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Egg dimensions of the Roller *Coracias garrulus* in farming areas of the Southwest Iberian Peninsula

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Abstract - Egg dimensions of the Roller *Coracias garrulus* in farming areas of Extremadura were studied in 1989 and 1990. Egg dimensions of Rollers tend to be smaller in the south compared to the north. Differences in egg dimensions were not found in the studied population in relation to years. Climatic conditions during the laying period did not influence egg size. No seasonal decline in egg size was detected and, similarly, we did not detect a clear trade-off between egg size and clutch size.

Introduction

The Roller *Coracias garrulus* is wide-spread across the Paleactic region (Cramp and Simmons 1988, Tucker and Heath 1994). Several studies have shown its drastic decline, that has brought about its extinction in northern countries of Europe (Glutz and Bauer 1980, Bracko 1986, Lemmetyienen 1987, Samwald and Samwald 1989, Robel 1991). The information available on its breeding biology, however, is scarce (Durango 1946, Creutz 1979, Sosnowski and Chmielewski 1996), though recently an increase in clutch size with a decrease in latitude has been demostrated for this species (Avilés *et al.* 1999). These results go against the prediction of an increase in clutch size with latitude in nidicolous birds (Royama 1969, Ricklefs 1969, Hussell 1985). Soler and Soler (1992) recorded a similar pattern of clutch size variation in the Jackdaw *Corvus monedula* as well as the decrease of egg size in southern latitudes for this species. They argued that larger clutches are more advantageous for the Jackdaw in the south, and clutch size decreases to the north because clutch size is constrained by egg size and larger eggs give more selective advantages in northern latitudes (Järvinen and Väisänen 1983).
In the present paper we show egg dimensions of the Roller in the most southerly latitude where its breeding biology has been studied. Comparisons are made with egg dimensions in the north of its distribution. Yearly and seasonal variation in egg size at the inter-clutch level of the studied population are analysed too. Finally, we examined the effect of clutch size, laying date and weather on egg dimensions in this species.

Study Area and Methods

We studied the variation in egg dimensions of Roller in the Serena region (39°03'N, 5°14'W) during May and June of 1989 and 1990. This area is characterised by the predominance of dry pastures and cereal crops (mainly wheat, barley and oats). There are little surfaces of shrublands (*Retama sphaerocarpa*), and areas with holm-oaks (*Quercus ilex*) (Sánchez and Sánchez 1991). The study area is included in the mesomediterranean climate (Rivas-Martínez 1981).
Temperature values (C°) and rainfall (mm) were calculated separately for each clutch and are mean daily values for the 11-day period five days before and five days after the laying of the first egg in the clutch (Järvinen 1991). All climatic data were obtained from the climatological station of Orellana which is in the study area.
All studied nests were in boxes of B type with the same dimensions (Negro 1987). Then the effects of the variations in this factor on breeding strategies of single brooded hole nesting bird species are not expected for the Roller in this experiment (See Slagsvold and Amundsen 1993).
Nest-boxes were visited regularly during the breeding season to determine accurately the laying of the first

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egg and the clutch size. In none of the cases double clutches were registered, confirming previous observations (Cramp and Simmons 1988). After the clutch was completed, we measured the maximum length (L) and breadth (B) of all eggs with sliding callipers (accuracy 0.01 mm). Using these two parameters we estimated egg volume (V) with the formula ($V = L \times B^2 \times 0.515$) (Hoyt 1979) which will be named as volume from now on.

Analyses in this paper were on means of clutches, since individual eggs are not independent observations (Järvinen 1991). Statistics are presented as means ± one standard deviation (SD). Normality of variables was checked by Kolmogorov-Smirnov test. For multivariate analysis, climatic variables were transformed as Zar (1996). The statistic tests used and sample sizes are detailed in the text.

Results

Egg length averaged 34.6 mm, egg breadth 27.5 mm and egg volume 13.3 cm^3. The between-clutch coefficient of variation was 3.1 % for egg length, 2.6 % for egg breadth and 6.0 % for egg volume (Measurements regarded 32 clutches. Table 1).

Egg length and egg breadth tended to increase together (Spearman correlation coefficient: $r_s = 0.44$; $P < 0.01$; n=32). When the within-clutch variation in egg length was larger the within-clutch variation in egg breadth tended to be larger too (Spearman correlation coefficient: $r_s = 0.55$; $P < 0.01$; n=32). Clutches with more volume did not show higher between-clutch variation (Spearman correlation coefficient: r_s=-0.07; $P < 0.01$; n=32).

Between years differences were not found for egg length (Mann-Whitney test: U=137.5; P = 0.66), egg breadth (Mann-Whitney test: U=144.0; P = 0.49) or egg volume (Mann-Whitney test: U=145.0; P = 0.50)(Table 2).

No seasonal patterns were detected for egg length (Spearman correlation coefficient: r_s = -0.02; P > 0.05; n=32), egg breadth (Spearman correlation coefficient: r_s = -0.15; P > 0.05; n=32) or egg volume (Spearman correlation coefficient: r_s = -0.14; P > 0.05; n=32). In the same way, between-clutch variation in egg volume did not show any seasonal trend (Spearman correlation coefficient: r_s = -0.05; P > 0.05; n=32).

There were no differences in egg length between the different clutch size classes (Kruskal-Wallis test: H=1.39; P = 0.70; df=3). In the same way egg breadth (Kruskal-Wallis test: H=1.46; P = 0.69; df=3) and volume (Kruskal-Wallis test: H=1.04; P = 0.79; df=3) did not show any variation in relation to clutch size (Table 3). Between-clutch variation in egg volume in relation to clutch size was stable too (Kruskal-Wallis test: H=0.68; P = 0.87; df=3).

Table 1. Basic breeding data for Roller in the Serena population in 1989-1990. Laying dates of Roller in days from 1 January. Climatic values (temperature and rainfall) calculated for each clutch as explained in methods. Egg dimensions based on clutch means. VC = coefficient of variation. (n=32 clutches).

	Mean (± sd)	Range
Laying date	141.7 ± 7.2	128 - 161
Clutch size	4.4 ± 0.9	3-6
Length (mm)	34.6 ± 1.3	32.4 - 38.2
Breadth (mm)	27.5 ± 0.8	25.9 - 29.3
Volume (cm^3)	13.3 ± 1.1	11.4 - 16.2
VC_{Length}	3.1 ± 3	0.6 - 17.3
$VC_{Breadth}$	2.6 ± 1.8	0.6 - 8.9
VC_{Volume}	6.0 ± 5.1	0.1 - 19.5
Maximum temperature (°C)	28.2 ± 1.5	25.2 - 31.2
Minimum temperature (°C)	12.5 ± 1.5	10.5 - 19.5
Mean temperature (°C)	20.4 ± 1.1	18.5 - 22.9
Mean rainfall (mm/day)	6.9 ± 9.8	0.0 - 36.5

Table 2. Egg dimensions of the Roller in Extremadura in relation to years. Sample size is presented in brackets.

	Length, mm (mean ± sd)	Breadth, mm (mean ± sd)	Volume, cm^3 (mean ± sd)
1989	34.3 ± 1.3 (n=18)	27.5 ± 0.7 (n=18)	13.2 ± 0.5 (n=18)
1990	34.5 ± 1.1 (n=14)	27.4 ± 0.9 (n=14)	13.2 ± 1.2 (n=14)

Table 3. Egg dimensions (mean ± sd) of Roller in relation to clutch size. Sample size is in brackets.

Eggs	3	4	5	6
Length (mm)	34.29 ± 1.33 (n=7)	34.94 ± 1.09 (n=11)	34.80 ± 1.49 (n=10)	34.39 ± 0.94 (n=4)
Breadth (mm)	27.38 ± 0.82 (n=7)	27.64 ± 0.95 (n=11)	27.30 ± 1.29 (n=10)	27.81 ± 1.00 (n=4)
Volume (cm^3)	13.15 ± 1.19 (n=7)	13.66 ± 1.27 (n=11)	13.27 ± 1.51 (n=10)	13.62 ± 1.23 (n=4)

Multiple linear regression showed that egg volume variance of Roller (n=32) was not explained by laying date, clutch size, maximum, minimum and mean temperature and rainfall during the 11-day period five days before and five days after the laying of the first egg. None of them was correlated to egg volume when the influence of the others were removed (Partial correlation for laying date: r_p= -0.16; cluch size: r_p=0.04; Maximum temperature: r_p=-0.14; Minimum temperature: r_p=0.26; Mean temperature: r_p=0.36; Mean rainfall: r_p=-0.08; P > 0.15 in all cases).

Discussion

Egg dimensions of Rollers tend to be smaller in Spain compared with northern latitudes (Russia: 35.0 x 28.0 mm (Dementiev & Gladkov 1952); Sweden: 36.4 x 28.9 mm (Rosenius 1929); Hungary: 35.8 x 28.3 mm (Makatch 1976)). This is the case for other single brooded hole nesting bird species (for a detailed revision see Soler and Soler 1992). These authors suggest a major advantage of large clutches in the south. They argue that in southern latitudes clutch size is not constrained by egg size that has a minor selective pressure (Järvinen and Väisänen 1983). In accordance with this hypothesis, the Roller clutch size tends to be larger in the south of Spain (4.2 ± 1.2, n = 817) (Avilés *et al.* 1999), compared with birds further north (Sweden (Durango 1946): 3.8 ± 0.9; n=49, , Two tailed t-test: t = 2.73 P < 0.01 and Poland (Sosnowski and Chmielewski 1996): 3.6 ± 0.8 n=29, Two tailed t-test: t = 3.90 P < 0.01). It has shown an increase in breeding success with an increase in clutch size (Avilés *et al.* 1999), indicating that there may be an advantage in increasing clutch size in single brooded hole nesting bird species in the south as suggested by Soler and Soler (1992).

The sequence of variation on egg dimensions was the same as that obtained for some hole nesting birds in North Europe (Ojanen *et al.* 1978, Järvinen and Väisänen 1983).

Annual differences in egg dimensions of Rollers are negligible in the Serena. This has been explained in relation to homogeneity in weather and foraging conditions between years (Arnold *et al.* 1991, Nager and Zandt 1994). In the study area, mean temperature between years during the previous month to egg laying were similar (1989: 14.0 ° C and 1990: 13.5 ° C), although the total rainfall in 1989 (81.4 mm) was greater than in 1990 (44.3). Neither laying dates nor clutch sizes of Rollers correlated with the spring rainfall in the Serena (Avilés 1997), and these reproductive traits, as well as egg volume, may not be influenced by weather conditions in temperate zones as has been shown in other species with similar distribution range (Nager and Zandt 1994, Corbacho *et al.* 1997). We found independence between egg dimensions of Rollers and weather conditions during egg-laying.

We did not observe any pattern in variation of egg volume in Roller through the season, although a clear seasonal decline in clutch size (rp = -0.57, P < 0.01, n = 710) as well as in productivity (rp = -0.44, P < 0.01, n = 710) were recorded for this species in the same area (Aviles *et al.* 1999) This perhaps indicates that as the breeding conditions worsen through the season, it is advantageous to maintain egg volume at the expense of clutch size.

Our results, however, show that there is no trade-off between the clutch size and egg dimensions of Rollers. Järvinen (1996) proposes that the correlation between these two variables varies annually in relation to climatic conditions, an so it can be no apparent in central regions of the distribution area of species from temperate regions. The independence between spring weather conditions and clutch size (Avilés 1997), and egg dimensions in our study, points out the lack of physiological constraints that would cause the trade-off between clutch size and egg dimension of Rollers in the Serena like in other species have been showed (Järvinen 1996).

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Riassunto - Le dimensioni delle uova della Ghiandaia marina *Coracias garrulus* sono state studiate nelle campagne dell'Extremadura nel 1989 e nel 1990. Le dimensioni tendono ao essere minore nel sud rispetto al nord Europa. Non sono state rilevate differenze dimensionali rapportabili agli anni. Le condizioni climatiche durante il periodo di deposizione delle uova noa influenzano la dimensione delle stesse. Non sono stati altresi osservate diminuzioni stagionali nelle dimensioni né una chiara relazione tra dimensioni delle uova e della covata.

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