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DEMOGRAPHIC DEVELOPMENT OF BREEDING POPULATIONS OF YELLOW-LEGGED GULL *Larus michahellis* NAUMANN, 1840 ON THE SMALL ISLANDS AND ALONG THE COASTLINE OF NUMIDIA (NORTH-EASTERN ALGERIA)

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ABSTRACT

The Yellow-legged gull (*Larus michahellis*), like most *Laridae*, has increased in number significantly over the 20th century. One of the major causes of this demographic explosion is supply by humans of abundant food resources through easily accessible open landfill sites. The objective of the study is to assess on a regional scale, the size of colonies of Yellow-legged gull and population dynamics. Yellow-legged gull population of Numidia had shown growth of 2.01% as compared to 1978. The average annual reproductive rate ($\bar{\lambda}$) is 1.03 Overall in study area. The highest density was observed on Srigina Island, with 106.7 pairs per hectare, followed by that of the Cap de Fer islet with 105 pairs per hectare, the Saint Piastre island with 93.3 pairs per hectare and that of the Lions islet with 80 pairs per hectare. The Yellow-legged gull exhibits early nesting on islands where the surface area is greater than one hectare, such as Srigina Island and Saint Piastre Island The study conducted in Numidia has allowed us to bring the latest information on the breeding populations of Yellow-legged gull at the local scale (Algeria) which remained unknown for nearly three decades. The data presented are compatible with most Mediterranean colonies.

Keywords: Yellow-legged gull, *Laridae*, demography, food resources, Numidia, Algeria.

INTRODUCTION

Many parameters related to ecology, behaviour and historical traits of marine birds are strongly influenced by availability of food resources. The choice of nesting sites (Jouventin and Mougin, 1981; Brown and Rannala, 1995), reproductive success (Brown *et al*., 1992; Chudzik *et al.*, 1994) and diet (Götmark, 1984; Belant *et al.*, 1993) partially depend on the nature and abundance of available food resources in the environment within a variable distance from reproduction sites.

Because of their opportunistic and anthropophilic characters which allow them to abundantly exploit food resources of human origin (Pons and Migot, 1995), some species of gulls have recently grown in demographic population, particularly in Europe (Thomas, 1972) and North America (Blokpoel and Scharf, 1991), and to a lesser extent in Asia and Australia (Coulson and Coulson, 1998). This phenomenon is typically attributed to the combination of two factors: availability of abundant and easily accessible food resources by humans (mainly open-air landfill sites and also industrial fishing waste) and protection of the species and favourable nesting sites (Bosch *et al.*, 2000).

Among *Laridae*, Yellow-legged gull (*Larus michahellis*) has been experiencing demographic and geographic expansion since the middle of the last century in its natural habitat, particularly in the western Mediterranean Basin (Thibault *et al*., 1996). The breeding population is estimated at more than 120,000 pairs (Pérennou *et al*., 1996). The largest colonies of Yellow-legged gull are distributed throughout small Mediterranean islands (Guyot and Thibault, 1988; Beaubrun, 1994; Morais *et al.*, 1995; Vidal *et al.*, 2001 and 2004; Moulaï *et al.*, 2006).

However, the numbers and sizes of North African Yellow-legged gull have remained unknown both in the number of breeding couples and in their distribution. It took until the 1980s for the work of Varela and De Juana (1986) and Beaubrun (1988) to appear, covering aspects related to the monography of the Yellow-legged gull on the Moroccan coast. For the Algerian populations, 38 colonies were counted by Jacob and Courbet (1980) along the coastline. In 2005, work

started on the biology and ecology of the Yellow-legged gull, but it remains highly localized geographically. We cite: Moulaï *et al.* (2005), Moulaï (2006), Moulaï *et al.* (2008) and Boughanem and Moulaï (2013) in some regions of Algeria, particularly Béjaïa and Jijel

The interest of this work involves updating the breeding population of Yellow-legged gull and health status of breeding populations on the islands and islets in the area of study we tried to explain in relation to environmental factors.

MATERIALS AND METHODS

Study Sites: The study area is located between Skikda and El Kala, along the western Algerian coast extending over 250 km of coastline, from Cap Srigina, also known as the Cap des Singes (Skikda region) in the west (36°93'75"28 N, 6°88'62"61 E) to Cap Roux in the east (36°56'31"80 N, 8°36'45"46"E) on the border of Algeria and Tunisia (Figure 1). This coastal strip is the main nesting site of Yellow-legged gull. From west to east, it includes Srigina Island, Lion Islet (Stora), cliffs of Skikda, Cap de Fer Islet, Saint Piastre Island (Kef Amor), Edough peninsula, Cap Rosa, Laouinet Islet and Cap Roux.

Numidia is part of the warm Mediterranean subhumid bioclimate. Climatic factors recorded for the study in 2006 are as follows: average annual temperatures range from 12.2 ° C to 25.9 ° C, average annual rainfall of 936.7 mm in the coastal zone and the prevailing winds are from the northwest to southeast, with maximum speeds of 9 m / s and 23 m / s (O. N. M., 2007).

i. *Srigina Island*: Covering a surface area of 2.4 ha (36° 56' N, 6° 53' E), Srigina Island is located 700 m from the coast and 4 km from northwest Stora. A lighthouse was built at the island's summit. It is sparsely vegetated and dominated in the south by the shrubs *Chamaerops humilis* and *Opuntia ficus indica* and grasses *Malva veneta*, *Melilotus* spp. and *Carpobrotus acinaciformis.* There is also a rocky islet without any vegetation neighbouring the island where Eleonora's falcon and Cory's shearwater nest (Telailia *et al.*, 2013 and 2014).

ii. *Lion Islet:* Located 2 km in the northwest of Stora (36°55'12.33'' N, 6°53'22.53'' E) and 200 m from the shore, this triangular islet has a surface area of 0.4 ha (Gueydan, 2010). The friability of the soil that makes up the islet, combined with its steep slopes, have contributed to keeping the bedrock exposed, hence, lacking any vegetation.

iii. *Cap de Fer Islet*: Located in the Marsa region (Skikda) near the Cap de Fer, this island lies 200 m from the coast. Its surface area is 0.6 ha, and its highest altitude is 10 m. The substrate consists of completely exposed rock domes.

iv. *Saint Piastre Island*: With a surface area of 3 ha and an elevation of nearly 33 m, Saint Piastre Island lies 2 km off the Chetaibi coast (37°4'48.97" N, 7°9'43.27" E) (Gueydan, 2010). This rocky island is nearly devoid of vegetation, represented mainly by *Malva veneta*. Saint Piastre Island is home to a colony of Cory's shearwater (Telailia *et al.*, 2014).

v. *Laouinet Islet*: Located east of the city of El Kala (36°54'24.85" N, 8°29'16.95" E), Laouinet Islet measures approximately 50 m^2. It is rocky and is a sandstone dome containing holes carved into the rock due to erosion. Laouinet Islet's highest point is 5 m above sea level. Vegetation is sparse, consisting of *Salicornia* (Michelot and Laurent, 1992).

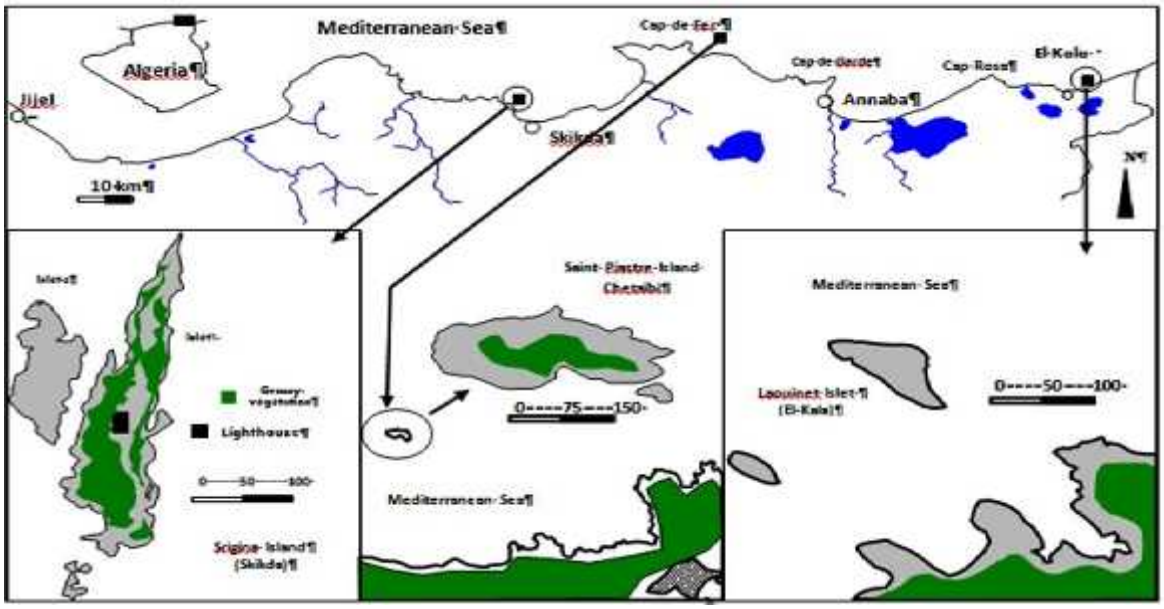

Figure 1- Location of the islands and islets in the Numidia, Algeria study region

vi. *Cliffs of the Numidia seaboard*: These coastal cliffs are almost entirely covered by crystalline schists west of the Cap de Garde and Numidia sandstone between Cap Rosa and Cap Roux. The plant covering is formed by localized clumps of *Ampelodesma mauritanicum* remains of multiple fires, *Pistacia lentiscus*, *Phillyrea angustifolia*, *Quercus coccifera* and *Chamaerops humilis* (Thomas, 1975).

i. Counting pairs of breeding Yellow-legged gulls: The breeding pairs count was conducted in 2006, during the reproduction period from the end of February until early June, at a rate of one outing per week in order to observe the number of nests. Site visits and counting methods are closely dependent on the accessibility of colonies and the state of the sea. For hard-to-access colonies, like those on cliffs, the number of nesting individuals was estimated from a boat or outcropping near the nesting sites using a pair of binoculars and a telescope. For other colonies that are easier to access, an individual nest by nest count was conducted by marking the nests when they are first spotted in order to avoid counting them again during the next sweep.

ii. Change in numbers and colonies of Yellow-legged gulls between 1978 and 2006: The only data on status of Yellow-legged gull populations come from Jacob and Courbet (1980), based on work conducted in 1978 in our study region. For data on population counts, we followed Moulaï *et al.* (2005), Moulaï (2006) and Boughanem and Moulaï (2013).

Given the lack of regular counts of breeding populations of Yellow-legged gulls in Algeria, the status of the species remains unknown to this day. The only baseline census is Jacob and Courbet (1980), compiled in 1978 along the Algerian coast. We, therefore, performed a theoretical calculation for assessing the change in the population of this species based on annual growth, density and annual reproductive rate, using the formula proposed by Migot and Linard (1984):

$$\bar{\lambda} = \sqrt[n]{\frac{Ef}{Ei}}$$

n = number of years between the two counts
E*f* = final number
E*i* = initial number
where

$\bar{\lambda} < 1$ = lower number

$\bar{\lambda} > 1$ = higher number

$\bar{\lambda} = 1$: stable number

iii. Annual growth of Yellow-legged gull: The annual growth of Yellow-legged gull was calculated based on the two data sets from the islands with a large surface area: Srigina Island and Saint Piastre Island:

- Counts of Yellow-legged gull colonies performed in 1978 (Jacob and Courbet, 1980).
- Counts of nesting pairs of the species during present study in 2006.

Density of Yellow-legged gull nests: The density of colony birds is expressed in terms of the number of pairs per surface unit (Launay, 1983). Density per hectare is calculated by dividing the total number of nesting pairs by the total surface area of the applicable island (Vidal, 1998). The nest count for the species, distributed throughout the coastline, is used to estimate the average number of nesting pairs per kilometre of coastline (Moulaï, 2006).

The evolution of density was calculated using the formula previously used to calculate enrolment growth.

RESULTS

i. Counts of nesting pairs of Yellow-legged gull: The number of gulls along the Numidia coastline was estimated at 690 pairs (Table 1).

In addition, it should be noted that the highest number of nesting pairs was located in the western part of Numidia. Also, we note that 90% of Yellow-legged gull pairs nest on islands. The nesting of the Yellow-legged gull in continental areas is relatively low, at 10%. This is based on the availability of preferred nesting sites in the area (cliffs, piles of rocks, and peninsulas).

ii. Chronology of the installation of Yellow-legged gull nests: The course of the egg-laying season was monitored on three colonies: Srigina Island, Saint Piastre Island, and Lion Islet. The first egg was laid on 22 February 2006 in the eastern part of Srigina Island and then on 1 March 2006 in the southern part of Saint Piastre Island. The first egg from the first pair on Lion Islet was recorded on 15 March 2006 (Figure 2). The installation method for reproducing pairs seems to differ from island to island. The change in the number of Yellow-legged gull nests on Srigina Island and Saint Piastre Island followed a similar trend. Nesting pairs on Srigina Island and those on Saint Piastre Island got settled earlier, particularly on Srigina. It is similar for the change in the number of nests in the colony on Lion Islet.

The change in average number of nests with laid eggs showed a variation over time. The chronology of egg-laying season showed a first phase, corresponding to the month of March, when the building of nests and laying of eggs were relatively low, or 18% of nests. During second phase in the month of April, egg-laying increased sharply to 60% and then stabilized during the first half of May, at a peak value in a third phase. It then gradually declined in a final phase, lasting from mid-May until the start of June.

Table 1. Counts of nests belonging to reproductive pairs of Yellow-legged gulls on the islands and along the coastal strip of Numidia.

Locations	Counting Methods	Numbers (pairs)	Comments
Srigina Island	Nest	256	
Lion Islet	Nest	32	
Wide beach - Stora Port coastal strip	Remote observation	13	Cliffs
Cap de Fer Islet	Nest	63	
Cap de Fer coastal strip (east and west)	Remote observation	6	Cliffs
Saint Piastre Island	Nest	280	
Sable d'Or - Chetaibi Port coastal strip	Remote observation	9	Cliffs
Roman fountain	Remote observation	1	Cliffs
Sugar loaf	Remote observation	3	Cliffs
Cap de Garde West	Remote observation	16	Cliffs
Cap Rosa – El Kala coastal strip	Remote observation	3	Cliffs
Laouniet Islet	Nest	2	
El Kala - Cap Roux coastal strip	Remote observation	7	Cliffs
Total count		**690**	

According to the table above, the number of Yellow-legged gull pairs has increased on the islands and islets in the study region. This increase is very pronounced on Srigina Island, where the number went from 73 pairs in 1978 to 256 pairs in 2006. Saint Piastre Island has also witnessed an increase, with its number increasing from 180 pairs in 1978 to 280 pairs in 2006. The same finding occurs for Lion Islet and Cap de Fer Islet. As for Laouinet Islet, only two pairs were recorded in 2006 (Table 2). The average annual reproductive rate for nesting pairs is $\bar{\lambda}$ equal to 1.03.

iv. Density of Yellow-legged gull nests on the main islands and islets of Numidia: Density of Yellow-legged gull nests was calculated for four islands and islets: Srigina Island, Saint Piastre Island, Lion Islet, and Cap de Fer Islet. The highest density was noted on Srigina Island, where density of nests was 106.7 pairs per hectare in 2006. Lion Islet and Cap de Fer Islet also experienced an increase in the number of nests with density of 80 and 105 pairs, respectively. For Saint Piastre Island, density of nests was (Table 3).

However, the average annual reproductive rate for the nests indicates a slight change over time on the four studied islands and islets. The most significant instead was recorded on Srigina Island ($\bar{\lambda}$ = 1.05), followed by Lion Islet ($\bar{\lambda}$ = 1.03) and Cap de Fer Islet ($\bar{\lambda}$ = 1.02). By contrast, Saint Piastre Island appears to stabilize ($\bar{\lambda}$ = 1.01).

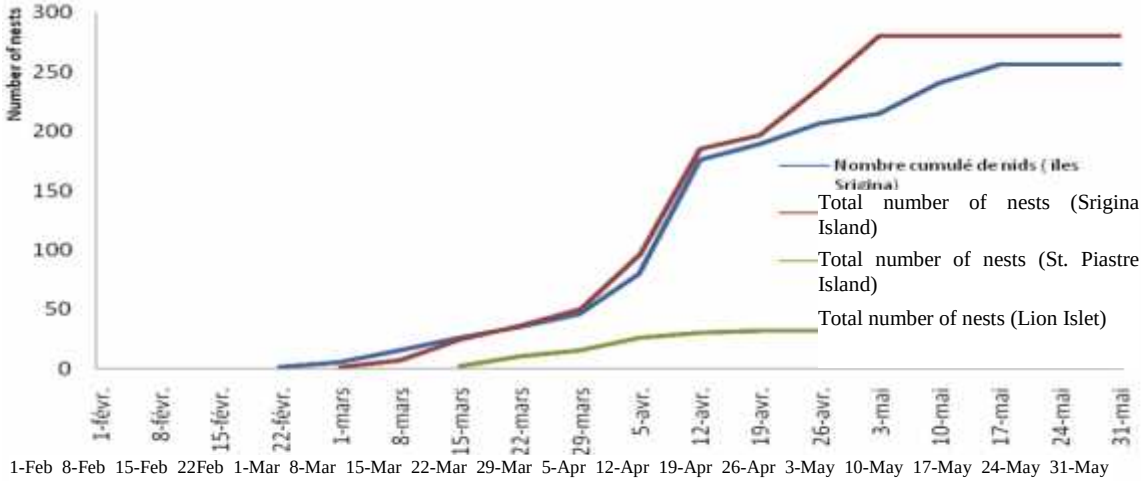

Figure 2 - Chronology of the installation of *Larus michahellis* nests in three island colonies of Numidia, Algeria

iii. Change in the Yellow-legged gull nesting numbers: The evolution of breeding populations of Yellow-legged Gull at Numidia, is reported in Table 2.

Table 2. Population growth rate (r as a percentage) and annual reproductive rate ($\bar{\lambda}$) for the Yellow-legged gull between 1978 and 2006.

Island	Count in 1978 (number of pairs)	Count in 2006 (number of pairs)	r	$\bar{\lambda}$
Srigina Island	73	256	3,5	1,04
Lion Islet	14	32	2,3	1,03
Cap de Fer Islet	48	63	1,3	1,01
Saint Piastre Island	180	280	1,6	1,02
Laouniet Islet	0	2	-	-
Total	**315**	**633**	**2,01**	**1,03**

Table 3. Densities and average annual reproductive rate ($\bar{\lambda}$) of Yellow-legged gull nests on four islands and islets between 1978 and 2006.

Island	Density of nests per hectare in 1978	Density of nests per hectare in 2006	r	$\bar{\lambda}$
Srigina Island	30,42	106,7	3,51	1,05
Lion Islet	35	80	2,29	1,03
Cap de Fer Islet	50	105	2,10	1,02
Saint Piastre Island	60	93,3	1,56	1,01

DISCUSSION

Comparison of data from the present study with data from Jacob and Courbet, (1980) showed a considerable increase in the number of nesting Yellow-legged gull pairs, with 315 pairs in 1978 compared to 633 pairs in 2006, a 100% increase. This increase in number is related to the expansion of the species range into the western Mediterranean (Launay, 1983; Beaubrun, 1993; Thibault *et al.*, 1996; Sadoul, 1998; Vidal *et al*., 1998; Duhem, 2004; Moulaï *et al*., 2006 and Boughanem and Moulaï, 2013).

Within the study region, Srigina and Saint Piastre Islands showed the biggest increase in the number of Yellow-legged gull nesting pairs, with +350% and +155%, respectively. This might be partly due to abundance of available food resources because of the sharp increase in human population in the coastal region, boosting the development of urban areas and an increase in open-air landfill sites, such as Skikda, Annaba, and Chetaibi. These landfill sites are accessible due to the proximity of the islands to the mainland. The same finding was recorded in the regions of Bejaia (Moulaï, 2006), Jijel (Boughanem and Moulaï, 2013), and the Marseilles Islands (Duhem *et al.*, 2007).

In general, the concept of travel distance to food is fundamental because foraging is the most costly activity for marine birds during the breeding season (Oro *et al.*, 1995). In addition to increased energy expenditure for individual birds, particularly during the breeding season, due to long distance from feeding areas, more time is spent away from the colony and consequently an increase in the rate of aborted eggs and chick mortality due to a lack of care or protection against predators and weather conditions (Hunt, 1972). Therefore, determining the quality of a site for setting up a colony probably includes a general estimate of the quality of site's surroundings, including its accessibility to feeding areas within the foraging radius for the species in question (Duhem *et al.*, 2008).

It is important to point out that the cohabitation between Yellow-legged gull and Audouin's gull colonies observed in 1978 on Saint Piastre Island (Jacob and Courbet, 1980) is no longer the case after 28 years. Thus, observations made on the island during the present study indicated the disappearance of Audouin's gulls in favour of Yellow-legged gulls, which reflects the invasive character of the Yellow-legged gull species.

In addition, attempts by the Yellow-legged gull to colonize new sites, such as El Kala on Laouinet Islet, have failed for the following reasons: the inability to cohabit with another nesting colony species at the site (common tern) and the island's smaller surface area (Michelot and Laurent, 1993).

Regarding reproduction progress, the first Yellow-legged gulls that reach the Srigina and Saint Piastre Islands claim the most favourable locations, areas with vegetation where they can lay their eggs and shelter their nests. Beaubrun (1993) reported that nests of the species are usually built at the base of bushes. Steep slopes are ideal locations for setting up nests. The same finding was made by Cezilly and Quenette (1988), Valle and Scarton (1999), Duhem *et al.* (2007) and Boughanem and Moulaï (2013).

The installation date of first nesting pairs depends on the number of Yellow-legged gulls present on each island. Nest building began early, specifically 22 February 2006 on Srigina, 1 March 2006 on Saint Piastre, and 15 March 2006 on the Lion Islet. It is spread over time within the largest colonies in terms of number of pairs. However, other parameters may also play a role in explaining this time spread, such as a difference in the age structure of the colonies. Among the *Laridae*, the

oldest and more experienced birds tend to begin nesting earlier than younger and less experienced birds (Coulson 1968, Becker and Erdelen 1986).

It is important to note that despite increase in the recorded numbers on islands in the study region, density of nesting gulls has grown only moderately over a 28-year period. This is explained by the fact that, in 1978, only a few small areas on those islands were used for nesting, but in 2006, almost all of Srigina Island, Lion Islet, and Cap de Fer Islet were colonized by nesting gulls.

Thus, this increase in surface area used for nesting reduces the effect of the increase in numbers on the increase in density of nesting gulls. This finding implies that these islands, which have already experienced significant colonization during the period, are far from being saturated in terms of available space and that they can probably accommodate even larger populations of gulls, contrary to what was reported by Boughanem and Moulaï (2013), underscoring that the islands in the Jijel region are saturated in terms of the number of nesting pairs of Yellow-legged gulls.

Conclusion: The Yellow-legged gull of Numidia is experiencing significant population growth. The colonization of island environments by Yellow-legged gulls is a result of multiple factors, including the proximity of numerous food sources and the existence of multiple islands and islets rarely visited by humans. The increase in the numbers of this species is not limited to the increased density of nesting gulls within the island colonies. Studies conducted in recent years have highlighted the bird's nesting in urban areas and inland.

However, the accessibility of food resources could be impeded by the creation of a household waste landfill site (measures taken by local authorities). One question that remains is whether the knowingly opportunistic species could become a predator with respect to other animal species. The emigration and immigration of these birds between the various colonies still needs to be determined, including the degree of philopatry. This operation could also be a way to explain these demographic trends.

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