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Impact of road improvements on the distribution and demography of rupicolous birds on the corniche of Jijel in Algeria

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Abstract Our study aims to identify the impact of road improvement works on rupicolous birds on the corniche of Jijel in Algeria between two periods: before the works began and after they were completed. The results show a large decline in nesting pairs of rupicolous birds between the two periods (2007: 307 pairs vs. 2017: 135 pairs). Thus, more than half of the breeding pairs disappeared between the start and the end of the work. The decline in the number of nesting pairs mainly concerned the most adapted and demanding species nesting on coastal cliffs: Pallid Swift *(Apus pallidus)*, Common Kestrel *(Falco tinnunculus)*, Peregrine Falcon *(Falco peregrinus brookei)*, Eurasian Crag Martin *(Ptyonoprogne rupestris)* and Blue Rock Thrush *(Monticola solitarius)*. The main factor in reducing the number of nesting pairs of species on cliffs and rocks is the degradation or loss of nesting sites due to developmental work. System restoration measures are proposed to encourage the return of nesting birds.

Keywords: road development works, coastal cliffs, breeding birds, Algeria

Összefoglalás Tanulmányunk célja, hogy azonosítsa az algériai Jijel környékén végzett útfejlesztési munkálatok hatását a sziklákon költő madarak állományaira a munkálatok megkezdése előtti és azok befejezése utáni időszakban. Az eredmények azt mutatják, hogy a két időszak között nagymértékben csökkent a fészkelő madarak állománya (2007: 307 pár – 2017: 135 pár); vagyis a fészkelő állománynak több mint a fele eltűnt a munkálatok befejeztére. A fészkelő párok számának csökkenése elsősorban a parti sziklákon fészkelő, ahhoz alkalmazkodó és azoktól függő fajokat érintette: halvány sarlósfecske *(Apus pallidus)*, vörös vércse *(Falco tinnunculus)*, vándorsólyom *(Falco peregrinus brookei)*, szirtifecske *(Ptyonoprogne rupestris)*, kék kövirigó *(Monticola solitarius)*. A fészkelő párok számának csökkenésének fő oka a fészkelőhelyek leromlása vagy elvesztése a fejlesztési munkák következtében. A szerzők élőhely-rekonstrukciós intézkedéseket javasolnak a fészkelő madarak visszatérésének ösztönzésére.

Kulcsszavak: Algéria, fészkelő madarak, tengerparti sziklák, útfejlesztési munkák

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Introduction

Facing with increasing urbanization, avian habitats are undergoing radical transformations (Shochat *et al.* 2006). These modifications represent both challenges for the survival of birds and opportunities for their adaptation to new ecological niches (Evans *et al.* 2018).

The Algerian coastline, which extends over more than 2,000 km, is characterized by a succession of cliffs, rocky areas and beaches, either sand, pebble or mixed. It should be noted that the rocky habitats are quite dominant. The presence of coves, mouths of small wadis, some coastal wetlands and island environments should also be noted.

These different coastal habitats are home to a significant diversity of birds, particularly coastal and sea birds, as well as waterbirds (Samraoui *et al.* 2011, Bougaham & Moulaï 2013). Certain coastal environments such as cliffs and rocky areas attract specialized avifauna called rupicolous or rupestral birds, for example Pallid Swift *(Apus pallidus)*, Common Peregrine Falcon *(Falco peregrinus brookei)*, Eurasian Crag Martin *(Ptyonoprogne rupestris)* and Blue Rock Thrush *(Monticola solitarius)*.

In recent years, Algeria has experienced major projects of public interest, notably the construction of highways, bridge roads, tunnels, intended to develop and improve infrastructure with a socio-economic and sustainable development goal. These various works have exerted consequences on wildlife in general, and birds in particular, because several natural habitats have been destroyed or modified (Mouhoub-Sayah *et al.* 2009).

Therefore, here we aim to assess the impact of road development works on the rupicolous birds of the Jijel corniche (National Road 43) in Algeria by comparing the diversity and distribution of the main species of rupicolous birds before the start of the work in 2007 (Bougaham & Moulaï 2013) and after its completion in 2017.

Methods

Study area

Our work is carried out along National Road 43, which extends from El-Aouana to Melbou, over a length of approximately 35 km *(Figure 1)*. The region is part of the coastal range of the Babors chain and the eruptive massif of Cavallo. From Jebel M'saada to the west to Taza, the chains form an extrusion of Liassic limestone. From the place called Aftis to Cavallo, the chain seems to make an intrusion of dacite and volcanic projections. Beyond that, towards the east, the range forms an intrusion made up of Oligocene sandstones and clays (Duplan 1952). This portion of coast is made up of landscape units which include a succession of cliffs, rocky areas, beaches either sandy or pebble, with the predominance of the rocky character. Certain portions of cliffs and rocky areas are covered with thin soil, which support flora characteristic of rupicolous environments such as European fan palm *(Chamaerops humilis)*, perennial hyoseris *(Hyoseris radiata)* and caper bush *(Capparis orientalis)*.

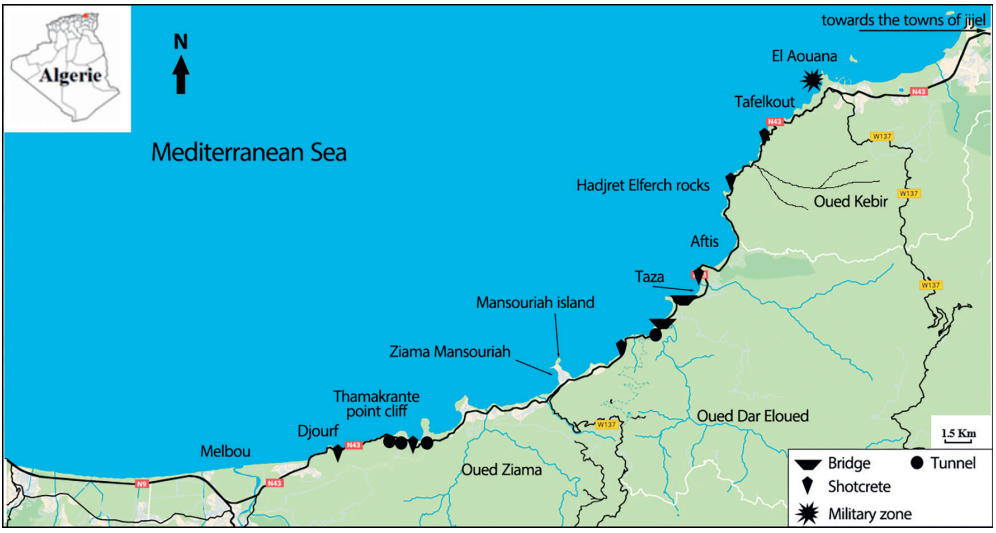

Figure 1. Geographical location of the study area and the main road developments along national road 43 in Algeria

1. ábra A kutatási terület földrajzi elhelyezkedése és a legfontosabb útfejlesztések az algériai 43. számú út mentén

Methodology

In the study area and along National Road 43 on the Jijel corniche, the location and counting of nesting pairs of rupicolous birds (Pallid Swift, Yellow-legged Gull *Larus michahellis*, Long-legged Buzzard *Buteo rufinus cirtensis*, Peregrine Falcon, Common Kestrel, Northern Raven *Corvus corax*, Eurasian Crag Martin, Blue Rock Thrush) were carried out during the period from March to June in year 2017. Observations were generally made using a pair of binoculars and from a distance of 50 to 500 metres. Nesting is established when the nest is accurately located for each species. Each nest spotted is geo-located to avoid any double counting during the breeding season.

During the period from 2007 to 2016, we noted the widening of the roadway extending from El-Aouana to Melbou over a distance of 35 km, with various engineering structures; notably the construction of a

Figure 2. Sprayed concrete at the level of the Cliffs of the Jijel cornice (Photo A. Birouk)

2. ábra Porlasztott beton a Jijel-sziklák párkányának magasságában (felvétel: A. Birouk)

tunnel in Dar El-Oued over 600 m, the construction of three tunnels in Melbou with a respective length of 880 m, 635 m and 268 m. In addition, a 137 m emergency tunnel was built. We also noticed the installation of an engineering structure over 102 linear metres and the construction of two bridges, one in Ghar Elbaz and the other in Dar Eloued. Along the way, reinforcement of mountain slopes with shotcrete was observed, aimed at preventing rockfalls and landslides on the road *(Figure 2)*. It is also noted that in the Tafalkout region a military barracks of the coast guard was established during this period with the presence of a shooting range *(Figure 1)*. These engineering structures that may affect the habitat and nesting sites of rupicolous birds are listed in *Figure 1*.

Our data obtained on the nesting of rupicolous birds at the Jijel corniche during the season in 2017 are compared to those of Bougaham and Moulaï (2013) obtained in 2007, i.e. before the start of road development works in order to identify the impact of this work on the number of nesting pairs of rupicolous birds and their distribution within the study area.

To evaluate the differences between the two periods (2007 vs 2017) and test the effect of human activities, we used the Wilcoxon signed-rank test implemented in the XLSTAT software version 2014. The species names followed the IOC World Bird List version 14.2 (Gill *et al.* 2024).

Results and Discussion

Table 1 shows large decreases in the nesting pairs of rupicolous birds between the two periods (2007 vs 2017), which amounts to 135 estimated pairs. Accordingly, more than half of the breeding pairs disappeared between the start and the end of the work. The road development work had a confirmed overall impact on the establishment of birds dependent on the cliffs and rocky escarpments of the region. The reduction in the number of nesting pairs mainly affected the species most adapted and most demanding to nest on coastal cliffs: Pallid Swift *(Figure 3)*, Peregrine Falcon *(Figure 4)*, Eurasian Crag Martin *(Figure 5)*, Blue Rock Thrush (*Figure 6)*. We also note a decrease in the number of pairs of the Yellow-legged Gull *(Table 1)*. Only one species was able to increase numbers during this period, the Common Raven. The numbers were zero for this species in 2007 and, in 2017 we found 12 pairs *(Table 1)*.

The main factor in reducing the number of nesting pairs

Table1. Number of nesting pairs of rupicolous birds between 2007 (before the works) and after the works in 2017 on National Road 43 in Algeria

1. táblázat A sziklákon költő madarak fészkelő párjainak száma 2007 (a munkálatok előtt) és a 2017-es munkálatok után az algériai 43-as számú úton

Species	2007	2017
Pallid Swift	120	71
Yellow-legged Gull	143	31
Long-legged Buzzard	1	2
Common Kestrel	7	4
Peregrine Falcon	3	1
Northern Raven	0	12
Eurasian Crag Martin	16	10
Blue Rock Thrush	17	4
Total	**307**	**135**

of species characteristic of cliffs and rocks is the degradation or loss of nesting sites following development work. The crevices, orifices, cavities and areas of rocky overhang were filled by spraying concrete onto the cliff or completely destroyed following the smoothing of the cliff to avoid rockfall. Another significant factor is the disruption linked to public works machinery, particularly during the construction phases of various structures, such as tunnels and bridges. The coast guard barracks with its shooting range also had an impact on the disturbance level of the birds during the breeding period. These disturbances lasted several years, which had a significant effect on the safety and well-being of rupicolous birds during the sensitive nesting period. The Common Raven did not appear to nest in the study region before the work period *(Figure 7)*. It ended up with a number of 12 pairs in 2017. This situation is probably linked to the decrease in the number of pairs of Yellow-legged Gull *(Figure 8)*. Gulls are known to be very aggressive towards other species of birds, particularly those which may nest nearby, such as Common Ravens, which may establish their nests on cliff ledges. The drop in numbers of Yellow-legged Gulls following the works may have been favourable to Common Ravens (Philo & Wilbert 2000, Whatmore 2002, Moulaï 2007). By performing the Wilcoxon signed-rank test at a significance level of 5%, with eight observations, with a critical value of 3, we obtained $W+=15$. Compared to $Wcrit=3$, $W+$ is much greater than $Wcrit$. This indicates that there is a significant difference in the average population of bird species between 2007 and 2017.

Pallid Swift *(Apus pallidus)*

The declining trend in the number of nesting pairs of Pallid Swift was more significant for this species as compared to that of Eurasian Crag Martin, because the latter species

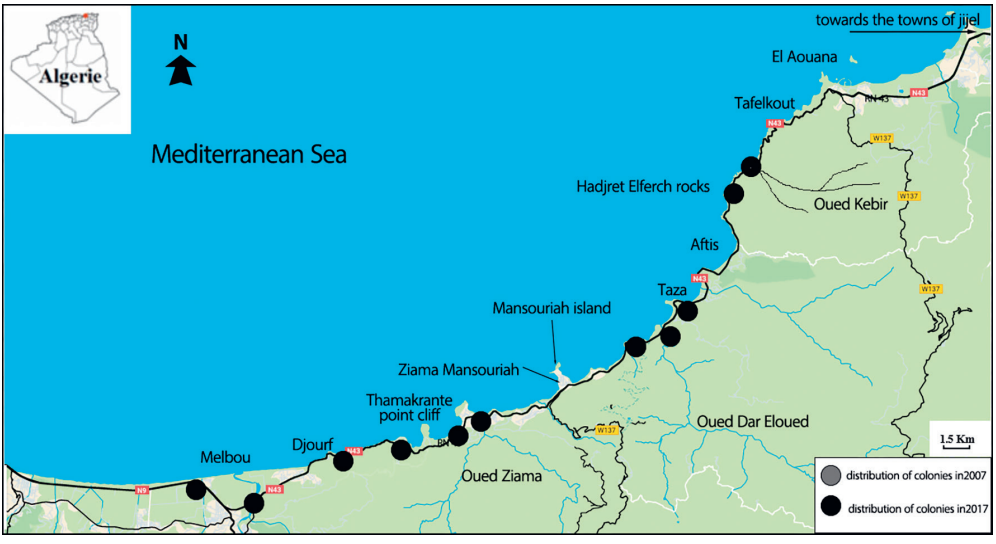

Figure 3. Distribution of Pallid Swift colonies along the west coast of Jijel between 2007 and 2017
3. ábra A halvány sarlósfecske kolóniáinak eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

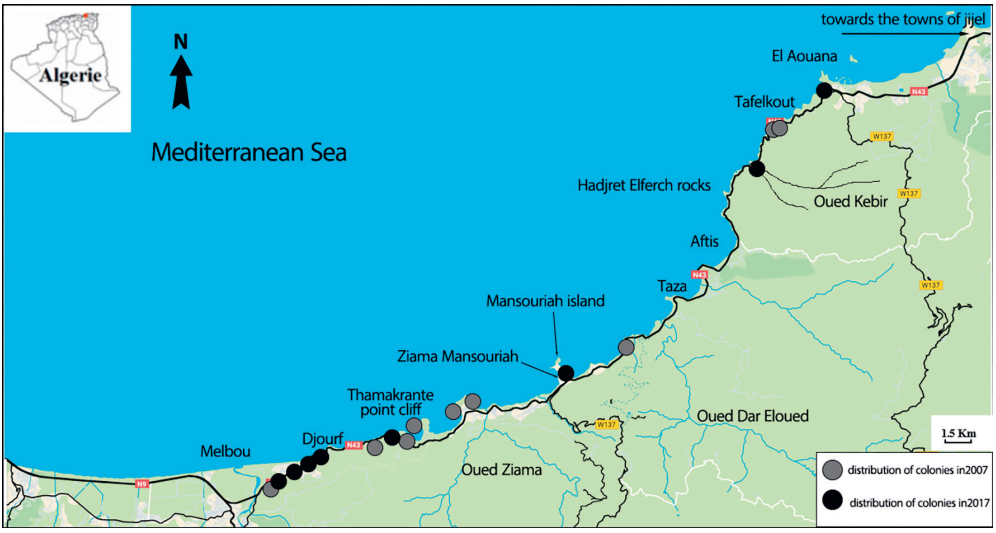

Figure 4. Distribution of Peregrine Falcon nesting pairs along the west coast of Jijel between 2007 and 2017

4. ábra A fészkelő vándorsólyom párok eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

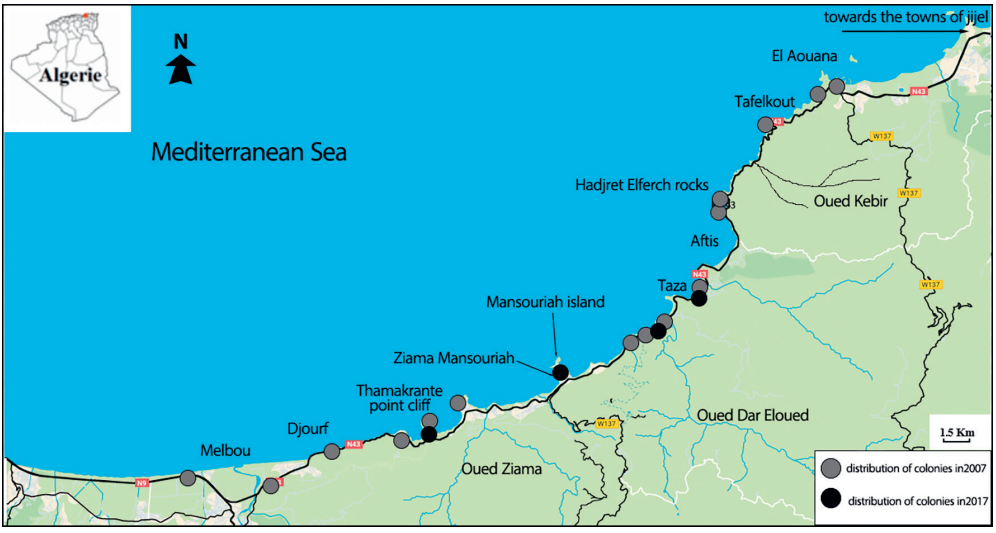

Figure 5. Distribution of Eurasian Crag Martin colonies along the west coast of Jijel between 2007 and 2017

5. ábra A szirtifecske kolóniáinak eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

generally nests in small colonies of a few pairs, which is not the case for Pallid Swift, or the colony may contain more than tens of pairs (Thorup 2001, Davies 2013).

Before the start of the work, Bougaham and Moulaï (2013) identified approximately fifteen colonies distributed between Melbou and El Aouana. In 2017, only three colonies remained at the cliffs of Pointe Thamakrante, at Ziama Mansouriah and Taza *(Figure 3)*. The same

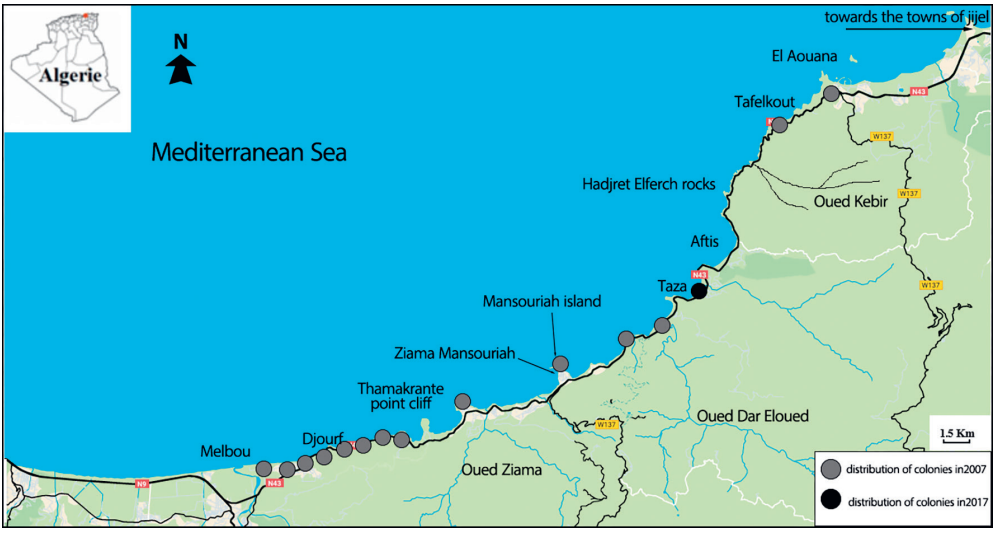

Figure 6. Distribution of breeding pairs of Blue Rock Thrush along the west coast of Jijel between 2007 and 2017.

6. ábra A fészkelő kék kövirigó párok eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

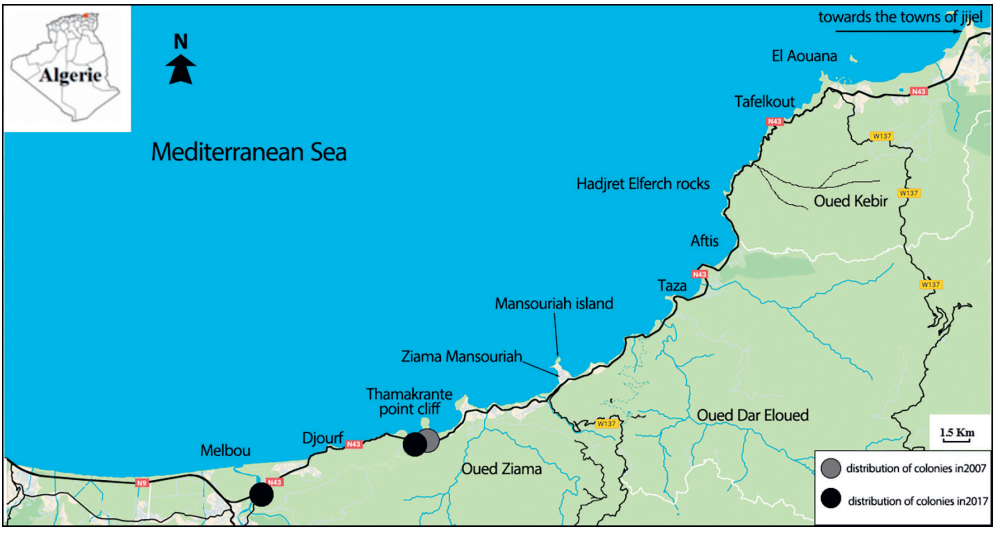

Figure 7. Distribution of Northern Raven nesting pairs along the west coast of Jijel between 2007 and 2017

7. ábra A fészkelő holló párok eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

causes observed for the Eurasian Crag Martin are valid for the Pallid Swift, because the two species have a similar reproductive ecology in the natural environment. The decrease in the number of nesting pairs of Pallid Swifts is linked to the loss of nesting sites on the cliffs and rocky areas of the region, following the smoothing of the cliffs and the projection of concrete on the walls.

Yellow-legged Gull *(Larus michahellis)*

The number of pairs of Yellow-legged Gulls also experienced a drastic decline between 2007 and 2017 *(Table 1)*. The number of colonies also decreased from 10 colonies in 2007 to seven colonies in 2017 *(Figure 8)*. The smoothing of the cliffs and the projection of concrete on the cliffs has greatly reduced the nesting sites favourable to the Yellow-legged Gull. The decrease in the nesting population of Yellow-legged Gulls may also be linked to changes in the behaviour of this species following the closure of illegal dumps, most of which are located near the large urban area of Jijel. In this context, we noted a shift in the nesting population from natural environments (cliffs and islands) towards the urban environment of Jijel, certainly to compensate for the lack of trophic resources following the closure of landfills (Birouk & Moulaï 2021, Hussein *et al.* 2021).

Long-legged Buzzard *(Buteo rufinus cirtensis)*

Between 2007 and 2017, we noted the appearance of a new reproduction site at the Melbou cliffs, in an area little affected by development work. The first pair recorded in 2007 kept the same location in 2017 at the Cliffs of Pointe Thamekrante *(Figure 9)*. It is reported that Long-legged Buzzard is a common species in Algeria which can tolerate a certain degree of disturbance in its habitat, in addition, it is less linked to rock habitats than the Common Kestrel or the Peregrine Falcon (Moulaï & Mostefai 2015, Elafri *et al.* 2020, Hachour *et al.* 2021).

Common Kestrel *(Falco tinnunculus)*

The kestrels in the region seem to have been impacted by the road development works. Before the work began, the pairs were distributed between the Melbou area and Taza. While in 2017, we found them confined to the region between Melbou and the cliffs of the Thamekrante points *(Figure 10)*. The influence that the work may have had on the nesting of this raptor is understandable, given that this species is linked to rocky cliffs in Algeria (Moulaï & Mostefai 2015, Elafri *et al.* 2020, Hachour *et al.* 2021).

Peregrine Falcon *(Falco peregrinus brookei)*

Similar to the Common Kestrel, we note a decrease in the number of nesting pairs of Peregrine Falcon. In 2007, there were three areas of this raptor: in El Djourf, near Ziama-Mansouriah and in Taflakout. In 2017, only the pair of El Djourf cliffs maintained their presence *(Figure 4)*.

Here, the impact of the road development work is also clear, besides the disturbance factor linked to the presence of a significant number of Northern Ravens, not present when the work began *(Table1, Figure 9)*. Latter must have exerted hounding and harassment pressure on the Peregrine Falcons, causing them to abandon their nesting areas (Ratcliffe 1993, Monneret 2000).

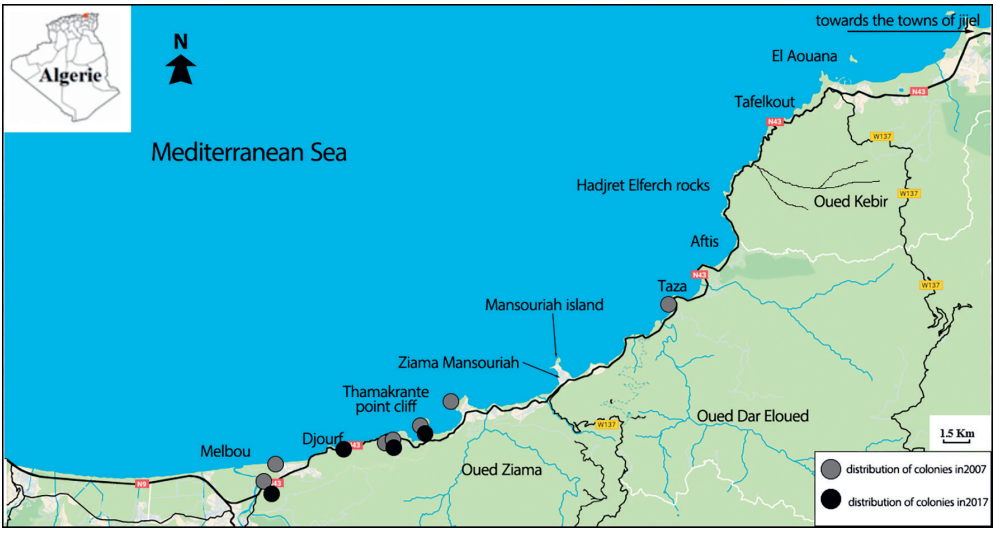

Figure 8. Distribution of Yellow-legged Gull colonies along the west coast of Jijel between 2007 and 2017

8. ábra A sárgalábú sirály kolóniáinak eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

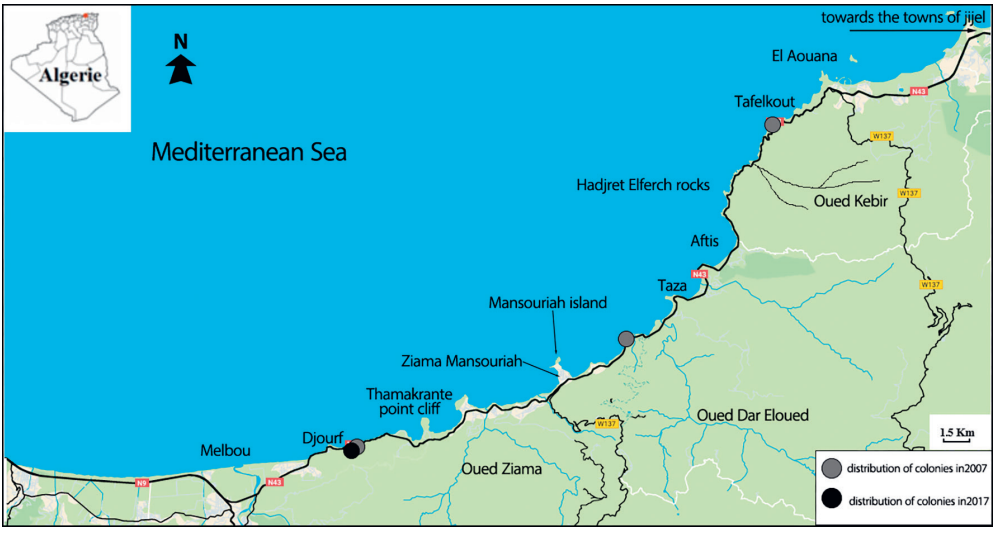

Figure 9. Distribution of breeding pairs of the Long-legged Buzzard along the west coast of Jijel between 2007 and 2017

9. ábra A fészkelő pusztai ölyv párok eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

Northern Raven *(Corvus corax)*

We counted 12 pairs of Northern Ravens, distributed between Oued Kebir and Melbou *(Figure 7)*. Most nests are established on cliffs and rocky areas in the region (Cramp & Perrins 1994, Aberkane *et al.* 2011). Note that no nesting event of this species was recorded

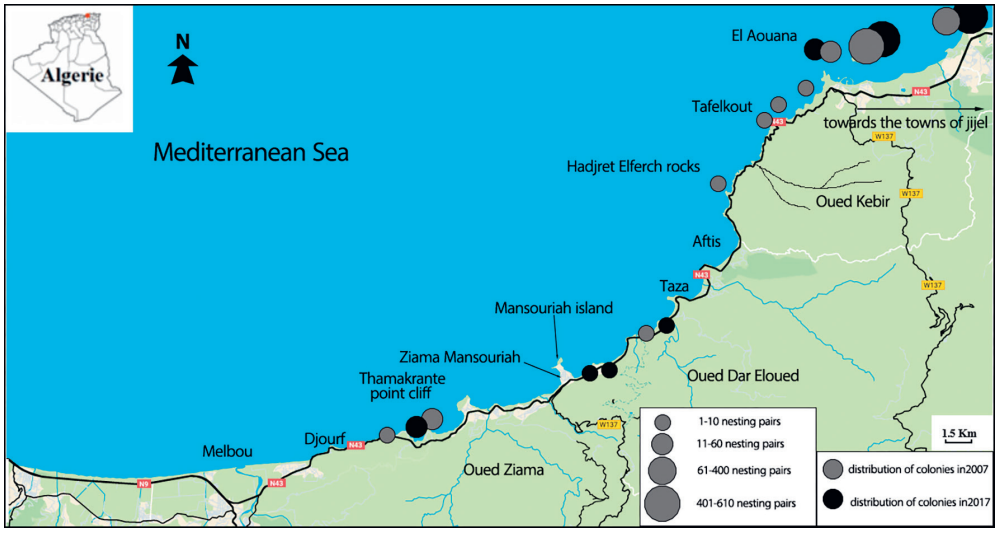

Figure 10. Distribution of breeding pairs of the Common Kestrel along the west coast of Jijel between 2007 and 2017

10. ábra A fészkelő vörös vércse párok eloszlása Jijel nyugati partvidéke mentén 2007 és 2017 között

during the period preceding the work (Bougaham & Moulaï 2007). It is likely that Northern Ravens have occupied the cliffs of the study region as a result of the decrease in the number of nesting pairs of Yellow-legged Gulls between 2007 and 2017 *(Table 1)*.

Eurasian Crag Martin *(Ptyonoprogne rupestris)*

The number of breeding pairs of Eurasian Crag Martins decreased between the two periods. Whereas in 2007 the breeding pairs were distributed all along the length of the study area, between the region of Melbou and Tafelkout *(Figure 4)*. In 2017, we noticed that breeding Eurasian Crag Martins disappeared from most sites observed in 2007, to the benefit of the Melbou region which was little affected by the impact of road development works *(Figure 4)*. The widespread use of sprayed concrete along the cliffs has resulted in the closure of most of the openings that served as nesting sites for swallows, resulting in a lack of favourable breeding sites in the areas affected by the spraying *(Figure 4)*.

Blue Rock Thrush *(Monticola solitarius)*

It is the bird that has been most impacted by road development work. Before the work began, this rupicolous bird had spread throughout the coastal stretch affected by the developments. In 2017, the pairs were located only at the Taza cliffs *(Figure 6)*.

Apparently, the work started has blocked most of the rocky crevices necessary for the nesting of the Blue Rock Thrush (Choi *et al.* 2011, Nayak 2020).

In conclusion, we can say that the road development work started in 2007 (Bougaham & Moulaï 2013) on National Road 43 in Algeria had a significant impact on the number of birds nesting on the cliffs and the rocky areas of the region. The strongest effect is observed on the species most adapted to and most dependent on the rocky habitat. All species have a high heritage value at least on a local or regional scale. These birds are, for example, protected by the Algerian legislator (Executive Decree No. 12-235 of 3 Rajab 1433 corresponding to May 24, 2012 establishing the list of protected non-domestic animal species (JORA No. 35)) hence a loss for the regional and national diversity.

In the future, it would be useful to integrate into the specifications for road development work on rupicolous habitats in Algeria, environmental impact studies which consider the possible impact of the work on the diversity and presence of birds from cliffs and rocks, in particular those with the label, species of high heritage value. We recommend the restoration of the natural rock ecosystem, by providing for maintaining a certain number of cracks and orifices in the rock and the establishment of artificial cement nest boxes suitable for certain rupicolous species, more particularly: Pallid Swift, Eurasian Crag Martin and Blue Rock Thrush.

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