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Comparison of the reproduction success of the Barbary partridge, *Alectoris barbara* (Bonnaterre, 1792) (Aves Phasianidae), of the two protected areas in Algeria

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ABSTRACT The bioecology of the Barbary partridge, *Alectoris barbara* (Bonnaterre, 1792) (Aves Phasianidae) remain less known compared to other Phasianidae species because of the paucity of informations and studies about this species. In this research we studied and compared the breeding success of the Barbay partridge in two protected areas in Algeria. The first indication of the monitoring is the search of nests; this aspect shows the dynamism of population in nature. We have opted for the Mayfield method by using a software (J_test) which is a developed program for MS-DOS to esteem the daily survival of nests between two protected areas (Zeralda and Djelfa). Besides, we have adopted the CONTRAST software to esteem the daily survivals over the years for each region. During 3 years of follow-up, we have found that the size of the average egg in the two protected areas: Zeralda and Djelfa vary between 12 and 13.42 egg/nest. During 2012, we noted that the factor of predation has extremely high rates: on both rock areas between 33% and 56%, respectively for Zeralda and Djelfa during the year. The confrontation of the obtained results for the two methods confirms well that the survival in the areas is not influenced by the ecologic factors that characterizes each protected area. Our results leads us towards the hypothesis of a high biological potential allowing partridge populations, in a semi-arid climate, to be able to turn over and compensate a low survival thanks to some adjustments on the populations density. This information concerning our endemic species allows the researchers to put the first pillars of data and information bank of the Barbary partridge in Algeria.

KEY WORDS Barbary partridge; biological potential; density; nest; predation.

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INTRODUCTION

The Barbary partridge, *Alectoris barbara* (Bonnaterre, 1792) (Aves Phasianidae), frequents environments as open forests and all the steppes of the Saharan Atlas (Maghnouj, 1983; Farhi & Belhamra, 2012). Despite its roots in popular Maghreb culture and its importance in terms of hunting scenes (Alaoui, 1992; Belhamra, 2005), it has never benefited from constant attention from the institutions in charge of conservation. Bio-demographic data are a basic element of hunting and fauna management (Aebischer, 1999). Most often, they require the implementation of reliable analytical techniques. These rely on a database accumulating long-term monitoring. However, there are very important gaps in terms of knowledge about dynamics and biodemographic kinetics. Few studies have treated the reproduction biology of Barbary partridge in North Africa (Mezerdi, 2015; Hanâne, 2019). Several methods rely on sampling techniques, sometimes involving the use of radio tracking (Boatman & Brockless, 1998). Nest monitoring is a major investment effort in data collection, and may be perceived by many ecologists as being ethically inappropriate (Aebischer, 1999; Qninba et al., 2008). Indeed, the knowledge of this parameter is dictated by the concern to improve the survival of the birds (Reitz, 1988, 1990,1997).

In this research, we have focused our efforts on establishing references in terms of nestling survival and breeding success of Barbary partridge in two protected areas. In order not to introduce statistical biases and to observe the ethical and deontological measures towards the animal populations, we have opted for the Mayfield method (1961, 1975); that facilitates the comparison between two study areas.

MATERIAL AND METHODS

Study area

This study was carried out in two protected areas, Zeralda and Djelfa, during three years of monitoring 2012, 2013 and 2014

The protected area of Zeralda is located 30 km west of Algiers, it is governed as a Hunting Reserve from 1983 (decree n° 84-45 of 18 February 1984, modified and supplemented by decree n° 07-09 of January 11, 2007). It is located in the Algiers region, its geographical coordinates are 36°53'N and 2,52'E, it covers an area of 634.84 ha and its altitude is 183.4 m. It borders four cities: in the north by the city of Staoueli, in the northeast the city of Souidania, in the southeast the city of Rahmania and in the southwest the city of Mahelma. The reserve area is characterized by relatively large cultivated plots of the total area. We find natural formations (forests, scrub...), cereal crops (barley, wheat and oats) and fruit plantations. The agricultural areas are distributed over the entire study area and they are represented by cereal crops (wheat and barley), which take precedence over other crops (fodder, vegetable and tree crops). The spatial heterogeneity and the mosaic of the distribution of the vegetation in Zeralda in the hunting reserve positively influence the richness of the wild fauna.

The national hunting reserve of Djelfa province is located in the forest massif of Sehary Guebli which is part of the Ouled Nail mountains beyond the southern foothills of the Saharian Atlas (34°47' and 34°57'N - 3°7' and 3°24'E). It covers an area of 31,866.2512 ha. It is located about 280 km south of Algiers, 17 km north of the capital of the province, 35 km south of the Daïra of Hassi Bahbah and east of the town of Ain Maabed. The headquarters of the Reserve structure is located in the city of Ain Maabed. This region has been the subject of several publications and works describing its particularities in terms of biodiversity. Like the processes of regression of the natural forests in the Mediterranean Basin, the protected area is the site of a degradation process which affects the *Pinus halepensis* Mill. and *Quercus ilex* L. formations (Pouget, 1980). This transitional phase is characterized by the emergence of strong spatial heterogeneity. Today, the agricultural forest environments of the Tell Atlas and the Saharan Atlas present a diversity of landscapes: open fields, shrubs and clearings on the mountain ranges.

The ecological diversity of the Djelfa Reserve has an ability to be characterized by different fauna species well adapted to their environment. Available observations highlight the observation of emblematic animal species such as the Houbara Bustard and many others (Reserve de Chasse de Djelfa, 2002; Guerzou, 2006).

Methods

The period of full nesting activity begins with the first fledging birds, taking into account two important periods in the bird cycle and extending from spring to autumn (Boatman & Brockless, 1998).

The search for nests is carried out in parallel during the counting of couples in spring. It consists in watching all the places of the studied grounds like the fields, borders of the maquis, forests, under the grass, cereal croplands, etc. (Mezerdi et al., 2017; Hanâne, 2019). However, the searching of nests is hard work because the studied areas are large and tricky due to the camouflage of the nests

(Mezerdi, 2011, 2015; Mezerdi et al., 2018). The success of breeding bird nests is estimated by the Mayfield method (1961, 1975) and supplemented by Aebischer (1999). This method makes it possible to identify and follow a sample of representative nests of the study population. Thus, calculating an average of the time between the last visit where the nest is active and the recorded date of failure or hatching of that nest.

In our study, we used a software (J_test), a program developed for MS-DOS to estimate the daily survival of nests between the two regions. In addition, we adopted the CONTRAST software to estimate the daily survival between the years of each region. The sample of nests we took into account is N = 104, with a frequency of visits of twice a week from March to June.

RESULTS

Assessment of nest success in the wild

To study the reproductive biology and dynamics of a bird population, consideration must be given to estimating the reproductive success of this population. We followed nests of the Barbary partridge during the three years of research in the two Zeralda and Djelfa study areas. The results are summarized in Table 1.

We noted that the average egg-laying size is 12 eggs/nest in the two study areas. During 2012 in Zeralda, the rate of nest loss by predation (the mongoose, wild boar, snake) is 11.11% and 22.22% by poaching, so the rate of nest loss is 33.33%. In Djelfa, the rate of nest loss by predation and destruction of sheep herds is 37.5% and 18.75% by poaching, so the rate of nest loss is 56.25%. However, during 2013 nest tracking results showed a similar average egg-laying size (13 eggs/nest) in both regions. Nest losses in Zeralda area by predators are 15.78% and 31.57% by poaching, so the rate of nest loss is 47.36%. In Djelfa, the rate of nests destroyed by predators is 21.42% and even by poaching is 21.42%, so the rate of nest loss is 42.85%. Finally, during 2014 the average egg-laying size is 12 eggs/nest in the Zeralda region and 10.87 eggs/nest in Djelfa region. The rate of nest loss by predation in Zeralda is 33.33% and 19.04% of the nests are poached, so the rate of nest loss is 52.38%. In Djelfa, the rate of nests destroyed by predators is 25% and 31.25% by poaching, so the rate of nest loss is 56.25%.

The comparison of the breeding success of each year between the two regions is done by a test application: J_test. We recorded the results in Table 2.

The daily probability survival during incubation is similar in both regions during the three years of survey (in 2012; $z = 1.3791 < 1.96$; in 2013; $z = 0.0069 < 1.96$ and in 2014; $z = 0.6308 < 1.96$).

Another comparison is made using CONTRAST test to determine the reproductive success of Barbary partridge in each region between the three years of monitoring. We recorded the results in Table 3.

Years	Region	N ° of nests monitored	Total eggs	Max	Min	Averagee gg size	N ° of failure nests
2012	Zeralda	18	216	15	7	12	6
	Djelfa	16	192	18	6	12	9
2013	Zeralda	19	250	19	9	13.15	9
	Djelfa	14	188	18	5	13.42	6
2014	Zeralda	21	252	17	7	12	11
	Djelfa	16	174	16	7	10.87	9

Table 1. Number of nests, eggs and average egg size in both study areas, during the three years of follow.

Our results showed that the daily probability of survival does not differ between the three years of survey in Zeralda (Chi-square = 1.8295 is less than 5.9915 for ddl = 2, P = 0.4006) or Djelfa (Chi-square = 0.8358 is less than 5.9915 for ddl = 2, P = 0.6584).

DISCUSSION

We have shown that the average egg-laying size in both protected areas (Zeralda and Djelfa) varies between 12 and 13.42 eggs/nest (max = 19

Years	2012		2013		2014	
Parameters	**Zeralda**	**Djelfa**	**Zeralda**	**Djelfa**	**Zeralda**	**Djelfa**
Nt	18	16	19	14	21	16
Ns	12	7	10	8	10	7
Ne	6	9	9	6	11	9
Jt	438	312	414	277.5	427.5	262.5
ŝ	0.98630137	0.9711538	0.9782609	0.9783784	0.974269	0.9657143
Varŝ	3.0847E-05	8.979E-05	5.137E-05	7.623E-05	5.864E-05	1.261E-04
z	1.3791		0.0069		0.6308	
P	0.1678		0.9944		0.5281	

Table 2. Estimation and comparison of Nest success between the two study regions by the Mayfield method (J-TEST). Nt: Number of nests monitored; Ns: Number of successful nests; Ne: Number of failure nests; ŝ: daily survival of nests; P: Probability.

Region	Zeralda			Djelfa		
Parameters/Years	**2012**	**2013**	**2014**	**2012**	**2013**	**2014**
Nt	18	19	21	16	14	16
Ns	12	10	10	7	8	7
Ne	6	9	11	9	6	9
Jt	438	414	427.5	312	277.5	262.5
Ŝ	0.98630137	0.9782609	0.974269	0.9711538	0.9783784	0.9657143
Varŝ	3.0847E-05	5.137E-05	5.864E-05	8.979E-05	7.623E-05	1.261E-04
√Var ŝ	0.005554006	0.007167	0.007658	0.009576	0.008731	0.011231
Chi-square Value	1.8295			0.8358		
Ddl	2			2		
P	0.4006			0.6584		

Table 3. Estimation and comparison of Nest success between the three years of monitoring in each study region, by Mayfield method (CONTRAST). Nt: Number of nests monitored; Ns: Number of successful nests; Ne: Number of failure nests; ŝ: daily survival of nests; ddl: degree of freedom; P: Probability.

eggs/nest), with an average egg laying interval of 1.5 eggs/day. In Yakouren Kabylie region, Akil & Boudedja (1996) and Akil (1998) recorded an average size of wild Barbary partridge spawning of 9.6 eggs/nest with an interval of 1.5 to 2 eggs/nest. However, the number of eggs laid by the Grey Partridge, is higher than the Barbary partridge, reaching densities of 14.4 to 16.2 eggs/nest (Aufradet, 1996), while Guyon (2005) reported that the Grey Partridge has an average of 13 to 18 eggs/nest with an average egg-laying interval of 1.4 eggs/day.

The incubation and global breeding success were established from a survey of three successive years (2012, 2013 and 2014), in the two protected areas representing different ecological conditions: the Zeralda area receives 699 mm of rainfall and enjoys a sub-humid climate, while the Djelfa area receives only 287.7 mm under a semi-arid climate. According to Reitz (1988), the climatic variable could explain thelarge extent of more than 93% of young per female. We also noted that, regardless of habitat, the daily probability of survival during the incubation phase is virtually the same. Furthermore, we can reasonably assume that environmental conditions do not affect a genotype such as egg size and that genetic determinism plays an important role in the emergence of this emblematic trait (Hartl, 1994). This particular aspect of fitness has been also mentioned in other bird species, such as Turtle Doves (Absi et al., 2015). The comparison of the results obtained by two methods J-TEST and CONTRAST, confirm that the survival in both study areas does not seem influenced by the ecological factors that characterize each study area.

Our sampling and clutch monitoring data showed clearly that predation and poaching are an important part of the Barbary Partridge population adjustments. Indeed, we noted only in 2012 anextremely high rate in both study areas; it oscillates 33% in Zeralda and 56%, in Djelfa. These losses give the two populations a sudden drop in numbers and maintain fairly low densities. However, other studies on Grey Partridge populations showed that the absence of the significant effect of predation and poaching allows the density dependence to play a regulatory role (Barbault, 1987; Del Hoyo et al., 1994; Novoa, 1998; Bro et al., 2003; Ponce-Boutin et al., 2006).

CONCLUSIONS

This bio-demographic evolution in two protected areas diametrically opposed from a bioclimatic point of view, and habitat, seems directs us towards the hypothesis of a high biological potential allowing populations of partridge, under a semi-arid climate to be able to catch up the turn over and compensate the poor survival by adjustments in successive densities. This is what we noted in the Djelfa area, where the number of young partridge per adult in a bad year is 3.2 and increases rapidly during the following years to 4 and to 5.53 young partridge average per adult seen in summer.

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