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Cover Page Footnote

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BREEDING BIOLOGY OF THE SARDINIAN WARBLER (*SYLVIA MELANOCEPHALA MELANOCEPHALA*) IN THE NORTH-EAST OF ALGERIA

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ABSTARCT

This work examined the reproductive phenology of the Sardinian warbler (*Sylvia melanocephala melanocephala*) in North-eastern Algeria, which is its main geographical nesting area. Twenty-eight (28) nests were studied during two successive seasons (2016 and 2017). The results obtained in this study confirm that the nests were constructed at an average height of (01.97±01.04 m) from the ground. The laying period lasted eight (08) weeks (mid-March to the beginning of the second week of May), so fifty-four (54) days. The mean clutch size is (4.14±0.97) eggs per brood. The recorder traits were previously observed in European populations. The average of hatching success was (47.38 %) and mean reproductive success (45.24 %) were relatively low compared to European populations.

Keywords: *Sylvia melanocephala melanocephala*, PNEK, North-east Algeria, Reproductive biology, Reproductive success.

INTRODUCTION

The family Sylvidae counts thirty-four (34) to sixty-eight (68) species in the world (Winkler et al., 2020). Fourteen (14) species belonging to the genus Sylvia nest in North Africa (Etchécopar and Hüe, 1964). Among these species, we were interested in the Sardinian warbler (*Sylvia melanocephala melanocephala*) which nests in North Africa. It breeds accidentally in Romania, Bulgaria, Brittany, Western Germany, Denmark, Finland, Hungary, Austria and Kuwait (Cramp, 1992) and also in the Saharan Atlas (Heim De Balsac, 1926; Etchécopar et Hüe, 1964; Isenmann et Moali, 2000; Thévenot et al., 2003; Isenmann et al., 2005).

In Algeria, the Sardinian warbler (*Sylvia melanocephala melanocephala*) is abundant throughout the coastal zone, on hills covered with *Cistus*, *Pistacia lentiscus* and *Calicotome villosa* (Heim De Balsac, 1926; Heim de Balsac et Mayaud, 1962; Benyacoub and Chabi, 2000). In Morocco, it is very common, except in the desert areas of the East and South, and in the highlands (Thévenot et al., 2003). It occurs much further East in Morocco up to the limits of the High Plateau and in Atlantic Morocco, but is poorly distributed and local further South in the Western Anti-Atlas and the and the Bas-Drâa (Thévenot and al., 2003). Its range extends into Western Sahara, as far as Saquiat Al-Hamra (from Layoune to Smara, and Oued Ad-Dehb to Imlilik), but nesting has not been confirmed since the 1970 (Congost-Tor, 1976; Heim de Balsac et Mayaud, 1962; Thévenot et al., 2003). It is found in the Rif and in the Central Plateau up to an altitude of 800-1000 m, but rare between 1000 and 1400 m (Heim de Balsac et Mayaud, 1962; Thévenot et al., 2003). Widespread in the Eastern Middle Atlas (for example up to 1000 m in Jbel Tazekka), but less common on the lower slopes of the Western Middle Atlas (for example at Sefrou, El-Hajeb and east of Khénifra, and up to 1500 m at DayetAoua) (Heim de Balsac et Mayaud, 1962; Thévenot et al., 1982; Thévenot et al., 2003). It is also common up to 1500-1800 m in the western and central High Atlas, East of Azilal (Barreau and al., 1987; Thévenot and al., 2003). In Algeria, it nests in the garrigues, the maquis du Tell and the Aurès, but it does not reach the High Plateaux (Heim De Balsac, 1926; Heim de Balsac et Mayaud, 1962; Isenmann and Moali, 2000), the olive groves and bushes on the edge of the cultures of the North (including Galite Island) and from the center of the country as far South as Jerba, the oases of the South (in Tunisia) (Heim de Balsac et Mayaud, 1962; Isenmann et al., 2005), low bushes or trees, *Tamarix*, *Limoniastrum* and *Euphorbia* (in Morocco) (Heim de Balsac et Mayaud, 1962; Thévenot et al., 2003). The present work aims at the characterization of the North African subspecies of the Sardinian warbler (*Sylvia melanocephala melanocephala*). It consists in highlighting the life history traits of this subspecies which nests in North-eastern Algeria.

METHODS

Study area

The study was located in North-eastern of Algeria (El- Kala National Park, 36°53'N; 08°30'E) over a two-year period (2016-2017) (Figure 1). Area's climate is characterized by an alternating dry season, from May to November, and a rainy season the rest of the year. Rainfall reaches 1000 mm per year (Benyacoub et Chabi, 2000).

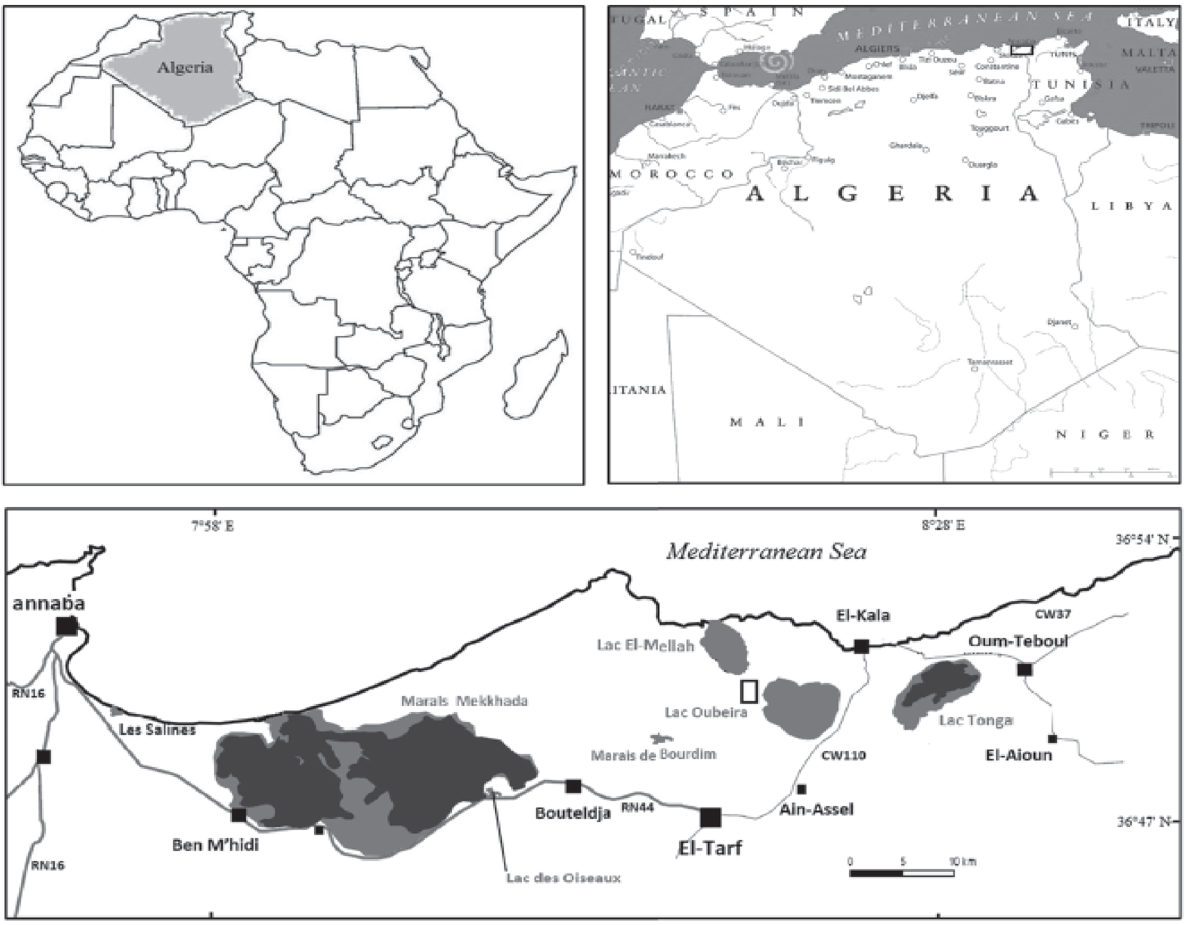


Figure 1: Location of the study area (Boulahbal et al., 2020).

The study site includes two stations which were located in the Brabtia area. The latter were the seat of forest fires in 2000 (Ramdani et al., 2019; Boulahbal et al., 2020). In fact, various degradation factors (fires, cutting, grazing, demascling etc) remain active in this area. Our sites were composed of cork oak *Quercus suber* (mean height 7 m). The undergrowth is composed by Mediterranean association, with, as the most typical, *Phillyria angustifolia*, *Pistacia lentiscus*, *Myrtus communis* and *Calycotome villosa* (mean height 0.5 m - 2 m). The herbaceous understorey is quite rare due to undergrowth density (Benyacoub et Chabi, 2000).

Methodology

Searchnig for nests for such studies involve considerable effort in the field and result in the discovery of a relatively small number of nests, we search nests among the branches of a trees or by observation of adult birds during nest building (Winter et al., 2003; Kouidri et al., 2012; Ramdani et al., 2019). Another nests were founded by chance were walking near them causing female disrupting (Brahmia et al., 2003; Kouidri et al., 2012 and 2016; Bensouilah et al., 2014 and 2016; Brahmia et al., 2015; Kafi et al., 2015; Zeraoula et al., 2015; Ramdani et al., 2019). When potential active nests were identified, a series of successive passes were made to establish the nest contents, including number of eggs, laying date, incubation period, hatching, fledging and breeding success. Also, other nests parameters were registered such as nest height, diameters, depth and nest weight. All egg measurements (length and width) were conducted using calliper and egg mass with electronic scale (0,1g). Egg volume was calculated by applying Hoyt's (1979) formula: V= 0.51* L* B2. (L: egg length and B: egg width).

The descriptive statistics were computed. One-way ANOVA was used to assess the variation between parameters. The data were analysed using a statistical software program (Statistix software, V8).

RESULTS

Nest Characteristics

Twenty-eight (28) nests were located during the two study seasons (16 nests during the first year and 12 nests during the second year). They were installed on six vegetation species: 39.30 % of the nests on *Erica arborea*, 21.40 % of the nests on *Clematis vitalba*, 17.90 % of the nests on *Phillyrea angustifolia* and 07.10 % of the nests on *Acacia dealbata*, *Myrtus communis* and *Crataegus monogyna*. Mean nest height is 01.97 m from the ground and are located between 0.50 and 04 m. The two seasons showed no significant difference in mean nest height ($F_{1.26}$=0.11; p=0.745; NS) (Table 1).

The nests are semi-spherical or open cups built by the pair. The characteristics of the nests are presented in the table (2) below. The results show that the mean of diameters are respectively 08.58 and 05.99 cm for the external and the internal diameters (n= 22 nests). The average of height and depth of the nests was respectively 05.62 and 04.25 cm. The average thickness of the nests was 01.47 cm and its average weight was 08.67 g.

Materials

The study of the nests allowed us to characterize the construction materials used by the nesting pairs. As shows on Figure 2, the species uses three types of materials (vegetal, animal and mud). The nests are made up mainly by the use of *Chamaerops humilis* and *Casuarina excelsior* as a vegetable part and by the use of hairs as an animal part (Photo 1).

Photo 1: Nest, egg and chicks of the *Sylvia melanocephala melanocephala* (Personal photo. K. Ramdani).

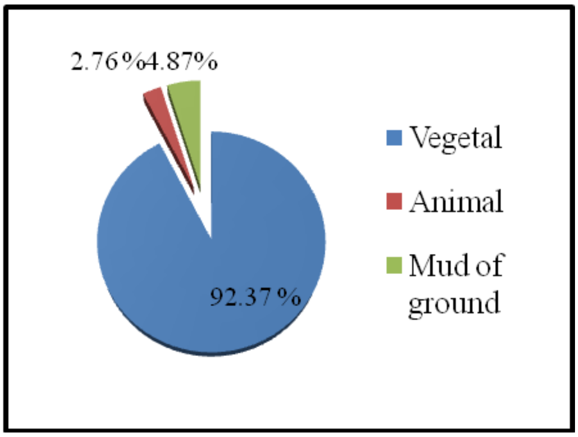


Figure 2: Frequencies of the different nest components in the *Sylvia melanocephala melanocephala.*

Laying Date and Laying Period

The laying period persisted during eight (8) weeks: from mid-March (15 March) to the beginning of the second week of May (8 May), that is to say a laying duration of fifty-four (54) days, with a significant laying frequency during the last five (5) weeks of the breeding season (3 April - 8 May) and a peak during the second (25-27 March) and the fifth week (14-19 April) (Figure 3). The mean date of laying was April 11 (41.82±15.03).

There was no statistically significant difference according to laying dates of the two follow-up years ($F_{1.26}$=0.01; =0.938; NS) (Table 3).

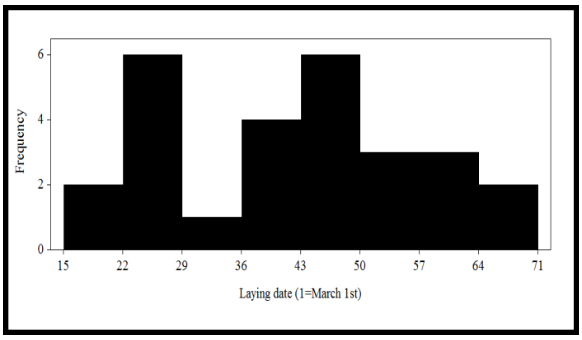


Figure 3: Egg laying chronology of the Sardinian warbler *Sylvia melanocephala melanocephala* (2016-2017).

Table 2: Characteristics of the nests of the Sardinian warbler Sylvia melanocephala melanocephala.

Characteristics	**n; mean±SD (min-max)**
Weight (g)	22; 08.67±02.63 (05-12.5)
Height of the nests (cm)	22; 05.62±01.29 (02.66-06.91)
Internal diametre (cm)	22; 05.99±0.53 (05.22-06.78)
External diametre (cm)	22; 08.58±0.52 (06.41-10.45)
Cup thickness (cm)	22; 01.47±0.20 (01.21-01.83)
Depth of the nests (cm)	22; 04.25±0.56 (03.22-05.11)

Clutch Size

The mean was (4.14±0.97) eggs per brood. No significant difference between the average clutch size in the two seasons was observed ($F_{1.26}$=0.08; p=0.785; NS) (Table 3).

Table 1: Construction support and nest height of the Sardinian warbler Sylvia melanocepha melanocephala.

Vegetation Year	*Erica arborea*	*Clematis vitalba*	*Acacia dealbata*	*Myrtus communis*	*Phillyrea angustifolia*	*Crataegus monogyna*	Nest height (m) n; mean±SD (min-max)
2016	06 (37.50 %)	04 (25 %)	01 (06.30 %)	01 (06.30 %)	03 (18.80 %)	01 (06.30 %)	n=16; 02.03±01.11 (0.5-04)
2017	05 (41.70 %)	02 (16.70 %)	01 (08.30 %)	01 (08.30 %)	02 (16.70 %)	01 (08.30 %)	n=12; 01.89±0.98 (0.5-04)
Mean	11 (39.30 %)	06 (21.40 %)	02 (07.10 %)	02 (07.10 %)	05 (17.90 %)	02 (07.10 %)	n=28; 01.97±01.04 (0.5-04)
One-Way ANOVA							$F_{1.26}$=0.11; p=0.745; NS

Table 3: Variation in laying date, clutch size, incubation time and reproductive success (n; mean±SD) (min-max) between the two season.

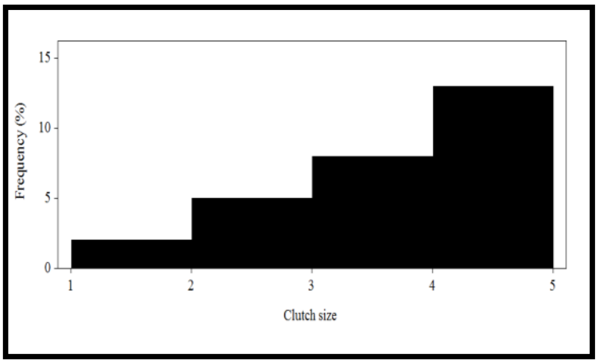
Year	Laying date (days)	Clutch size	Incubation time (days)	Reproductive success (%)
2016	16; 41.63±14.00 (21 March-08 May)	16; 4.19±0.98 (2-5)	09; 13.22±0.44 (13-14)	16;50,63±47,82 (0-100)
2017	12; 42.08±16.94 (15 March-06 May)	12; 4.08±1.00 (2-5)	06; 13.33±0.52 (13-14)	12; 44,17±48,14 (0-100)
Mean	28; 41.82±15.03 (15 March-08 May)	28; 4.14±0.97 (2-5)	15; 13.27±0.46 (13-14)	28; 47,86±47,17 (0-100)
One-Way ANOVA	$F_{1.26}$=0.01; p=0.938; NS	$F_{1.26}$=0.08; p=0.785; NS	$F_{1.13}$=0.20; p=0.662; NS	$F_{1,26}$=0,12; p=0,727; NS

Table 4: Traits of the eggs (n; mean±SD (min-max)) of the Sardinian warbler *Sylvia melanocephala melanocephala.*

Year	Weight (g)	Length (mm)	Width(mm)	Volume (cm^3)
2016	67; 1.94±0.32 (1.5-3)	67; 18.41±1.21 (16.07-20.93)	67; 14.30±0.69 (13.20-15.39)	67; 1.93±0.29 (1.48-2.53)
2017	49; 1.92±0.27 (1.5-2.5)	49; 18.52±1.22 (16.06-20.93)	49; 14.26±0.71 (13.20-15.39)	49; 1.93±0.30 (1.48-2.53)
Mean	116; 1.93±0.30 (1.5-3)	116; 18.46±1.21 (16.06-20.93)	116; 14.28±0.70 (13.20-15.39)	116; 1.93±0.29 (1.48-2.53)
One-Way ANOVA	$F_{1.114}$=0.22; p=0.638; NS	$F_{1.114}$=0.24; p=0.628 ; NS	$F_{1.114}$=0.08; p=0.782; NS	$F_{1.114}$=0.00; p=0.971; NS

The most frequent clutches were those of 4 and 5 eggs per brood, which represented 28.60 % (08 nests) and 46.40 % (13 nests) respectively, with the presence of other clutches of 2 and 3 eggs per brood representing 07.10 % (02 nests) and 17.90 % (05 nests) respectively (Figure 4). In the Sardinian warbler, there was no significant report between laying date and laying size (r=-0.272; p=0.161; NS).

Figure 4: Clutch size proportions of the Sardinian warbler *Sylvia melanocephala melanocephala* (2016-2017).



Eggs Characteristics

The average mass of the eggs was (1.93±0.30 g). Varying between 1.5 and 3 g. Egg mass does not show a significant difference between seasons ($F_{1.114}$=0.22; p=0.638; NS). The mean of egg length was (18.46±1.21 mm), varying between 16.06 and 20.93 mm. No significant difference in mean egg length was observed between seasons ($F_{1.114}$=0.24; p=0.628). The mean width of the eggs was (14.28±0.70 mm), ranging between 13 and 15.39mm. There was no significant difference between the mean egg width of the two seasons ($F_{1.114}$=0.08; p=0.782; NS). The average volume of the eggs was (1.93±0.29 cm^3), ranging between 1.48 and 2.53 cm^3. The mean of egg volume was relatively stable between seasons ($F_{1.114}$=0.00; p=0.971; NS) (Table 4).

Incubation Period

The mean incubation period was (13.27±0.46 days), ranging from 13 and 14 days. The two seasons showed no significant difference in mean incubation duration ($F_{1.13}$=0.20; p=0.662; NS) (Table 3).

Hatching Date

The average hatching date was April 24 (54.73±13.29), ranging from

April 02 to May 20. The two seasons show no significant difference in their mean hatching dates ($F_{1.13}$=0.001; p=0.982; NS) (Table 5).

Table 5: Variation in hatching date (n; mean±SD (min-max)) between the two seasons.

Year	Hatching Date (days)
2016	09; 54.67±11.39 (09 April-12 May)
2017	06; 54.83±16.94 (02 April-20 May)
Moyenne	15; 54 .73±13.29 (02 April-20 May)
One-Way ANOVA	$F_{1.13}$=0.001; p=0.982; NS

Eggs Hatched

The average number of eggs hatched was (2.14±2.17) per clutch, varying between 0 and 5 eggs per clutch. The two seasons show no significant difference in the average number of eggs hatched ($F_{1.26}$=0.02; p=0.903; NS) (Table 6).

Table 6: Variation in the number of eggs hatched (n; mean±SD (min-max)) between the two sesons.

Year	Eggs hatched per clutch
2016	16; 2.19±2.26 (0-5)
2017	12; 2.08±2.15 (0-5)
Moyenne	28; 2.14±2.17 (0-5)
One-Way ANOVA	$F_{1.26}$=0.02; p=0.903; NS

Hatching success

The mean was 47.38±46.01 %, ranging between 0 and 100 %. The two seasons show no significant difference in mean hatching success ($F_{1.26}$=0.00; p=0.966; NS) (Table 7).

Table 7: Variation in hatching success (n; mean±SD (min-max)) between the two seasons.

Year	Hatching success (%)
2016	n=16; 47.71±47.32 (0-100)
2017	n=12; 46.94±46.29 (0-100)
Mean	n=28; 47.38±46.01 (0-100)
One-Way ANOVA	$F_{1.26}$=0.00; p=0.966; NS

Young in Flight

The average number of young at flight was (2.00±2.07) per clutch, ranging between 0 and 5 young per clutch. The two seasons show no significant difference in the mean number of young at flight ($F_{1.26}$=0.03; p=0.858; NS) (Table 8).

Table 8: Variation in number of young in flight per brood (n; mean±SD (min-max)) between the two seasons.

Year	young in filight per brood
2016	n=16; 2.06±2.11 (0-5)
2017	n=12; 1.92±2.11 (0-5)
Mean	n=28; 2.00±2.07 (0-5)
One-Way ANOVA	$F_{1.26}$=0.03; p=0.858; NS

Success at Fledging

The average fledging success was 51.43±49.12 %, ranging between 0 and 100 %. The two seasons show no significant difference in mean fledging success ($F_{1.26}$=0.08; p=0.779; NS) (Table 9).

Table 9: Variation in success at fledging (n; mean±SD (min-max)) between the two seasons.

Year	Success at fleding (%)
2016	16; 53,75±49,38 (0-100)
2017	12; 48,33±50,78 (0-100)
Mean	28; 51,43±49,12 (0-100)
One-Way ANOVA	$F_{1,26}$=0,08; p=0,778; NS

Reproductive Success

The average reproductive success was 47.86±47.17 %, ranging from 0 and 100 %. The two seasons show no significant difference in mean reproductive success ($F_{1.26}$=0.12; p=0.727; NS) (Table 3).

DISCUSSION

The results of the present study on the breeding biology of the Sardinian warbler (*Sylvia melanocephala melanocephala*), breeding in an evergreen oak forest of Brabtia located at 30 m of altitude, at the level of the National Park of El-Kala (North-east Algeria), revealed that the nests were installed on six plant species. It is a species that nests in various habitats: on the tree stratum (*Argania spinosa*, *Quercus suber*, *Quercus ilex*, *Juniperus oxycedrus*, *Acacia dealbata*, *Olea europaea*, *Phoenix dactylifera* and *Tamarix*) (Thévenot et al., 2003; Isenmann et al., 2005) and on the shrub layer (*Erica arborea*, *Cistus salvifolius*, *Euphorbia*, *Phillyrea angustifolia*, *Calycotome villosa*, *Pistacia lentiscus*, *Clematis vitalba*, *Lycium*, *Myrtus communis* and *Retama retem*) (Heim De Balsac, 1926; Thévenot et al., 2003; Isenmann et al., 2005). On the herbaceous stratum (*Chamaerops humilis* and *Inula viscosa*) (Thévenot et al., 2003).

Generally, nesting materials in our region do not differ from their counterparts in Europe (Cramp, 1992) and Algeria (El-Kala National Park, North-east Algeria). The elevation of the nests registered in our study was similar to that reported in Algeria at El- Kala National Park (2.19 m, varying between 1 to 4 m above ground level), and higher compared to European populations (between 0.75 to 1.35 m above ground level) (Cramp, 1992) and Morocco (between 0.4 to 2 m and 0.15 m above ground level) (Thévenot et al., 2003).

The nests characteristics (external and internal diameter, height and depth of the cup) in the present study are similar to those mentioned in Europe (Cramp, 1992) and in North-east of Algeria (Table 10).

Table 10: Measurements (mean) of the nests of the Sardinian warbler.

Parametrs	Europe	Algeria
External diameter (cm)	9,1	8,56
Internal diameter (cm)	5,8	6,04
Cup Height (cm)	/	5,68
Cup depth (cm)	3 à 5	4,31

Chronologically, the laying date of the Mediterranean breeding Sardinian warbler (*Sylvia melanocephala melanocephala*) is earlier than that reported in North-west Africa, North Africa, Algeria, Morocco and Tunisia (early April) (Heim de Balsac et Mayaud, 1962; Etchécopar and Hüe, 1964; Isenmann et Moali, 2000; Thévenot et al., 2003; Isenmann et al., 2005), in Greece (end of April) and in South-Western Europe (beginning of May) (Cramp, 1992). However, it was late in Malta (mid-February) (Cramp, 1992) and similar to that reported in the same area (mid-March). Generally in passerines, the laying dates vary or depend mainly on habitat quality or vegetation type, latitude and altitude (Lack, 1950 and 54; Dhondt et al., 1984; Blondel et al., 1987; Isenmann, 1987; Perrins and McCleery, 1989; Cramp, 1992; Chabi et al., 1995; Chabi et Isenmann, 1997; Kouidri et al., 2015; Ramdani et al., 2019). Several works explain that the laying dates are related to the phenological stage of plants and more precisely the bud burst (Von' Haartman, 1969; Jones, 1972; Van Balen, 1973; Slagsvold, 1976; Chabi and Isenmann, 1997). This phenomenon, conditions the food availability during the period of feeding of the young, considered as an ultimate factor that determines the period of reproduction of birds in temperate and Mediterranean regions (Lack, 1966 and 1968; Greenwood and Hubart, 1979; Cramm, 1982; Dhondt et al., 1984; Blondel et al., 1987; Clamens, 1990; Perrins and McCleery, 1989; Zandt et al., 1990; Chabi et Isenmann, 1997). Other work has shown that the laying date can be advanced by additional feeding early in the breeding season (Källander, 1974; Von Brömssen and Jansson, 1980; Smith et al., 1980; Clamens and Isenmann, 1989).

The size of the eggs in the present study is similar to those reported in Central Sahara and South Algeria (3-4 eggs per brood) (Heim de Balsac, 1926), in North-west Africa (4.2 eggs per brood) (Heim de Balsac et Mayaud, 1962), in North Africa (n=36; 4.5±0.53 (4-5) eggs per brood) (Etchécopar et Hüe, 1964), in Malta (3.77 eggs per brood) (Cramp, 1992), in Algeria and Tunisia (n=52; 4.19±0.74 (3-5) eggs per brood) (Isenmann et al., 2005), in Morocco (n=42; 3.86±0.61 (3-5) eggs per brood) (Heim de Balsac, 1952; Littel, 1980; Thévenot et al., 2003) and in the Algerian North-east (El-Kala National Park) (n=14; 3.79±0.8 (2-5) eggs per brood). The results obtained show that the traits of the eggs are similar to those reported in several works: in Europe (n=125; 18x13.6 mm (20 x 15.2-14.5 x 131)) (Cramp, 1992), in Central and South Algerian Sahara (n=11; 17.9x 13.58 mm (18.9 x 16.9-14.2 x 12.9) (Heim de Balsac, 1926), in North Africa (n=36; 19 x 14-15.2 x 13.2)) (Etchécopar et Hüe, 1964) and in North-east of Algeria (n=44; 20.93 x 16.06-15.39 x 13.20).

The duration of egg incubation recorded is similar to that reported for European populations (13 and 15 days) (Cramp, 1992) and in North-east of Algeria (n=12; 13.58 (13 and 14 days).

Hatching success and reproductive success in the present study are relatively low compared to results obtained in studies conducted in Europe (Cramp, 1992) and in North- eastern of Algeria. These differences are related to several factors, in this case, the infertility of eggs, frequent human disturbances in the site and predation (*Malpolon monspessulanus*, *Timon pater*, *Rattus norvegicus*, *Apodemus sylvaticus*, *Mus spretus*, *Genetta genetta*, *Camponotus cruentatus*, *Creamatogaster scutellaris*) (Boulahbal et al., 2008; Ramdani et al., 2019).

Finally, these first data on the reproductive biology of the Sardinian warbler (*Sylvia melanocephala melanocephala*) subspecies in Algeria require a more thorough follow-up addressing other aspects like food availability, chick's diet and parasitism influence on the population and breeding success.

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AUTHORES CONTRIBUTION

All authors contributed equally in performing research activities and compilation of results.

CONFLICT OF INTEREST STATEMENT

The researchers/scientist do not owe any conflict of interest.

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