

Monitoring of the reproduction of the European Roller (*Coracias garrulus*) population in the Vallée des Baux during the 2023 breeding season

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INTRODUCTION

The extinction rates seen today (100 times higher than natural) are unprecedented since 65 million years ago. This fact leads us to consider that we may be facing the 6th mass extinction (Ceballos et al., 2015). Virtually all of Earth's ecosystems have been dramatically distorted and altered by anthropogenic activity, leading to various direct and indirect drivers inducing biodiversity loss, with the main ones being habitat alteration, climate change, invasive species, overexploitation, and pollution (Rawat & Agarwal, 2015; IPCC, 2015). Particularly dramatic is the decline in vertebrate populations over the last decades, averaging a 68% decrease between 1970 and 2016 (WWF, 2020).

In this context, the species we are focusing on in this report, the European roller (*Coracias garrulus*) (herein after "roller"), is a species whose populations have been steadily declining in recent decades, having become extinct in much of the central and northern territories (Finch et al., 2015). It is the only representative of the genus *Coracias* breeding in Europe, distributed as a breeder throughout the Palearctic, from northern Morocco to the western Himalayas (Cramp & Simmons, 1988). It is a medium-sized bird with a robust appearance and a strong beak, easily recognizable thanks to its colourful plumage, ranging from the greenish-blue of the head to the indigo of the central tail feathers or rump. In contrast, the back exhibits a reddish-brown tone. The plumage of both sexes is similar and becomes more vibrant during the breeding season (SEO Birdlife).

It is an obligate secondary cavity-nesting bird dependent on a supply of large nesting cavities, especially those made by woodpeckers, easily recognized by their characteristic circular hole entrance with an approximate diameter of 8 cm, mostly made in white poplar (*Populus alba*) (BirdLife International, 2017; Bouvier et al., 2014). Its diet is predominantly insectivorous, primarily consisting of beetles and medium to large-sized orthopterans (Hebda et al., 2019; Milinski et al., 2022). This need for prey makes agricultural habitats, especially meadows and cereals with fallow lands where hedges (as well as powerlines) are essential components of the habitat as foraging perches (BirdLife International, 2017). Upon arrival on their European breeding grounds in spring, individuals spend several weeks in pair-bonding activities (Cramp & Simmons, 1998). The laying, which usually takes place in June, consists of three to five eggs (two to seven), white in colour, incubated for 20-25 days by both adults. The hatching of chicks is asynchronous, as the incubation process begins after the laying of the third egg. Between 25 and 30 days after hatching, the young leave the nest (SEO Birdlife).

Predictions have been made based on the hypothesis that the decline in the population of Nearctic migrants has occurred as a result of changes in the quantity or quality of breeding habitat (Rappole & McDonald, 1994). In the case of the preferred habitat of the roller, it is interesting to consider how agricultural intensification can affect it, especially during the breeding season. Diversity was generally distinctly negatively related to the use of pesticides (herbicides, insecticides, or fungicides) and fertilizer application, although the relationships varied extensively between organism groups and regions (Emmerson et al., 2016). In the case of the roller, this use of pesticides usually occurs in June, during the breeding season, and with orthopterans, the main prey during this period, which can affect chick mortality (Avilés, 2016).

Given this dilemma, it is advisable to adopt strategies to increase chick survival rates. Indirectly, it is important to raise awareness among local stakeholders about minimizing the use of pesticides (Drum et al., 2015). Directly, the installation of nest boxes that mimic the natural cavities that rollers typically occupy is a measure supported by numerous studies conducted in different European populations (Avilés et al., 2000; Rodriguez et al., 2011; Milinski et al., 2022).

A Rocha France has developed a program to restore and monitor the Roller population in the Vallée des Baux. It is based on nestboxes maintained and monitored since 2002, and cavities individuated in 2017, and subsequently mapped and monitored. Here, we describe the results of the monitoring of the reproduction of this population during the 2023 breeding season. We compare the reproductive parameters with previous years and discuss the trends of the population and the perspectives of the program.

STUDY AREA

The study area is the « Vallée des Baux » (43°41'N; 4°46'E. WGS84) is located in the Provence region of France. The area is characterised by a variety of ecosystems: wetlands, garrigue, farmland, Mediterranean riparian forest, and waterways such as rivers and channels. For this reason, it is also very rich in biodiversity. The Vallée des Baux is located between three important biodiversity areas: the southwestern Camargue wetlands, the steppic Crau plain to the south-east, and the Alpilles range to the North. Most of it is included in the Alpilles natural park and belongs to the Natura 2000 network: it has the aim of protecting and preserving threatened habitats and endangered species in the EU (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora).

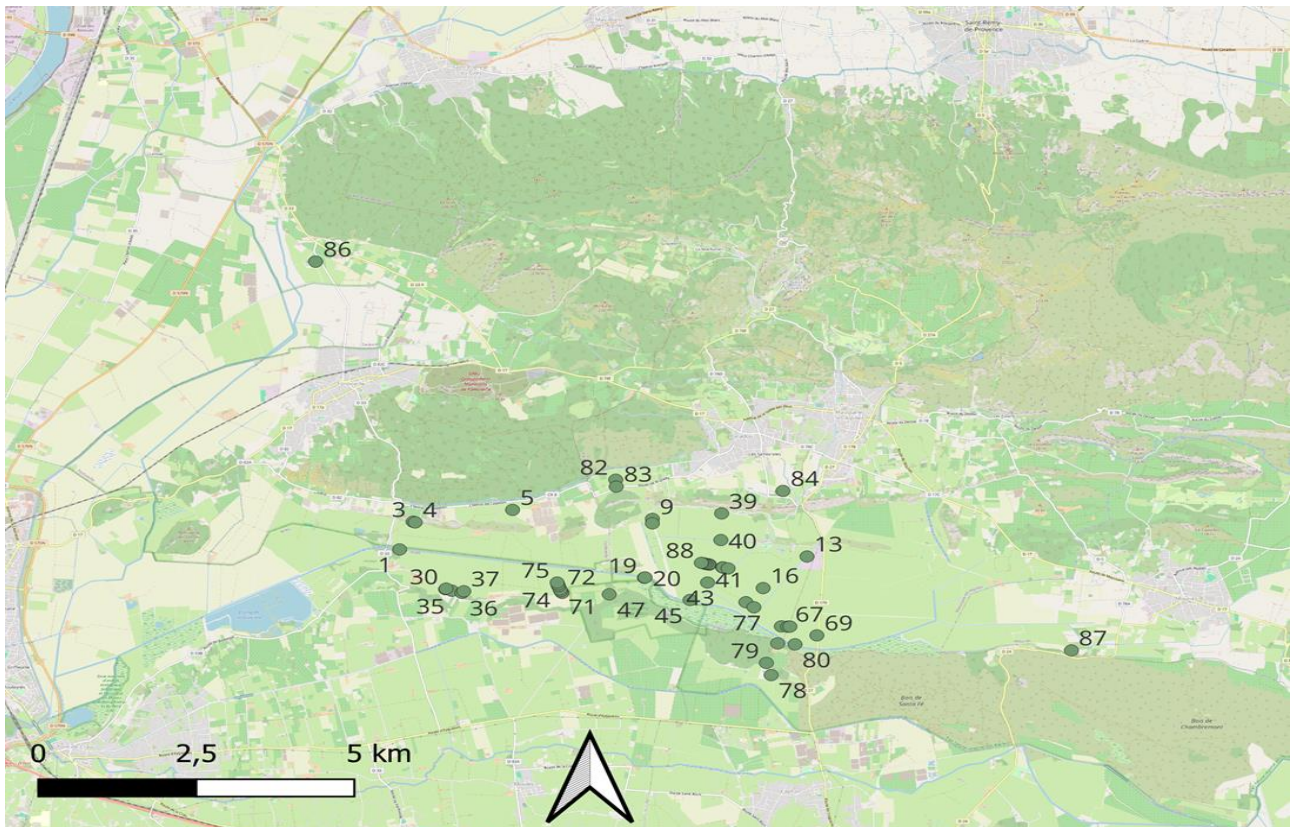


Figure 1. Study area and distribution of nestboxes.

METHODS

To conduct this study, we checked the 52 nest boxes installed in previous years, whose distribution can be seen in Figure 1. This installation was carried out with certain criteria to optimize the occupation and survival of the rollers. Suitable locations were selected in open or semi-wooded areas, such as forest edges or agricultural fields, mounting the box at a height of at least 3-4 meters above the ground. Whenever possible, the entrance was oriented towards the east or southeast to avoid direct exposure to the sun during the hottest hours of the day. Additionally, 49 natural cavities were also inspected, some already located in previous years and others during the year 2023. The fieldwork was conducted by a group consisting of the scientific director of A Rocha France, as well as interns and volunteers, including volunteers from the European Solidarity Corps. The project was developed following three phases: Cleaning (Winter), Census (Spring), and Ringing (Summer).

The first phase, cleaning, took place between November 2022 and February 2023. It involved cleaning the interior of the nest boxes, removing remains left by rollers from the previous season, old nests of other species (such as starlings, great tits), rats, ant nests, hornet nests, etc. Simultaneously, an inspection of the condition of the nest boxes and the cables holding them was carried out, and any damaged elements were replaced. Once both processes

were completed, the entrance was blocked with a small grid to prevent the occupation of the nest boxes by other species. This grid was removed in April, shortly before the arrival of the rollers. The necessary equipment for these tasks included: an all-terrain vehicle, a 6-meter ladder, climbing equipment, insulated electrical cable, a screwdriver, metal grids, a stapler, new nest boxes, gloves, and a field sheet.

The second phase, the census, began in May. With the aid of an endoscopic camera to disturb the environment inside the nest boxes as little as possible, the interior of these was inspected. Initially, we sought to determine which boxes were occupied by rollers, and once this was confirmed, a more regular monitoring of these nest boxes was carried out to track the number of eggs and the hatching moment, allowing an estimation of the fledging date based on the size of the clutch or the presence of chicks. This phase continued throughout the spring. The equipment required for this phase was the same as that used during cleaning, with the addition of the endoscopic camera.

The final phase, ringing, took place from late May to late July. The first weeks (from end of May to end of June) were spent at ringing breeding adults. Catching occurred at the nesting sites during the incubation of the eggs and after clutch completion, in order to avoid nest abandonment. One person, assisted by a net attached to a telescopic perch, blocked the entrance with a net to catch the incubating adults that would want to escape. When the adults staid in the nest box, another person ascended to the nest and captured the adult directly inside the nest box. Ringing involved placing a metal ring on the bird's leg (tarsus), provided by the National Natural History Museum in Paris, containing a unique alphanumeric code. Additionally, a coloured plastic ring was placed on the other leg, along with a flag bearing a simple alphanumeric code. This latter measure allowed us to identify the bird from a distance using methods such as camera trapping or direct observation with binoculars. Various measurements were taken (tarsus, wing, and beak), weight, age, and sex of the bird were recorded, and feather samples were taken for possible genetic studies in the future. Once the ringing was completed, the adult was released. Chick ringing occurred during the third and fourth week after hatching, which spanned between late June and end of July according to each nest development. Chicks were ringed in the same way as adults, although measurements were limited to the tarsus and weight. Chicks were returned to the nest once ringed. The entire ringing process of the rollers was carried out under a capture authorization and as part of a personal research program granted by the National Natural History Museum in Paris to Timothée Schwartz.

RESULTS

During the 2023 breeding season, as depicted in Figure 2, we located a total of 41 Roller nests, comprising 21 in nest boxes and 20 in natural cavities. The number of occupied nest boxes, although exhibiting fluctuations between some years, showed a consistent growth from installation in 2011 until 2019. From that year onward, including the year 2023, the quantity of occupied nest boxes settled at stable values, ranging between 20 and 22 per year. The quantity of occupied natural cavities fluctuated significantly, making it more challenging to draw conclusions compared to the nest boxes, as the number of cavities inspected varies each year, as we will see below.

As shown in Figure 3, the availability of nest boxes remained stable over the years, fluctuating between 50 and 51. The occupancy rate by the roller during the year 2023 is 43.13%, confirming the stabilization of values seen since 2019, fluctuating between 39% and 44% during these years. Regarding occupancy by other species, especially the common starling, this year it was 19%, slightly lower than last year (26%).

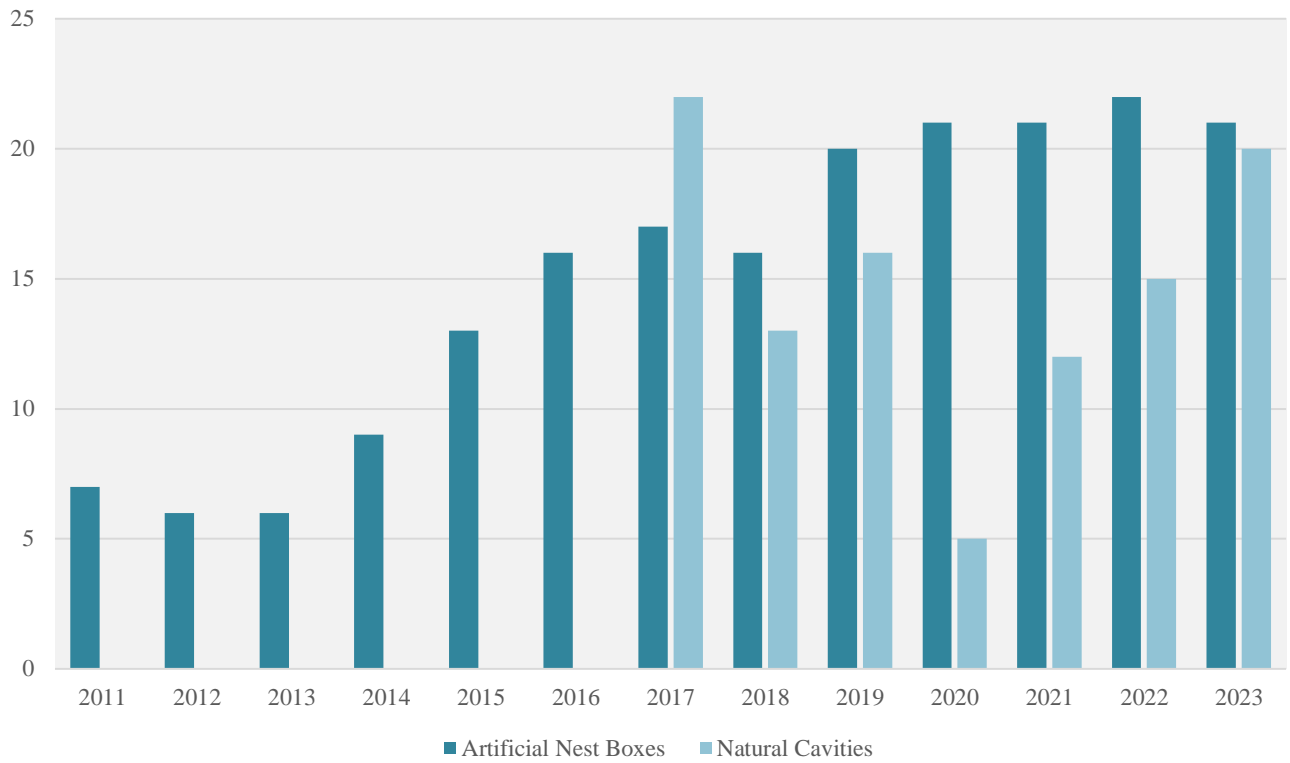


Fig. 2: Number of nest boxes and natural cavities occupied by the European Roller from 2011 to 2023 in the Vallée des Baux (France).

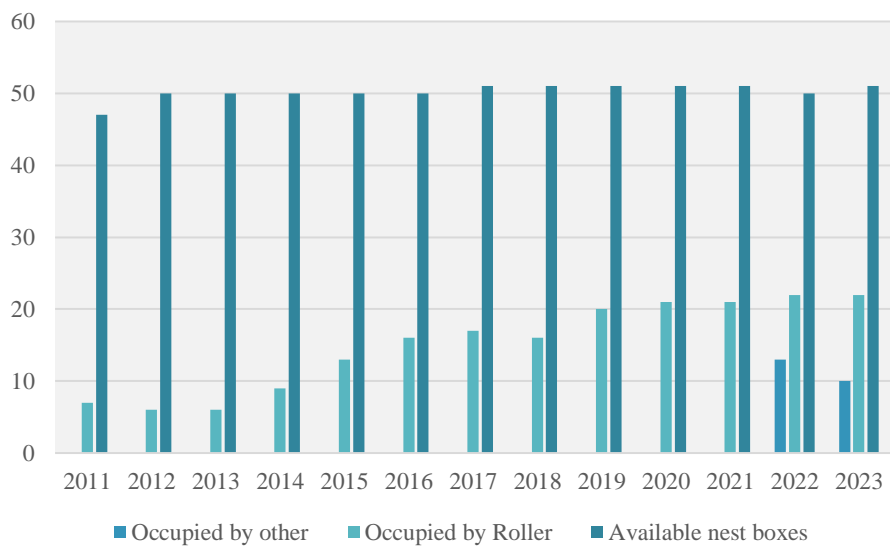


Fig. 3: Number of available nestboxes and ones occupied by the Roller in the Vallée des Baux from 2011 to 2023.

The values showed in Figure 4 for the occupancy of natural cavities are much more fluctuating than those of the nest boxes. This is primarily due to variations in the number of cavities inspected each year. Specifically, during the year 2023, 49 cavities were monitored, with 20 of these being occupied by rollers, resulting in an occupancy rate of 40.8%, very similar to the previous year (41.6%). These last two years show a significantly higher occupancy rate than previous years, when it fluctuated between 11% and 18%.

Occupation rate of natural cavities in Vallée des Baux

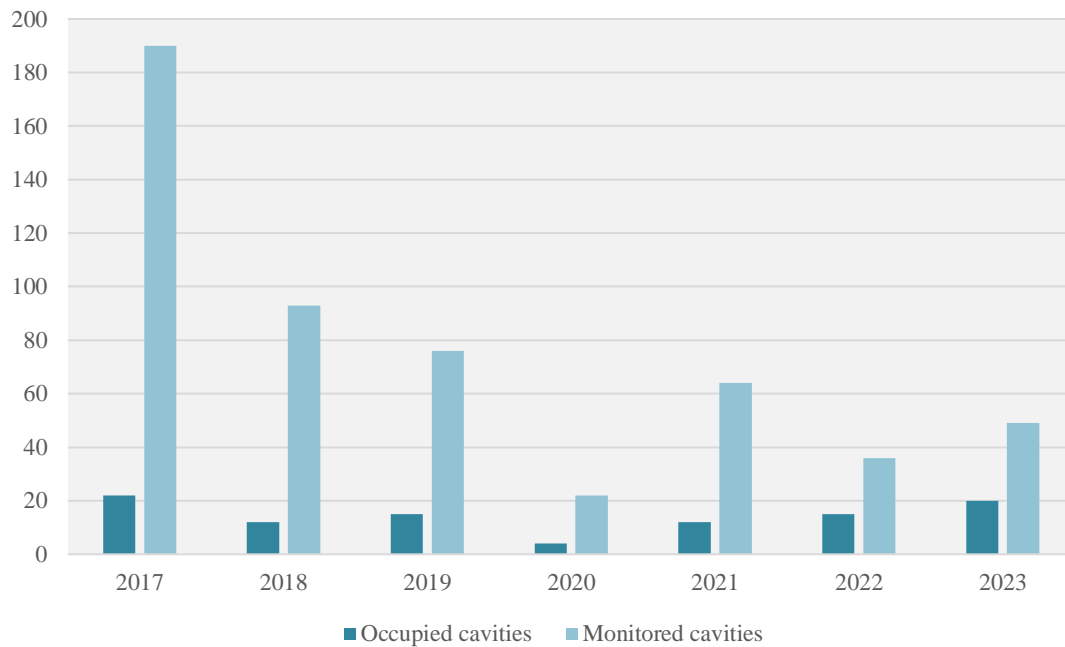


Fig. 4: Number of monitored cavities and cavities occupied by the Roller from 2017 to 2023.

Among the 21 occupied nest boxes, a total of 106 eggs were laid, with 87 of them hatching; 65 of these hatchlings were confirmed as mature enough for ringing. There is a general upward trend in the number of eggs laid, eggs hatched, and fledglings produced over the years. Starting from 2014, there has been a gradual increase in these metrics, reaching peak levels in 2022 (Figure 5).

Regarding reproductive success, during the year 2023, the hatching success rate was 82.07%, among which we confirmed that 74.71% of the chicks reached a sufficient size for ringing. The data we have from 2011 does not show a marked trend; however, generally, there is a higher value for the survival rate than for hatching.

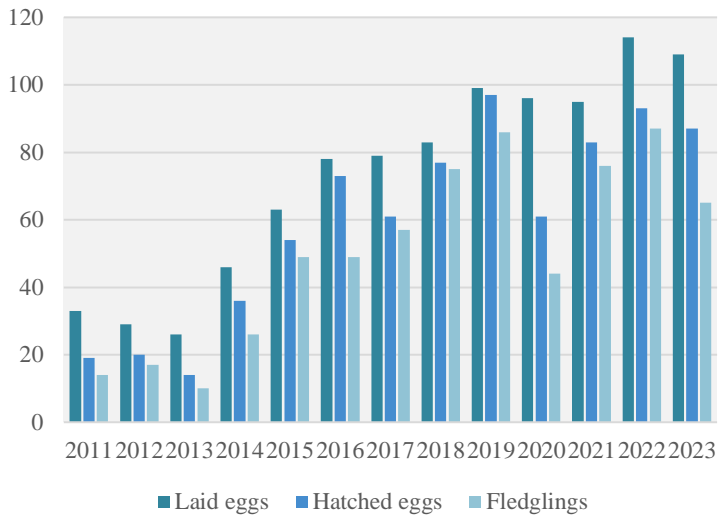


Fig. 5: Number of eggs laid, hatchlings and fledglings of European Rollers breeding in nest boxes in the Vallée des Baux from 2011 to 2023.

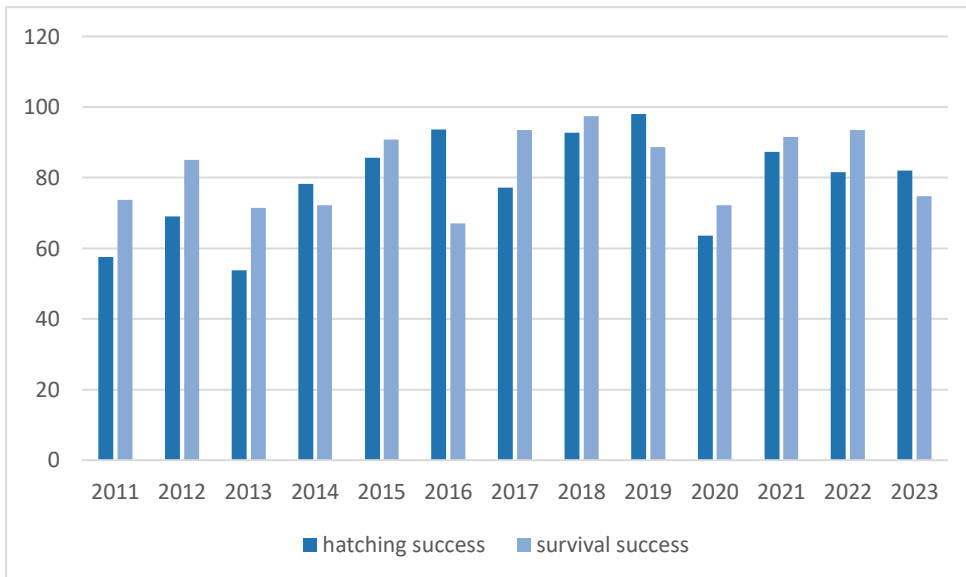


Fig 6: Percentage of hatching and survival success in nest boxes in the Vallée des Baux from 2011 to 2023.

In the case of natural cavities, we do not have as comprehensive data as with the nest boxes. During monitoring, 81 roller eggs were found, and we were able to confirm at least 35 hatches. Comparing with previous years, we can observe an increase in the number of eggs laid parallel to the aforementioned increase in cavities studied during these last years; however, this pattern does not translate to the number of hatches, which shows much more irregular fluctuations.

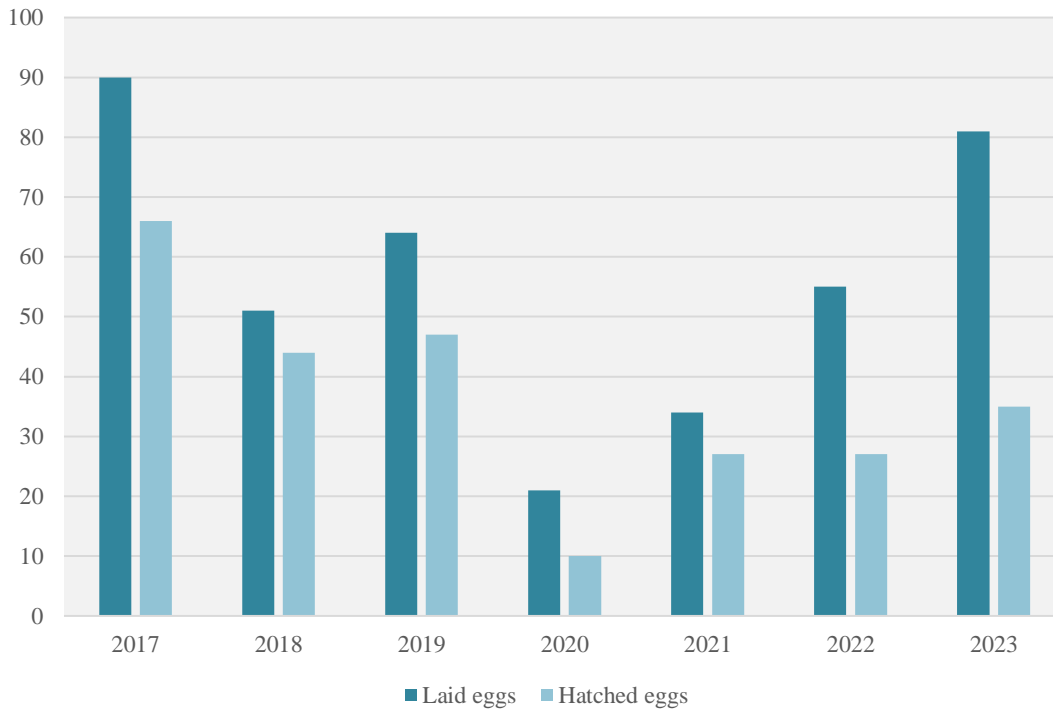


Fig. 7: Number of eggs laid and hatched in natural cavities occupied by the Roller from 2017 to 2022.

Another important piece of data regarding the nest boxes is the clutch size, which this year was 4.95 eggs per nest, a figure similar to those obtained in previous years. However, what is noteworthy is the number of fledglings that were ringed, which decreases to 2.95, the lowest figure in the last 10 years.

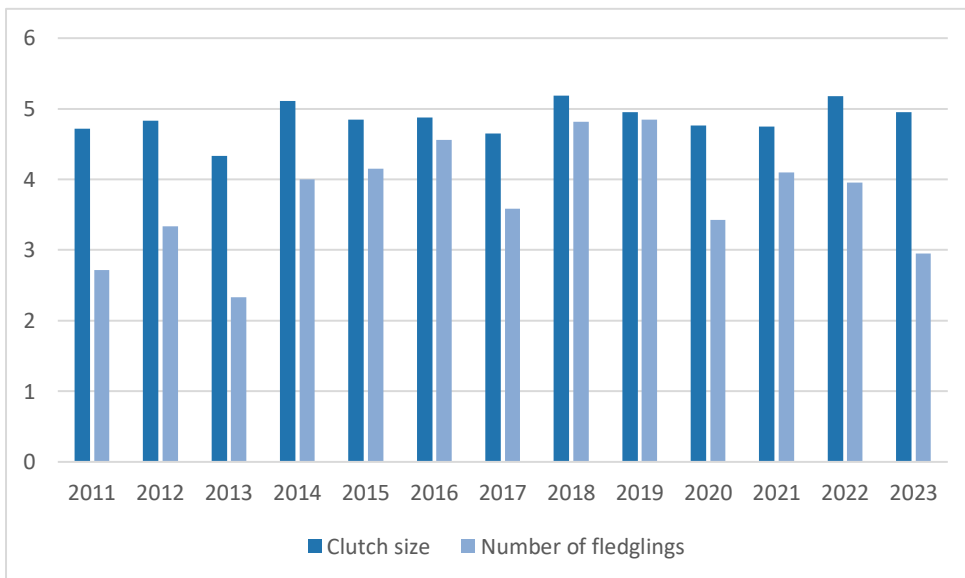


Fig 8: Average clutch and number of fledglings in nestboxes occupied by Rollers from 2011 to 2023.

DISCUSSION

The occupancy data align with those obtained in recent years, with figures close to 40%. This suggests a stabilization in population size following the progressive increase observed between 2011 and 2018. However, it is worth considering that this stabilization could be due to shifting from natural cavities to nest boxes, as the Roller tends to prefer nest boxes over natural cavities (Schwartz et al., 2020). In any case, the number of breeding pairs located in the Vallée des Baux in 2023 is more than twice as high as found in 2002, before the installation of the nestboxes (Crofton 2002).

The information provided by the natural cavities is a bit more imprecise, as the number of cavities studied fluctuates greatly from year to year. It is noteworthy that in 2022 and 2023, occupancy rates exceeded 40%, similar to nest box occupancy and much higher than those obtained in previous years, which were always below 20%. However, this does not necessarily imply an increase in population size; it could be due to the increasing knowledge gained by the A Rocha team each year about the location of new cavities with potential for occupancy, combined with knowledge from previous years about which cavities have been occupied. For example, this year, 21 new natural cavities were found, with 3 occupied by rollers.

Regarding reproductive success, we find a very similar trend in the total number of eggs as in the number of breeding pairs. Focusing on the hatching percentage, during the year 2023, it reached 79.8%, a positive figure; however, there is a noticeable slight progressive decrease over the last 3 years. The percentage of chicks banded was 74%, lower than in previous years. However, this data is influenced by different elements: predation in the nest (observed for nest box 37) and some fledglings that could not be counted because when we checked the nest, the brood had already partially or completely flown away.

In the natural cavities, we find highly fluctuating reproductive success values due to irregular and less intensive monitoring compared to nest boxes.

The average egg clutch size did not vary significantly since records began in the Baux Valley. However, there has been a progressive decrease in the average number of fledglings per nest over the last 3 years. While it cannot be ruled out that we are underestimating the number of fledglings (see above), it is important to consider other factors that may be affecting this decline. Various environmental factors can indirectly or directly affect reproductive success, such as temperature or precipitation. Habitat changes, such as increased agricultural intensification, can also affect roller populations, especially regarding potential decreases in prey availability. Another factor, confirmed in the case of nest box 37, is predation, although this is the single documented case in nest boxes in 2023, which indicates a predation rate of 4.76% and would only marginally contribute to such a significant decline.

CONCLUSIONS

The data obtained through the nest boxes shows a stable population over the last 5 years. While data from the cavities also suggest a stabilization in the roller population, in this case, we do not have data that confirm it with the same certainty. The study of cavities provides information on population status, but if we want to establish comparisons between both habitats and/or estimate population size more accurately, it is recommended to continue exploring potential natural cavities suitable for rollers and establish a group of cavities that will be regularly monitored over the years. The only data that showed a negative trend in recent years is the percentage of ringed nestlings in nest boxes, so it is important to pay attention to these data to verify if there is a downward trend in nestling survival rates. Considering that Southern French roller populations have a fast-paced life compared to populations in other regions (Schwartz et al., 2021), it might be interesting to conduct studies on prey availability, specifically orthopterans, to assess if there are fluctuations in the populations of these insects and how they may affect roller reproductive success. Nevertheless, putting into perspective the data obtained over the last 12 years, we can conclude that the installation of nest boxes has had a positive impact, and it would be advisable to apply these methods in other regions where the European roller population is declining.

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