

CAN HUMAN ACTIVITIES HAVE AN IMPACT ON THE DEMOGRAPHY OF THE YELLOW-LEGGED GULL, *LARUS MICHAHELLIS* IN NORTH-EASTERN ALGERIA?

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Abstract: On the eastern coast of Algeria, two situations arise for *Larus michahellis*. High demographic growth was observed between 1978 and 2007 at the level of island nesting sites with an annual growth of around 3.89 % and an annual multiplication rate of 1.03 and an important decrease in the breeding population on the same sites, between years 2007 and 2017, with an annual decrease of more than 9% and an annual multiplication rate ($\lambda = 0,91$) which shows a significant decline in the number of breeding pairs at the island level in the region. The area occupied by couples of *Larus michahellis* on the islands of the region evolved in the same way. Nesting sites appeared to be saturated in 2007. Less than ten years later (2017), the density has decreased and is approaching that noted in 1978. In the urban area in Jijel, the situation is different, the first breeding pairs appeared in 2000 with 5 pairs, and from this date, urban nesting did not stop increasing, reaching a figure of 328 pairs in 2018. In 20 years, the urban Gulls of the city of Jijel have experienced considerable annual growth (23%). Human activities through the management of household waste seem to be at the origin of the modifications noted in the level of the population dynamics of the Yellow-legged Gull.

Keywords: *Larus michahellis*, demographic dynamics, islands, urban environment, refuse dump.

INTRODUCTION

On the level of its distribution in the Mediterranean, Yellow-legged Gull (*Larus michahellis*) is considered the most frequent and abundant seabird. It has experienced a strong demographic and geographic expansion during the previous decades (Berger et al., 2011, Cadiou et al., 2014; Serra et al., 2016). This strong demographic and geographic expansion of the Yellow-legged Gull may be the result of two main factors: the exploitation of anthropogenic resources, as a result of the development of open landfills, industrial fishing, and the protection of numerous sites where the colonies are established, in particular marine islands and islets (Beaubrun, 1994; Sadoul, 1998; Vidal et al., 1998; Moulai et al., 2006).

Generally, due to its ecological plasticity and synanthropic habits, the Gull is able to modify its breeding habitat, it is now installed on buildings in coastal cities and even beyond. These findings are observed both on the north shore of the Mediterranean and on the south shore in north Africa (Moulai et al.,

2005; Cadiou et al., 2014; Talmat-Chaouchi et al., 2020). In recent years, especially in Europe, there has been some decrease in the populations of *Larus michahellis* probably due to better management of household waste from the early 2000s. In this sense, waste is managed in the context of technical landfill centers (Duhem, 2004; Serra et al., 2016). What about the current situation in the northeast of Algeria? especially around the Jijel region, where the Yellow-legged Gull experienced a strong increase in its population between 1978 and 2007, accompanied by the colonization of new habitats, in particular the urban environment (Jacob and Courbet, 1980; Moulai et al., 2010; Bougaham and Moulai, 2013).

MATERIAL AND METHODS

Study areas

The study area includes two main sites; the city of Jijel (urban environment) and the natural environments where the Yellow-legged Gull nests (islands and islets) (Fig. 1).

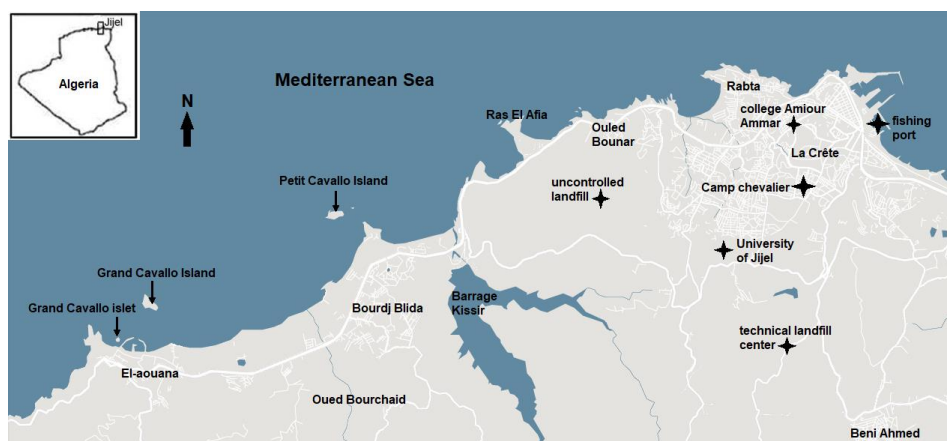


Fig. 1. The geographical location of the city of Jijel and the main island environments (scale: 1 / 20 000).

City of Jijel

Jijel (36 ° 52 'N, 5 ° 49' E), is a coastal town located 400 km east of Algiers. It is divided into two parts; the old city which includes among other things, the historic city center and the Ammour Ammar college, and the new city where we find the Jijel University Campus and the great district of Camp Chevalier. As in all the cities of Algeria, Jijel lived a rural displacement towards the center town during the decade 1991-2000, which considerably increased the population of the chief town which passed from 35.940 inhabitants in 1978 to 133.524 in 2007. In 2017, the number of inhabitants was estimated at 158.712 (ONS, Jijel, 2020). This increase in population was followed by an increase in the quantity of household waste, which passed from 25,728,369 tons per year in 2009 to 41,921,360 tonnes in 2018 (Dir. Envir. Jijel, 2018). It should be noted that a technical landfill center was opened in Jijel in 2008 on an area of 4 hectares and this to replace the uncontrolled landfill. We also note the opening of a modern fishery near the port of Jijel in 2005.

Island environments

On the west coast of Jijel, there are three small island environments, which constitute the main nesting sites of *Larus michahellis* in the region (Fig. 1).

Grand Cavallo Island: it is located 20Km from the capital of the city of Jijel. It is distant from the mainland is 950m, with an area of about 6 ha, its relief is quite uneven, its west face includes a cliff with a maximum altitude of 50m. Generally, the vegetation cover is of the high matorral type, it can reach 4m in height, it is formed mainly of *Pistacia lentiscus*, *Phillyrea angustifolia*, and *Olea europea* and partly of a nitrophilic flora like *Malva cretica*, *Urtica membranacea*, and *Chenopodium murale* (Bouyahmed and Moulai, 2018).

Grand Cavallo islet: is located in the locality of El-Aouana, it is separated from the shore by a distance of 50m, it has an area of 0.15ha with a maximum altitude of 30m. The site has largely a rocky and bare structure. The vegetation cover is in the form of tufts located at the top of the islet, we find *Pistacia lentiscus*, *Phillyrea angustifolia*, *Chamaerops humilis*, and some subjects

of *Genista numidica*. We also note, some herbaceous plants, for example, *Limbarda crithmoides*, *Halimione portulacoides*, *Sonchus tenerrimus*, and *Asteriscus maritimus* (Bouyahmed and Moulai, 2018).

Petit Cavallo Island: is located 13 Km from the town of Jijel in the locality of Bourdj Blida (Andreu). It is separated from the continental front by a distance of 750m, it extends over an area of 4 ha, the terrain is fairly flat with a maximum altitude of 10m. Overall, the site is covered with a more or less high matorral. It is the richest island in plant species, it is mainly composed of *Pistacia lentiscus*, *Phillyrea angustifolia*, *Rhamnus alaternus*, *Arundo donax*, *Arundo plinii*, and *Myrtus communis* (Bouyahmed and Moulai, 2018).

Methodology

The count of breeding pairs of Yellow-legged Gull took place both in the city (urban environment) and in the natural environment (island environment).

In the urban environment

The census of the breeding population of Yellow-legged Gull in urban areas in Jijel took place between March and June 2018. The identification of breeding pairs is undertaken during the breeding season in the city. The nests can, if they are not highlighted, very easily go unnoticed (Cadiou, 1997). The observation period relative to each sector is a function of both the extent of the visible sector, the nature of the urban habitat, and the density of gulls (GOES, 2012). The methods known for the census of colonies of urban gulls are remote observation and systematic prospecting (Moulai et al., 2005; Cadiou et al., 2009). In this case, remote observation appeared to be the most suitable method. It consists of counting birds from selected high observation points or counting gulls on the ground using a pair of binoculars CONDOR (16×40). Each gull detected was subject to more specific observation to determine its possible nesting status (GOES, 2012). A continuous observation (10 minutes) and/or recurrent allows assessing the probability of nesting of the individual. Only proven and probable nesting cases are taken into consideration.

In island environment

The census of breeding pairs at the three Jijel Islands took place between March and May 2017, at the rate of 3 to 5 trips per month, depending on the area of the island and the state of the sea. On-site counts were carried out, nest by nest, where nests were first marked on the first pass.

Population dynamics of the Yellow-legged Gull in north-eastern Algeria

The results of the counts of nesting pairs of Gulls in urban areas were compared with the work of Moulai and al., (2005) made in 2000. Concerning island environments, we took into account the study of Bougaham and Moulai (2013), carried out in 2007. As an indication, our results were also compared with older data, obtained in 1978 by Jacob and Courbet (1980). The comparisons are expressed in terms of annual multiplication rate and density.

➤ The average rate of annual multiplication

The results of the two censuses of 2007 and 2017 are expressed as an average rate of multiplication annual (λ) according to the formula of Migot and Linard, (1984):

$$\lambda = \sqrt[n]{V_f/V_i}$$

n = number of years between two censuses;

V_f = final value;

V_i = initial value,

With $\lambda < 1$ = decrease in numbers; $\lambda > 1$ = increase in numbers; $\lambda = 1$: corresponds to stable numbers.

➤ Densities of Yellow-legged Gulls

The density per hectare of seabirds is generally calculated by making the ratio of the population to the total area of the island considered (Launay, 1983; Vidal et al., 1998; Duhem, 2004; Moulai, 2006).

RESULTS AND DISCUSSIONS

In Jijel (North-eastern Algeria), *Larus michahellis* breeding in islands and in anthropogenic areas of the city (Fig. 2). The counts carried out in 2017 and 2018, indicated that the number of breeding pairs in urban areas is quite close to that of the island environment is fairly close, it was respectively 328 and 425 pairs, respectively (Tab. 1). The largest numbers were noted on Grand Cavallo Island with 301 pairs, followed by the two urban sites; the Jijel university campus and the Amieur Amar college, with 153 and 105 pairs, respectively (Fig. 2 and Tab. 1).

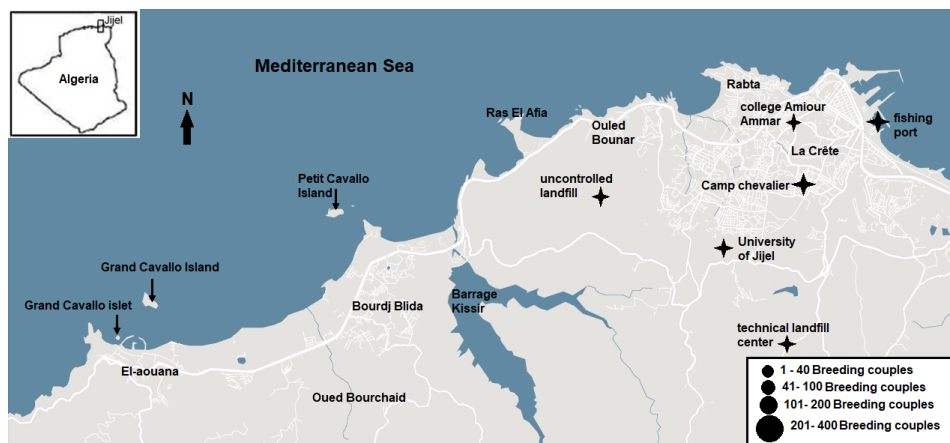


Fig. 2. Distribution of breeding pairs of the Yellow-legged Gull in the region of Jijel (scale: 1 / 20 000).

Table 1.

Intrinsic Rate of Population Growth (r in Percentage) and Annual Multiplication Rate (λ) of Yellow-legged Gulls, between 1978 and 2018 in Jijel (North-eastern Algeria)

Sites	Couples 1978	Couples 2007	r	λ	Couples 2017	Couples 2018	r	λ
Islands								
Grand Cavallo Island	320	610	2.2	1.02	301		-7.06	0.93
Grand Cavallo islet	-	53			36		-3.86	0.96
Petit Cavallo Island	22	395	9.9	1.10	88		-15.01	0.86
S/total	342	1058	3.89	1.03	425		-9.12	0.91
Urban								
University of Jijel	-	-				153		
Amieur Amar College	-	-				105		
Camp chevalier	-	-				63		
Ancient city	-	05				07		
S/total	-	05				328	23.24	1.26
Total	342	1063			753			

Numbers are given in the number of breeding pairs. Urban nesters data are for 2000 and not 2007

The gulls of the city of Jijel, occupy various urban nesting sites. The majority of couples (78%) nest in administrative buildings (schools, universities). The other (22%) choose collective housing buildings (dwellings).

Demographic dynamics of the Yellow-legged Gull in the Jijel region

At the island sites and between 1978 and 2007, there was strong growth in the breeding population of *Larus michahellis*. It passed from 342 pairs in 1978 to 1058 in 2007, with an annual growth of about 3.89%. The latter was not uniform. The colony on Petit Cavallo Island experienced a notable annual growth of about 10%, while it was 2.2% on Grand Cavallo Island.

The calculation of the annual multiplication rate showed a significant increase in numbers at the level of the islands in the region ($\lambda = 1.039$). On the scale of the sites already colonized in 1978, there is a significant multiplication for the gulls on Petit Cavallo Island ($\lambda = 1.10$) and a stabilization trend for breeding animals on Grand Cavallo Island ($\lambda = 1.02$) (Tab.1).

Between the years 2007 and 2017, there is a notable trend towards a decrease in the breeding population of Yellow-legged Gull in the island environment. The breeding population went from 1058 pairs in 2007 to

425 in 2017, an annual decrease of more than 9% (Tab. 1). During this period, the colony of Petit Cavallo Island experienced the largest decrease, with a decline of about 15%. That of Grand Cavallo Island was 7%. The Grand Cavallo islet experienced a smaller decrease (3.8%). Thus, in less than 10 years, the calculation of the annual multiplication rate shows a non-negligible reduction in the breeding population of the Yellow-legged Gull at natural sites of the region ($\lambda = 0.91$) (Tab.1).

In the urban environment of Jijel, the situation is quite different. The first breeding pairs in town appeared in 2000, with 5 pairs. In 2018, the number has increased to 328 pairs. Before, the urban nesting was noted only in the old city, whereas currently, the Gull has colonized various sectors as well in the new, as in the historic city. The largest number of couples was noted on the buildings of the Jijel university campus (Fig.3) with 153 pairs, followed by the buildings of the college Amiour Amar, with 105 pairs. The breeding population in the Camp Chevalier district is not negligible, it is around 63 pairs (Tab.1). Over almost 20 years, the urban Gulls of the city of Jijel have experienced strong annual growth (23%). The annual multiplication rate ($\lambda = 1.26$) showed a considerable increase in nesting Gulls in the city of Jijel (Tab.1).



Fig.3. A nest on the roof of the university building. (Photo: Amine Birouk)

For the density of Gulls, the value obtained on Grand Cavallo Island (Fig.4) went from 53.3 pairs per hectare in 1978 to 101.6 pairs per hectare in 2007. For Petit Cavallo Island, there has been a considerable increase from 5.5 pairs per hectare in 1978 to 98.7 pairs per hectare in 2007 (Tab. 2). In 2017, there was a significant decrease in the density of breeding pairs across all island sites. The most notable decrease was

observed, in Petit Cavallo Island, where the density went from 98.7 pairs per hectare in 2007 to 22 pairs per hectare in 2017. In Grand Cavallo Island, the area occupied by Gulls has halved (101c. / Ha in 2007 to 50 c. / Ha in 2017). In the Grand Cavallo islet, the area occupied decreases less (353 c. / Ha in 2007 to 240 c. / Ha in 2017) (Tab. 2).



Fig.4. A nest under a *Pistacia lentiscus* in the Grand Cavallo Island. (Photo: Amine Birouk)

Table 2.

Densities of Yellow-legged Gull on the island environments of Jijel (Algeria) between 1978 and 2017

Island environments	Area in hectare	Couples in 1978	Density in ha	Couples in 2007	Density in ha	Couples in 2017	Density in ha
Grand Cavallo Island	06	320	53.33	610	101.66	301	50.16
Grand Cavallo islet	0.15	-	-	53	353.33	36	240
Petit Cavallo Island	04	22	5.5	395	98.75	88	22
Total		342		1058		425	

In the northeast of Algeria, two cases arise for Yellow-legged Gulls. Strong demographic growth was observed between 1978 and 2007 at the level of island nesting sites with an annual growth of around 3.89% and an annual multiplication rate of 1.03 (Jacob and Courbet 1980, Bougaham and Moulai 2013) and a significant decrease in the breeding population on the same sites, between the years 2007 and 2017, with an annual decrease of more than 9% and an annual multiplication rate ($\lambda = 0.91$) which shows a significant decline in the number of breeding pairs at natural sites in the region. The area occupied by the couples of *Larus michahellis* on the islands of the region evolved in the same way. The nesting sites appeared saturated in 2007 or, for example, the density of breeding pairs increased on Petit Cavallo Island from 5.5 pairs per hectare in 1978 to almost 100 pairs per hectare in 2007. Less than ten years later (2017), the density decreased to only 22 pairs per hectare on the same site. In an urban environment in Jijel, the situation is different, the first breeding pairs appeared in 2000 with 5 pairs (Moulai et al. 2005), and from this date, urban nesting did not stop gaining momentum, to reach a figure of 328 pairs in 2018. In 20 years, the urban Gulls of the city of Jijel have experienced considerable annual growth (23%).

The Yellow-legged Gulls are known to be an anthropophilic species. Population dynamics are correlated with food resources of anthropogenic origin, in particular those offered by domestic refuse landfills and trawl fishing (Oro et al., 1995; Duhem et al., 2003). Human activities can therefore have a significant impact on the demography of the species, especially in the Mediterranean (Vidal et al., 1998; Moulai et al., 2006). For the Jijel region, the strong

population growth observed between 1978 and 2007 is certainly linked to greater accessibility to trophic resources of human origin, especially those present at uncontrolled landfills. In this context, a study carried out on the diet of adult Gulls from the Jijel Islands in 2007 showed that the diet of these birds relies quite heavily on the waste from landfills. The other feeding habitats (marine and terrestrial) are more or less fairly well frequented by these birds (Moulai and Bougaham, 2010) At the time, the municipal landfill of the city of Jijel, an uncontrolled landfill located in the region of "Mezghitane" (Fig. 2), seems to be the main source of food for gulls from colonies of the west coast of Jijel. This landfill is located less than 7 km as the crow flies from nesting sites (Moulai and Bougaham, 2010). The human population of the city of Jijel increased from 35 940 inhabitants in 1978 to 133 524 in 2007 (ONS, Jijel, 2020). This increase in population was followed by an increase in the quantity of household waste, which was estimated at more than 25 000 tons per year in 2007 (A.p.c.J, 2007; Dir. Envir. Jijel, 2018). This fact largely explains the considerable increase in the number of gull nesting birds between 1978 and 2007 in the region. The ability of large gulls to efficiently use landfills as feeding habitat is considered the main cause responsible for the expansion of their populations (Bosch et al., 1994; Thibault et al., 1996; Moulai et al., 2008).

From 2008, the uncontrolled municipal landfill in Jijel was closed in favor of a technical landfill center opened in the locality of Beni-Ahmed (Dir. Envir. Jijel, 2018) (Fig. 2). Consequently, the quantity of waste available to gulls in the region seems to be limited from this date, and adults are forced during the breeding season to seek alternative resources in marine

and terrestrial habitats. These resources in general are less predictable and rarely available in large quantities. In this sense, Duhem, (2004); Moulai et al., (2008) indicated that when accessibility to landfills is low, the fraction of other food resources, determined by the proportion of balls containing food remains from three feeding habitats, and in particular marine remains, and the diversity food tends to increase. The fall in the number of nesters observed in less than ten years, between 2007 and 2017 may be linked to lower availability of predictable resources present in uncontrolled landfills. On the other hand, it is likely that the Gulls moved to the city to nest at the expense of natural sites, hence an exponential increase in birds using buildings in urban areas in Jijel in 2018. Indeed, the increase in the number of Gulls in the urban environment is a reflection of the decline of the species in the natural habitats of the Mediterranean coast (Cadiou et al., 2015; Fraissinet, 2015). In Jijel city, the distribution of breeding populations in the urban fabric depends on two main factors; the availability of favorable nesting sites and the presence of regular and accessible food resources. Concerning the nesting places, the Yellow-legged of Jijel chooses to a large extent the prominent buildings (>R+2), whose terraces or roofs are rarely visited, as noted by Derradji and Moulai, (2020) in the city of Algiers. We have noticed that the breeding pairs of *Larus michahellis* are more numerous in the areas where the management of urban waste is the least adequate, several sectors of the city are characterized by uncontrolled deposits of waste and where the garbage bins are almost absent, especially near the municipal market and the fishery. In this sense, more than 40 uncontrolled landfills and household waste deposits are listed in Jijel (Dir. Envir. Jijel, 2018), hence potential sources of food for urban Gulls are available.

CONCLUSION

In north-eastern Algeria at Jijel, if the reduction in the numbers of *Larus michahellis*, following the closure of the large municipal landfill in 2008 had rather a beneficial effect on island ecosystems by reducing, the impact of the glut of this bird on the soil, the flora and fauna of the islands (Bouyahmed and Moulai 2018), it is not the same in urban areas where the increase in the number of breeding pairs, will certainly generate a certain number of nuisances (Rock, 2013; Derradji and Moulai, 2020). In our opinion and in the current state of the situation and available means, the best solution to manage the gulls of the city of Jijel is the mastery of the management of urban waste at the level of cities and districts, first of all by the inhabitants and secondly by the municipalities, which will have to better organize and put more resources into the removal and collection of waste.

ACKNOWLEDGEMENT

The authors wish to Mr. Ziad BIOUD, Mr. Mohammed SIFOUR, Mohammed El-Arbi MAYACHE, the agents and employees of the University of Jijel for their precious help as well as the general direction of scientific research and

technological development (DGRSDT), Ministry of Higher Education (Algeria).

AUTHORS CONTRIBUTIONS

Conceptualization, R.M. methodology, A.B.; data collection R.M. and A.B.; data validation, R.M. and A.B.; data processing R.M. and A.B writing—original draft preparation, R.M. and A.B writing—review and editing, R.M. and A.B.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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