Egg dimensions variation in relation to the laying order in Black Redstart (*Phoenicurus ochruros* Gmelin, 1774) in NW Croatia

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Egg size dimensions are generally held to be important indices of egg quality and correlate with chick survival in many bird species (e.g. MURTON, 1974; AMAT et al., 2001) (1) (2). Birds possess several mechanisms by which they can adjust the magnitude and pattern of their breeding effort to environmental conditions and their own breeding condition (SLAGSVOLD et al., 1984) (3). In birds, egg size varies with laying date (e.g. HILL, 1984) (4), female age (e.g. DESROCHERS & MCGRATH, 1993) (5), year (e.g. PERRINS, 1969) (6), seasonal variations (e.g. COULSON, 1963) (7), laying order (e.g. MURPHY, 1994) (8), female condition (e.g. HÕRAK et al., 1995) (9) and other factors. Different patterns of egg size versus laying order have been recognized, with egg size decreasing (e.g. HEEB, 1994; ERIKSTAD et al., 1998) (10) (11), increasing with each sequence (HAFTORN, 1986; ENEMAR & ARHEIMER, 1999) (12) (13) or unrelated (e.g. MITRUS & ROGALA, 2001; HARGITAI et al., 2005) (14) (15). SLAGSVOLD et al. (1984) (3) analysed intra- clutch variation in egg size in 67 bird species and identified two strategies : birds which lay relatively larger final eggs are adopting the 'brood survival strategy' (the last nestling is capable of rivalry with its older siblings), whereas birds which lay relatively small final eggs are adjusting to the 'brood reduction strategy' (the last nestling will be sacrificed in the event of food shortage).

This study has two tasks. First, to investigate the influence of laying order on egg dimensions and second, to calculate the deviation of the final egg from mean referred here as%D (according to SLAGSVOLD et al., 1984) (3).

Research took place in Hrvatsko Zagorje region (45º58' – 46º10'N, 15º50' – 16º08'E) in NW Croatia, in 2002 and 2004. Nests were visited daily during laying period. Eggs were marked with pens. All eggs were measured to the nearest 0.01 mm (maximum length and maximum breadth). Egg volume was calculated from the formula V 0.51 x L x B², where L is maximum length and B is maximum egg breadth (HOYT, 1979) (16). Egg shape index (ES) was calculated using the formula ES LENGTH / BREADTH. The relative size of the final egg laid (%D) was calculated according to SLAGSVOLD et al. (1984) (3) as the percentage deviation from the mean egg size of all the eggs in the clutch. Nests with abandoned clutches were excluded from analysis. As different internal and external factors can obscure a potential pattern of variation in egg size in relation to the laying sequence (BAÑBURA & ZIELIÑSKI, 1995) (17), this analysis includes only first clutches with 5 eggs where first eggs were laid within three-days period (from 13 to 15 April 2002 and from 19 to 21 April 2004). These two periods were in the middle of breeding season and were chose because most birds started their breeding in this period. The five-egg clutch is the dominant clutch size of the first clutch in the study area (DOLENEC, 1999) (18). Statistical analyses were performed using the SPSS 12.0 statistical package.

A total of 125 Black Redstart eggs from 25 clutches were used in the analysis. Basic egg characteristics are presented in Table 1. Both in 2002 (11 clutches) and 2004 (14 clutches) egg volume sequences were significantly concordant (Kendall`s coefficient of concordance : 2002, W = 0.326; ÷² = 14.427; df = 4; p = 0.006; 2004, W = 0.282; ÷² = 15.771; df = 4; p = 0.003) and correlations between egg volume and laying order were statistically significant (Pearson : 2002, r = 0.341; p = 0.011; 2004, r = 0.338; p = 0.004). By contrast, analyses for the egg shape index revealed statistically non-significant results (concordance : 2002, W = 0.159; ÷² = 6.982; df = 4; p = 0.137; 2004, W = 0.036; ÷² = 2.0; df = 4; p = 0.737)(Pearson : 2002, r = - 0.039; p = 0.779; 2004, r = 0.006; p = 0.925). For clutches with 5 eggs values of %D in 2002 and 2004 was 5.63 and 6.12 resp. To my knowledge, no other intraclutch egg dimensions (laying order and/or values of %D) data of importance have been published for this bird species. Following the arguments of Slagsvold et al., this Black Redstarts population therefore would adopt a 'brood survival strategy' where females allocate greater resources in the final eggs of the clutch which have a high reproductive value. This is consistent with the view put forward by HOWE (1976) (19) that larger egg size (weight or volume) represents parental effort to increase the survival chances of the late hatched young. A life-history framework adds an important dimension to the study of 'brood strategy', but also makes the task for field workers more complex (MOCK & FORBES, 1994) (20).

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TABLE 1

Egg dimensions of Black Redstart in 2002 and 2004. SD = standard deviation, n = number of clutches

Year	Length, mm		Breadth, mm		Volume, mm^3		Shape index		n
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
2002	18.98	0.81	14.53	0.55	2050.86	200.33	1.31	0.06	11
2004	19.45	0.79	14.46	0.52	2104.45	181.06	1.34	0.07	14

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