, and in particular, rafts in Switzerland, also salt marshes, and sandy or gravel sites in the US coastal sites (Greenhalgh, Greenwood, 1975; Friednieks, Viksne, 1989; Fasola, 1993; Fasola, Canova, 1996; Leibak et al., 1994; Becker, Sudmann, 1998; Beaud, 2001; Sudmann et al., 2003). Our results are overall consistent with those of the previous studies (Hakala, Jokinen, 1971; Axell, Hosking, 1977; Skinner, 1998) in which the Common Tern also occupy rocky or stony islands during the breeding period.

We recorded a marked decline in the Common Tern population ($\lambda = -0.60 \pm 0.087$) over the period of our study, this phenomenon was also observed in many regions in the world (Europe, USA, etc.) and was debated by many authors (Scarton, 2010; Erwin et al., 2011; Morris et al., 2012; Szostek, Becker, 2012; Nisbet et al., 2013). The decline of Common Tern population over time can be caused by several factors such as: sea level rise (Scarton, 2010), flooding that leads to decreased productivity in Common Terns (Becker, Anlauf, 1988; Palestis, 2009) and the combination of increased emigration and decreased recruit-

ment (Erwin et al., 2011; Szostek, Becker, 2012). In Algeria, in the month of May, the Common Tern individual breeders are present in small numbers. These findings are translated into a low recruitment rate. However, in the month of August, the recruitment rate increases with the birth of the Common Tern chicks, which indicates a high emigration rate. We think that the main cause of the decline of the unique population of Common Tern is the decreased recruitment. The Common Tern may move to a new site because of predation or other reasons for breeding failure (McNicholl, 1975; Gochfeld, 1979).

According to Shurulinkov et al. (2016), four types of Common Tern nests were recorded in Romania based on their different constitutions; nests built by mussel shells, nests formed as a small inundation in the sand without any building material, nests hidden in the vegetation or among and other objects like stones or pieces of timber, and nests built by wooden sticks and straws. In our study, the building material used in the Common Tern nests was mainly mussel shells Sandpit, stems and leaves as reported in Romania. The Common Tern nests' measurements in our study revealed a mean external diameter of 17.61 ± 2.26 cm (varying between 11.60 and 24 cm) and a mean internal diameter of 11.78 ± 1.07 cm (varying between 8.5 and 13 cm); our results are similar to those recorded by Bocheński (1966).

Many studies have shown that there is a little variation in Clutch size between Charadrii formes species, but a lot of them marked a constant clutch size of 4 eggs (Lack, 1968; Maclean, 1972; Arnold, 1999; Adamou et al., 2009). Becker, Ludwigs (2004) stated that the Common Tern laid usually 2–3 eggs, occasionally 1 or 4 eggs and very rarely >4. The average clutch size in our study area (2.45 ± 0.65) is similar to those reported in many studies conducted over the Common Tern breeding range, as Tunisia (2.46; Chokri et al., 2010), Romania (2.44; Shurulinkov et al., 2016), Orkney and Shetland (2.55; Bullock, Gomersall, 1981), NE Slovenia (2.55; Janžekovič et al., 2003 and 2.69; Vogrin, 1998), England (2.65; Langham, 1972), France (2.7; Yésou et al., 2005), USA (2.76; Nisbet, Welton, 1984), Germany (2.84; Witt, 1970) and Russia (2.88; Borodulina, 1960). The Common Tern clutch size is influenced by many factors: parental age (Hays, 1978; Nisbet et al., 1984), laying date (Nisbet, Welton, 1984; Becker, 1996), habitat and site (Nisbet, Drury, 1972; Safina et al., 1989), year (Frick, Becker, 1995), and weath-

er (Becker, 1985). However, the clutch size does not vary with latitude (correlation between clutch size and latitude in different parts of the world, $r = 0.46$, $p = 0.208$) (Table 3).

Egg size is an important life-history parameter, may either reflect female characteristics and/or environmental conditions, and influences survival and reproductive success (Thomas, 1983; Stokland, Amundsen, 1988; Williams, 1994; Rutkowska, Cichon, 2005). The investment in egg size is thought to represent a strong mechanism through which maternal effects can influence components of offspring fitness. Within several avian species and races, egg size varies significantly and is often positively correlated with hatchling phenotype, growth and survival (Vaisanen, 1969; Makatsch, 1974). Mean egg length, breadth and volume in the Algerian population of Common Tern is within the range of those characteristics known for a few other populations of this species, in different parts of Europe (Table 3).

It seems that the Common Tern egg size does not change with latitude and longitude, in Europe (Vogrin, 1998) and in North Africa (based on our results); also, it does not vary with latitude ($r = 0.32$, $p = 0.135$). However, our study shows that the Common Tern egg size (egg volume and breadth) varied between years and increased over the six years of monitoring, but does not vary according to the number of eggs per nest. Our results confirmed those suggested by Lack (1947). Brenninkmeijer et al. (1997) and Nisbet (1997) supposed that food availability and calcium resources have an effect on Common Tern egg size. Fasola, Bogliani (1990) recorded that the foraging distribution of Common Terns depended on the location of their preferred habitats, which were available only at given distances from the colonies. The colony was observed in neighboring El Mellah lagoon (Telailia et al., 2017); this lagoon has been referred by Chaoui et al. (2006) with a very important diversity, richness and abundance of ichthyofauna.

We recorded a mean incubation period of 25.5 ± 3.4 days ranging from 22 to 31 days. The incubation period in our population varied and increased from year to year. Many authors showed that the mean incubation periods increase from 24 to 31.5 days, however, the individual egg's hatching takes place after 33 days (Nisbet, Cohen, 1975; Nisbet, Welton, 1984; Wendeln, Becker, 2000). The increasing or the decreasing of the incubation period depended on egg temperature maintained within the bird-nest incubation unit (Ar, Sidis, 2002; Deeming, 2002; Turner, 2002) and the nest predation (Becker, Ludwigs, 2004), that becomes locally a limiting factor due to the reduction of colonies and concentration numbers. Several opportunistic native species sometimes have serious impacts on colonies (Yésou et al., 2005). In our study area, the presence of (*Larus michahellis*) (pers observation by Salah Telailia) Common Tern predator in the nesting site may explain the increase in the incubation period.

Our results showed a stabilized hatching success ranging from 69.23 to 71.42%, our approach with Langham (1972), where no adverse factors exist, hatching success may reach typically over 90%. Becker (1998) has studied 5 Common Terns' colonies over 17 years in Wadden Sea, Germany, and recorded a hatching success of 87%, Witt (1970) in south-west Germany, recorded a hatching success of 77%. However, in Finland, the hatching success recorded by Lemmetyinen (1973) was 80%.

Conclusion

This study provides the first traits of population dynamics and breeding biology of Common Tern in North Africa, and highlighted the alarming population decline. For a better understanding of life history, protection and conservation patterns of *Sterna hirundo*, this work needs to be deepened and extended to define various important parameters of bio-ecology of this migratory sea bird in its North African breeding habitat such as: habitat selection and management, nest site selection, diet, and so on.

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