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Clutch and egg size variation in the coot *Fulica atra* breeding on fishponds in eastern Poland – test of the optimal egg dimensions hypothesis

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Abstract. Clutch and egg size variation of the coot, *Fulica atra*, was studied in eastern Poland from 2005 to 2008. The study areas were extensively managed fish farms in the Lublin region. A total 797 eggs from 106 clutches were measured during four nesting seasons. Mean clutch size was 7.52 ± 1.59 (range 5-14), modal clutch size was 7. Average values of the egg dimensions are as follows: egg length – 52.70 ± 2.33 mm, egg breadth – 36.52 ± 1.22 mm and egg volume 35.72 ± 3.44 cm^3. Egg dimensions were positively correlated. No significant differences in clutch and egg sizes during the four seasons were found. This suggests that the environmental conditions in the studied fishponds during the study period did not change or had no influence on egg size. There was no significant relationship between egg dimensions and clutch size and the study does not support predictions based on the hypothesis of optimal clutch/egg size.

Key words: *Fulica atra*, clutch size, egg size, breeding values.

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I. INTRODUCTION

In birds, egg size variation may be influenced by factors such as genotype, laying date, female age and condition, laying order, and ambient temperature just before laying (CUSTER & FREDERICK 1990; SWENNEN & VAN DER MEER 1992; BAŃBURA & ZIELIŃSKI 1995). Birds possess several mechanisms by which they can adjust the magnitude and pattern of their nesting effort to environmental and their own breeding condition (NAGER & ZANDT 1994; DOLENEC 2006). Intraspecific and intraclutch variation in egg size is of biological interest as egg size may influence the size of the nestling at hatching and its survival (BLACKBURN 1991; PROFUS et al. 2004). Bigger eggs contain more nutrients thus chicks from these eggs are larger, grow faster and show a higher survival rate than those from smaller eggs (MITRUS & ROGALA 2001). Some researchers have analysed the influence of several factors on clutch and egg size in the coot *Fulica atra* L. (SAGE 1969; RIZI et al. 1999; BRINKHOF et al. 2002; SAMRAOUI & SAMRAOUI 2007; RĘK 2010). The coot is a medium-sized rallid that breeds almost exclusively in flooded emergent vegetation in littoral eutrophic lakes, fishponds, river valleys, fen mires and other wetlands (CRAMP 1980). Coots are generally reported to nest on wet vegetation stands with rich food (plant or animal) resources (GLUTZ et al. 1981). Water plants and water animals constitute their main food (BOROWIEC 1975; STOCZKOWSKI & STAŃCZYKOWSKA 1995). Studies on the breeding biology of this species are desirable as a population decline has recently been reported in Poland (CEMPULIK & BETLEJA 2007).

The optimal egg dimensions hypothesis predicts a trade-off between the number and size of propagules produced (BLACKBURN 1991). The main aim of this study was to test this hypothesis and describe egg size in relation to season for the coot. This research is based on a large data set, including more than 100 nests found and monitored in nine extensively managed complexes of fishponds in eastern Poland.

II. MATERIAL AND METHODS

Fieldwork was carried out in the following fishpond complexes in eastern Poland: Chodel, Czesławice, Garbów, Kraśnik, Niedrzwica, Opole Lubelskie, Orlicz, Piaski, Samoklęski (Lublin region, N 50°55′-51º29′; E 21°58′-22º54′). Fishponds varied in size from 15 to 203 ha and were partially covered by vegetation stands dominated by the common reed *Phragmites australis*, the narrow-leaved cattail *Typha angustifolia* and sedges *Carex sp.* The water depth in emergent vegetation varied from 0 to 120 cm. Fish-rearing mostly involved the common carp *Cyprinus carpio* (95-100% in biomass) and was characterised by extensive management with occasional reed cuts. Management practices were similar for all study sites and the fish farms belonged to formerly state-owned fisheries. The ponds were similar in depth (from 0.7 m to 1.3 m), but they strongly differed in the coverage of emergent aquatic vegetation and in surface area. They were filled with water from adjoining rivers and streams and/or from atmospheric precipitation. The ponds were surrounded by arable fields, meadows and small villages and woodlots of different age.

The material was collected in 2005-2008. Birds occupied small, isolated patches of reed belt surrounding the fish ponds. Emergent vegetation growing on the studied fishponds was checked regularly (at least once a week) from the end of April to early July and nests were located by systematic walking through vegetation. A total of 106 nests with complete clutches were found. The length and breadth of each egg (n = 797) were measured with a calliper to the nearest 0.1 mm by the same person. Egg volume was estimated by the equation (HOYT 1979), volume = 0,000507*length*(breadth)^2. The nests were controlled during the whole breeding season. Only eggs from the first (no replacement) broods (found in the first half of the nesting period) and complete clutches (when all eggs were laid in the clutch) were included into analyses. The clutches were estimated as complete when the same number of eggs was found during two controls. The mean parameters of eggs from each clutch were used in order to calculate correlations between dimensions of eggs and to analyse the influence of some factors such as the clutch size or season. Statistical data processing was performed using the STATISTICA 6.0 package (STATSOFT Inc. 2001). The Kolmogorov-Smirnov test was used to test for statistical normality. In the analyses, ANOVA (for normally distributed data) or Kruskal-Wallis (for non-normal distributions) tests were applied. All tests were two-tailed. Data are presented as means ± SDs.

III. RESULTS

Coot clutches contained from 5 to 14 eggs (Fig. 1). Mean clutch size was 7.52 ± 1.59, modal clutch size was 7. No significant differences in clutch size between years were recorded (Kruskal-Wallis test, $H_{3, 106} = 3.65$, $P = 0.30$). Mean values of the egg dimensions were as follows: egg length – 52.70 ± 2.33 mm (n = 797), egg breadth – 36.52 ± 1.22 mm (n = 797) and egg volume 35.72 ± 3.44 cm^3 (n = 797). None of the egg dimensions (length, breadth and volume, respectively) differed signifi-

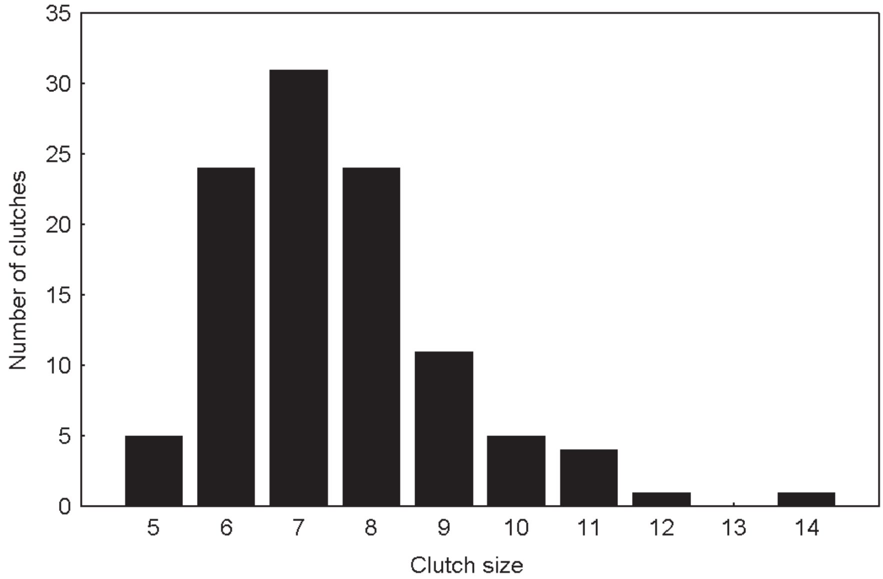

Fig. 1. Frequency distribution of clutch size in the coot population breeding on fishponds in Lublin region in 2005-2008 (n = 106).

cantly between years (ANOVA; $F_{3, 102} = 2.46$, $F_{3, 102} = 0.29$, $F_{3, 102} = 0.81$, ns). The correlation between length and breadth was highly significant (Pearson's correlation; $r = 0.58$, $p < 0.0001$, $n = 106$).

Egg dimensions (length, breadth and volume, respectively) did not depend on the clutch size (Fig. 2, ANOVA; $F_{6, 97} = 1.12$, $F_{6, 97} = 0.24$, $F_{6, 97} = 0.30$, ns).

IV. DISCUSSION

Life history predicts a trade-off between the number and size of propagules produced (BLACKBURN 1991; RĘK 2010). The results of this study and data from other studies (MITRUS & ROGALA 2001; DOLENEC et al. 2007; DOLENEC et al. 2008) do not support predictions based on the hypothesis of optimal egg dimensions concerning the negative relationship between clutch and egg size (BLACKBURN 1991). Some other researchers also found that clutch and egg size are independent of each other in several bird species (SURMACKI et al. 2003; ZDUNIAK & ANTCZAK 2003; PROFUS et al. 2004). This study indicates that there was no significant correlation between egg dimensions and clutch size in coot.

The clutch size recorded in the present study (5-14 eggs) falls in the range reported by other authors (SAGE 1969; CRAMP 1980; GLUTZ et al. 1981; RIZI et al. 1999; SAMRAOUI & SAMRAOUI 2007). It has been hypothesized that clutch size in this species increases with latitude (RIZI et al. 1999). Generally, average clutch size (7.5) on fishponds in eastern Poland was in the upper range compared to other areas. It was slightly smaller than those recorded in former Czechoslovakia and Germany (7.9; LELEK 1958 according to SAGE 1969; CRAMP 1980) and Latvia (7.6; CRAMP 1980), similar to the values reported in the Netherlands (6.9-8.0; BRINKHOF et al. 2002) and larger than the records obtained in UK (5.9; SAGE 1969), in Milicz in SW Poland (6.6-7.0; RĘK 2009), in northeast

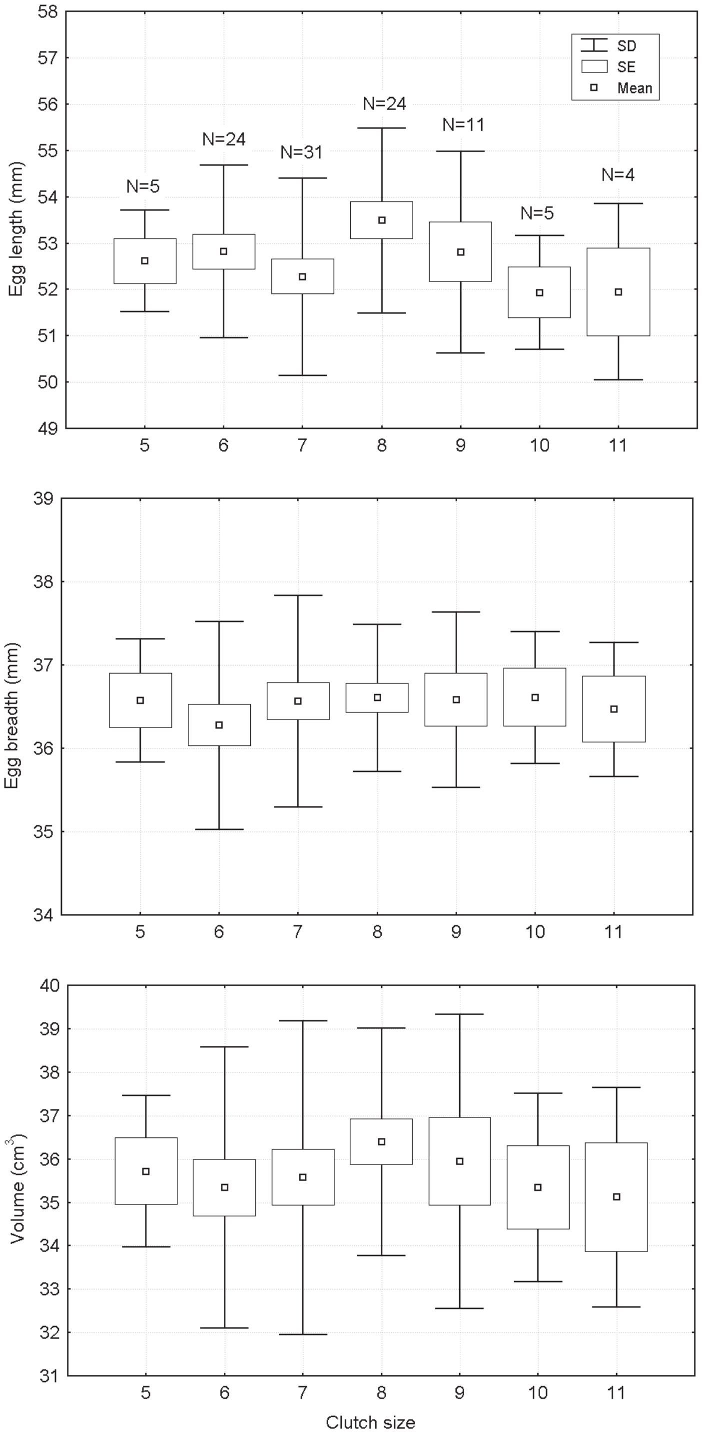

Fig. 2. Variation in egg dimensions with clutch size. Due to small sample size clutches containing 12 and 14 eggs were excluded.

Algeria (6.1-7.2; SAMRAOUI & SAMRAOUI 2007) and in Sweden (7.2; ASKANER 1959 according to SAGE 1969). The smallest clutches of 4.3 eggs were reported in northern Algeria (RIZI et al. 1999), corresponding to a latitudinal pattern of clutch size variation. However, SAMRAOUI and SAMRAOUI (2007) suggested that the pattern is more complex than just latitudinal, and probably related to relative food abundance between regions and/or habitats, or to the relative variation in food abundance among years within each site. These authors also indicated that conspecific brood parasitism (and supernormal clutches) may be confounding factors in analyses concerning geographic variation in clutch size.

Generally, between clutch differences in egg size are related to differences between females, which are in turn linked to individual or environmental conditions (NAGER & ZANDT 1994). Average egg size values (length, breadth, volume) found in this study were similar to those reported in other studies (CRAMP 1980; GLUTZ et al. 1981; RIZI et al. 1999; SAMRAOUI & SAMRAOUI 2007). The studied eggs of coots from eastern Poland were slightly larger than those noted in Lakes Oubeira and Tonga (northern Algeria, RIZI et al. 1999). Egg sizes were very similar to those from Timerganine pond (northern Algeria, SAMRAOUI & SAMRAOUI 2007). The results of this study indicated a correlation between egg dimensions. This finding seems to be a more general rule and was reported for many avian species (MITRUS & ROGALA 2001; ZDUNIAK & ANTCZAK 2003; PROFUS et al. 2004).

In the studied population there was no significant effect of year on clutch size and mean egg dimensions, although such effects have been found in other avian species (SWENNEN & VAN DER MEER 1992; SURMACKI et al. 2003). The results indicated stable environmental conditions throughout the studied seasons or no effect of this factor on egg size variation. On the other hand this may also indicate that phenotypic plasticity in egg size according to environmental conditions is relatively limited in the coot, maybe due to high heritability or a genetic component in egg size. The clutch size depends mainly on food conditions (LACK 1966) and hence, one can infer that food resources did not change much over this period. A lack of variation in egg size among years has also been reported in other bird species (NAGER & ZANDT 1994; MITRUS & ROGALA 2001; DOLENEC et al. 2007). However, some researchers indicated that the main source of variation is related to the population characteristics (CHARMANTIER et al. 2006). Recently, new evidence shows that changes over time even within a single population facing some environmental modifications, are the results of microevolution (i.e., genetic change) rather than a simple plastic response (see CHARMANTIER et al. 2006 for the mute swan *Cygnus olor*).

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