Acta zool. cracov. **43**(1-2): 165-169, Kraków, 30 July, 2000

Repeatability of size and shape of eggs in the urban Magpie *Pica pica* (Passeriformes: Corvidae) population

Leszek JERZAK, Marcin BOCHEŃSKI, Lechosław KUCZYŃSKI, Piotr TRYJANOWSKI

Received: 16 Dec. 1999
Accepted for publication: 24 Mar, 2000

JERZAK L., BOCHEŃSKI M., KUCZYŃSKI L., TRYJANOWSKI P. 2000. Repeatability of size and shape of eggs in the urban Magpie *Pica pica* (Passeriformes: Corvidae) population. Acta zool. cracov. **43**(1-2): 165-169.

Abstract. This study was conducted over four breeding seasons, 1986, 1987, 1998 and 1999 in Zielona Góra, western Poland. Repeatability patterns for length, breadth, volume index, and elongation index are presented (based on 234 Magpie eggs from 42 clutches). Mean repeatability estimates were 0.63, 0.59, 0.60, 0.64 for length, breadth, volume and elongation index, respectively. These data suggest that in the Magpie population in Zielona Góra variation between clutches both in the size and shape of eggs is dependent on the body condition and physiological limitations of the female.

Key words: Magpie, eggs, repeatability, female quality.

Leszek JERZAK, Marcin BOCHEŃSKI, Pedagogical University, Wojska Polskiego 69, PL 65-762 Zielona Góra.
e-mail: ljerz@lord.wsp.zgora.pl
Lechosław KUCZYŃSKI, Piotr TRYJANOWSKI, Institute of Environmental Biology, Adam Mickiewicz University, Fredry 10, 61-701 Poznań.
e-mail: ptasiek@main.amu.edu.pl

I. INTRODUCTION

The Magpie *Pica pica* (LINNAEUS, 1758) is a common bird in the Palearctic (GOODWIN 1986), which has been the subject of many biological, ecological and behavioural studies (see reviews in BIRKHEAD 1991, TROST 1999). There have been a number of papers concerning variation in egg dimensions but most of them concentrate on descriptions of egg size for specific populations (MAKATSCH 1976, SMETANA 1978, KELLER 1979, ARIAS DE REYNA et al. 1984, BIRKHEAD 1991). It is known, however, that eggs in a single clutch of any individual female may differ strongly (BIRKHEAD 1991). To date, there has been no quantitative description of the variation in egg dimensions within clutches. The best method of describing such variation is that of repeatability which is useful in separating the variation in egg dimensions within a clutch into its genetic and environmental components (BOAG & VAN NORDWIJK 1987, FALCONER1989 , BAŃBURA & ZIELIŃSKI 1998).

Both breeding success and egg size are correlated with many factors including female quality and territory quality. However, CLARKSON (1984) suggested that the strongest effect in the Magpie is the "female factor", although this is still not clear. Using the repeatability method arguments are put forward in favour of one of these hypothesis.

In the present paper are presented repeatability patterns for length, breadth, and derivatives of both, plus volume index and elongation index. Also presented are possible explanations of differences found between various eggs characteristics.

A c k n o w l e d g e m e n t s. Brendan KAVANAGH provided helpful comments on the manuscript and improved the English.

II. METHODS

This study was carried out during the breeding seasons of 1986, 1987, 1998, and 1999 in Zielona Góra, western Poland (51°56'N; 15°30'E). Details of the study area were described elsewhere (JERZAK 1995). A Magpie population has existed in Zielona Góra since at least the 1920's (GRUHL 1929) long before the more recent colonization of urban areas by this species (JERZAK 1995). The town is surrounded by forests, this reducing opportunities for contact with farmland populations. It may thus be concluded that the Zielona Góra Magpie population is an old urban population.

A total of 42 nests (6-19 per year) was examined. Only eggs from completed clutches were chosen for analysis (JERZAK 1995). Clutch size ranged from 2 to 8 eggs, with a mean ±SD of 5.6±1.4. Further details regarding the breeding biology and ecology of the studied population are available in KAVANAGH et al. (1992) and JERZAK (1995).

The maximum length and breadth were measured with sliding callipers to the nearest 0.1 mm. Two people (LJ, MB) were involved in the collection of measurements. The egg volume index (EV in cm^3) was calculated from the length (EL) and breadth (EB) using the formula $EV=0.5*EL*EB^2 / 1000$ (HOYT 1979, see also BIRKHEAD 1991). An index of egg elongation was calculated by dividing EL by EB. To avoid the problem of pseudoreplication, egg size was defined as the mean volume of all eggs laid in each nest (LESSELLS & BOAG 1987). The data from the four years were pooled.

A one-way analysis of variance (ANOVA) was carried out to obtain variance components. The repeatabilities were calculated as intra-class correlation coefficients (SOKAL & ROHLF 1995), applying the formula:

$$r = (MS_A - MS_W) / [MS_A + (n_o - 1) MS_W],$$

where MS_A is the between-groups (i.e. between-clutch) mean square, MS_W is the within-group mean square and n_o is a coefficient related to the sample size per group in ANOVA, given by:

$$n_o = 1 / (a-1) [\sum n_i - (\sum n_i^2 / \sum n_i)],$$

where n_i is the size in the i-th group and a is the number of groups (LESSELLS & BOAG 1987, FALCONER 1989). Standard errors for repeatability values were calculated as described in BECKER (1984).

III. RESULTS

A total of 234 Magpie eggs from 42 clutches were used in the analysis (Table I). None of the egg measurements were significantly correlated with clutch size ($p>0.2$ in all comparisons).

The smallest variability in clutch was observed for egg breadth, followed by egg length, and then elongation index. The largest variability was observed for egg volume. All differences in variability were statistically significant (ANOVA; $F_{3,164} = 32.01$; $p<0.0001$).

Significant differences in within-clutch variation between females were found for all egg dimensions (one-way ANOVA, Table II). Maximum differences of repeatability between measurements were 5%.

Table I

Ranges, means, and coefficients of variation (CV) for Magpie egg measurements from Zielona Góra, W Poland

Trait	Clutch mean (SD)	CV (clutch mean)	Range (clutch mean)	Range (all eggs)
Length (mm)	33.22 (1.75)	3.25	28.9-39.5	27.7-41.7
Breadth (mm)	23.02 (0.57)	1.73	21.2-25.3	21.2-25.3
Volume (cm^3)	8.81 (0.69)	5.24	6.74-10.6	16.34-11.23
Elongation index	1.44 (0.08)	3.48	1.34-1.73	1.27-1.83
n	42	42	42	234

Table II

Repeatability values (r) of length, breadth, volume and elongation index of Magpie eggs. Note: All *F* ratios (one-way ANOVA) are significant at $p < 0.001$

Trait	*F*-ratio	df	r	±95% CL
Length	10.45	41, 192	0.63	0.51-0.75
Breadth	9.01	41, 192	0.59	0.46-0.72
Volume	9.23	41, 192	0.60	0.47-0.72
Elongation	10.89	41, 192	0.64	0.52-0.76

IV. DISCUSSION

Evidence that egg size reflects female quality comes from the strong correlation between egg size and breeding success (CLARKSON 1984, BIRKHEAD 1991). At first sight this relationship suggests that egg size determines breeding success but it is unlikely that this is a causal relationship. It is much more probable that both breeding success and egg size are correlated with one or more other factors, such as female quality or territory quality.

The repeatability values obtained in this study supports the ‘female factor’ hypothesis as suggested by CLARKSON (1984). The repeatabilities for egg parameters of the Magpie are moderate to large (0.59 – 0.64) and are similar to values calculated for other passerines (BOAG & VAN NOORDWIJK 1987, BAŃBURA 1996). The levels of repeatability of all dimensions were similar and the 95% confidence limits do not contain zero. Unfortunately, there are no published data for repeatability of size and shape of eggs in other Magpie populations. The inference from all these facts is that egg measurements are characterized by a relatively low level of sensitivity to environmental impacts (OJANEN et al. 1979, VAN NOORDWIJK et al. 1981, LESSELLS et al. 1989, but see also POTTI 1993).

The high level of repeatability observed in the Zielona Góra Magpie population was a surprise, because earlier authors had described great variation in other populations even between clutches

(SMETANA 1978, KELLER 1979, ABDREIMOV 1981, KOSTIN 1983, BIRKHEAD 1991). The present authors conclude that the between-clutch variation observed in the Zielona Góra Magpie population with respect to size and shape of eggs was due to a combination of variation in the body condition and physiological limitations of the female.

A better strategy for birds may be to invest in a greater number of eggs or in more yolk and lipid components within the eggs rather than simply increasing the size of each egg. To test this first idea HOGSTED (1980) manipulated Magpie broods by adding or removing chicks. Regardless of their initial clutch size, pairs that were given additional chicks were less successful in rearing young. Indeed, the original clutch size laid by the females was the most productive one, as was observed in control clutches. HOGSTED (1980) then examined clutch size in relation to particular females and the territory in which they bred. He showed that most of the variation in clutch size could be attributed to differences in territory quality, only 14 % being attributable to differences between females. These results support the hypothesis that there is no single optimal clutch size, but a range of clutch sizes each adapted to the quality of a particular territory. A similar result had previously been obtained for great tits (PERRINS & MOSS 1975).

Earlier experiments were conducted on the effect of additional food on reproductive output in the Magpie (HOGSTED 1981, HOCHACHKA 1988). In many studies (HOGSTED 1981, CLARKSON 1984, HOCHACHKA 1988) the provision of additional food for breeding birds resulted in larger eggs showing that food availability can affect egg size. Chicks hatching from large eggs were heavier and structurally larger than those from smaller ones. BIRKHEAD (1991) found that egg size in the Magpie was not related to clutch size and territory quality had a negligible effect on breeding performance when compared with individual bird quality.

Young Magpies are altricial. They hatch blind and helpless and must be brooded by the mother almost continuously for the first 5-10 days of life. The yolk:albumen ratio is important for this kind of strategy. In the Magpie this is 0.23 (BIRKHEAD 1991), which is similar in other passerines. Yolk formation is energetically costly and time-consuming for the female. It takes 5-10 days of intensive foraging to accumulate sufficient reserves to form a clutch. Thus, the size of the yolk will be affected by the amount and quality of food that the female can obtain during the pre-laying period.

The Magpie population in Zielona Góra is a typical urban population (JERZAK 1995). Populations living in farmland may be subjected to more variable environmental conditions (EDEN 1985, JERZAK 1988, BIRKHEAD 1991). Research on repeatabilities of egg dimensions in other environments could make a useful contribution to the arguments as discussed in this paper.

REFERENCES

ARIAS DE REYNA L. M., RECUERDA P., CORVILLO M., CRUZ A. 1984. The reproduction of the Magpie (*Pica pica*) in Sierra Morena, Andalusia. Doñana, Acta Vertebrata, **11**: 79-92.

ABDREIMOV T. 1981. Birds of deserts and lowlands of Amu Daria. Publ. FAN, Uzbetskaya SSR, Tashkent. (In Russian with English summary).

BAŃBURA J. 1996. [Intra-population variability of egg measurements in the Barn Swallow *Hirundo rustica*]. Wyd. UŁ, Łódź. (In Polish).

BAŃBURA J., ZIELIŃSKI P. 1990. Within-clutch repeatability of egg dimensions in the Black-headed Gull *Larus ridibundus*. J. Orn., **131**: 305-310

BAŃBURA J., ZIELIŃSKI P. 1998. An analysis of egg-size repeatability in Barn Swallows *Hirundo rustica*. Ardeola, **45**: 183-192

BECKER W. A. 1984. Manual of quantitative genetics, 4th ed. Pullman: Academic Enterprises, WA.

BIRKHEAD T. R. 1991. The Magpies. T&AD Poyser, London.

BOAG P.T., VAN NOORDWIJK A. J. 1987. Quantitative genetics. [In:] P. A. BUCKLEY, F. COOKE (eds) – Avian Genetics. Academic Press, New York. Pp. 45-78.

CLARKSON K. 1984. The breeding and feeding ecology of the Magpie *Pica pica*. Unpubl. Ph.D. Thesis. University of Sheffield.

EDEN S. F. 1985. The comparative breeding biology of Magpies *Pica pica* in an urban and a rural habitat (Aves: Corvidae). J. Zool. (London), **205**: 325-334.

FALCONER D. S. 1989. Introduction to quantitative genetics, 3rd ed. Longman, London.

GOODWIN D. 1986. The crows of the world. British Museum, London.

GRUHL K. 1929. Tier- und pflanzenwelt des kreises Grünberg i. Schl. Levisohn u. sohn, Grünberg.

HOCHACHKA W. 1988. The effect of food supply on the composition of black-billed magpie eggs. Can. J. Zool., **66**: 692-695.

HOGSTED G. 1980. Evolution of clutch size in birds: adaptive variation in relation to territory quality. Science, **210**: 1148-1150.

HOGSTED G. 1981. Effect of additional food on reproductive success in the Magpie (*Pica pica*). J. Anim. Ecol., **50**: 219-229.

HOYT D. F. 1979. Practical methods for estimating volume and fresh weight of birds eggs. Auk, **96**: 73-77.

JERZAK L. 1988. Distribution and nest sites of magpie in non-urban habitats in Poland. Not. orn., **29**: 27-41. (In Polish with English summary).

JERZAK L. 1995. Breeding ecology of an urban Magpie *Pica pica* population in Zielona Góra (SW Poland). Acta ornith., **29**: 123-133.

KAVANAGH B., JERZAK L., GÓRSKI W. 1991. Factors affecting the breeding performance of the Magpie (*Pica pica*) in three European cities. [In:] J. PINOWSKI, B.P. KAVANAGH, W. GÓRSKI (eds) – Nestling mortality of granivorous birds due to microorganisms and toxic substances. PWN, Warszawa. Pp. 71-81.

KELLER M. 1979. Infrapopulational variability of egg-size of the magpie (*Pica pica*), song thrush (*Thurdus philomelos*), and great (*Parus major*) and blue tits (*Parus caeruleus*). Not. orn., **20**: 1-16. (In Polish with English summary).

KOSTIN Y. V. 1983. [Birds of Krimea]. Nauka, Moscow. (In Russian).

LESSELS C. M., BOAG P. T. 1987. Unrepeatable repeatables: a common mistake. Auk, **104**: 116-121.

LESSELLS C. M., COOKE F., ROCKWELL R. F. 1989. Is there a trade-off between egg weight and clutch size in wild Lesser Snow Geese (Anser c. caerulescens)? J. Evol. Biol., **2**: 457-472.

MAKATSCH W. 1976. Die Eier der Vogel Europas 2. Radebeul.

OJANEN M., ORELL M., VÄISÄNEN R. A. 1979. Role of heredity in egg size variation in the Great Tit *Parus major* and the Pied Flycatcher *Ficedula hypoleuca*. Ornis Scand., **10**: 22-28.

PERRINS C. M., MOSS D. 1975. Survival of young Great Tits in relation to age of female parent. Ibis, **116**: 220-224.

POTTI J. 1993. Environmental, ontogenetic, and genetic variation in egg size of Pied Flycatchers. Can. J. Zool., **71**: 1534-1542.

SMETANA N. M. 1978. [Ecology of Magpie at the Naurzumskom reservation (Northern Kazakhstan) during the incubation and nestling foraging period]. Biologiya ptits v Kazakhstani. AN Kaz. SSR. Alma-Ata. Trudy Inst. Zool., **38**: 20-28. (In Russian).

SOKAL R. R., ROHLF F. J. 1995. Biometry. 3rd edition. Freeman, New York.

TROST H. C. 1999. Black-billed Magpie. [In:] A. POOLE, F. GILL (eds.) – The Birds of North America, Philadelphia. PA. No. 389.

VAN NOORDWIJK A. J., KEIZER L. C. P., VAN BALEN J. H., SCHARLOO W. 1981. Genetic variation in egg dimensions in natural populations of the Great Tit. Genetica, **55**: 221-232.