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VARIATION IN EGG SIZE OF URBAN KESTRELS (STUDY IN WARSAW, POLAND)

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Abstract. During study on Kestrels' breeding biology conducted in Warsaw, Poland, 60 eggs were measured. The mean egg weight was 20.5 g ± 1.88, length was 39.5 mm ± 2.2, and breadth was 31.9 mm ± 1.4. Laying date was found to be a significant indicator for differences in egg characteristics. Eggs from clutches found in the central part of the city were similar in length, breadth and mean egg volume to those from the outskirts.

Key words: European Kestrel, *Falco tinnunculus*, Warsaw, egg volume, urban area.

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Варіація розміру яєць міського боривітра у Варшаві. - Рейт Л., Рачиньська М. - Беркут. 12 (1-2). 2003. - У 2002 р. в ході вивчення гніздової біології звичайного боривітра проміряно 60 яєць в 11 кладках. В середньому маса яєць була 20.5 г ± 1.88, довжина — 39.5 мм ± 2.2, ширина — 31.9 мм ± 1.4. Яйця, відкладені на початку гнізового періоду, були більшими у порівнянні з відкладеними пізніше. Не виявлено відмін у величині яєць між боривітрами з центральних та підміських зон.

INTRODUCTION

The Kestrel (*Falco tinnunculus*) is one of the few diurnal birds of prey to inhabit the urban environment (e. g. Brownά 1976). The breeding ecology of this species in the open landscape is well documented (e. g. Glutz et al.á 1971; Brown 1978; Dijkstra et al., 1982; Hasenclever et al., 1989; Village 1990; Meijer et al., 1992; Plesnik, Dusik 1994; Kostrzewa, Kostrzewa, 1997; Aparicio 1998 and others) in contrast to the few papers available on urban populations (Pikula et al., 1984; Plesnik 1986, 1990; Salvati et al., 1999a, 1999b). Kestrels have lived in the towns of Western Europe for over 100 years (Rejt, 2001b). They appeared in Warsaw (central Poland) in the 1970s (Luniak et al., 2002). Today, their expansion over central and eastern Poland is well documented (Rejt, 2001b). Studying the parameters of its breeding biology could provide answers to questions of whether the urban environment seriously affects the population of Kestrels.

This study tried to find a link between egg size and some other life history traits and breeding characteristics of urban Kestrels. Egg volume was the indicator used to compare eggs from clutches of different size, hatching success, laying date and nest location. Additionally, data collected in Warsaw was compared to data available from other European studies.

STUDY AREA, MATERIAL AND METHODS

The study was carried out in Warsaw (21°E 5°23'N), Poland, where there is a total of about 70 breeding pairs of Kestrels (Rejt, 2001a). The diameter of all eggs from complete clutches found within the city and available to researchers was measured 14–21 days after the first egg was laid. Maximum length and breadth of eggs were measured to the nearest 0.1 mm with a dial caliper. Eggs were weighed on an electronic TANITA 1475T scale (to the nearest 1g). Egg volume was calculated using Hoyt's equation (in Wiebe, Bortolotti, 1995):

$$\text{Volume } (mm^3) = \text{breadth}^2 \times \text{length} \times 0.51$$

Eggs in a clutch are not independent measurements (Wiebe, Bortolotti, 1995). But many previous studies used eggs rather than means from clutches so the same was done in the present study to allow the comparison of results with other research.

The area within a 10 km radius around the

Table 1

The characteristic of eggs collected in Warsaw in 2002
Характеристика яєць, зібраних у Варшаві у 2002 р.

Egg characteristic	Clutch size			
	3	5	6	7
Length (mm)	33.57 ± 3.33	39.81 ± 1.92	39.84 ± 1.62	39.39 ± 0.6
Breadth (mm)	29.13 ± 0.42	31.59 ± 1.31	32.32 ± 1.23	33.09 ± 0.99
Egg volume (cm^3)	1.4 ± 0.19	2.0 ± 0.25	2.1 ± 0.22	2.2 ± 0.15
N eggs measured	3	26	24	7

central point of Warsaw was designated the central part of the city (C). The area beyond this 10 km radius was called "external" (Ex).

The nests were categorized by clutch size, hatching success and location within the city. 35 nests whose eggs were measured were divided into two groups by size of the nest cavity: small (< 1100 cm^2, n = 16 nests) and large (> 1100 cm^2, n = 19).

Those clutches laid before mid-April were defined as early.

RESULTS

In 2002, the length and breadth of 60 eggs (from 11 full clutches) were measured. A total of 57 eggs were weighed. There was one clutch containing 7 eggs, five with 6 eggs, four with 5 eggs, and one containing 3 eggs. Most of the clutches (n = 7) were found in the central zone of the city. Among the clutches studied, all the eggs hatched in 8 cases. In 3 nests hatching success varied from 0 % (one abandoned nest) to 80 %.

The mean weight of an egg was 20.5 g ± 1.88, mean length – 39.5 mm ± 2.2 and mean breadth – 31.9 mm ± 1.4. Deviations from the mean length and breadth of eggs laid in 5- or 6-egg clutches did not exceed 1 % and for the 7-egg clutches – 4 %. Deviations from the mean of 15 % in length and 9 % in breadth occurred only in 3-egg clutches. By comparing mean egg volume from different clutches it was seen that as the number of eggs in a clutch increased, so did egg volume. The volume of eggs from 3-egg clutches was about 30 % less than the mean volume of all the eggs. The volume of eggs from 7-egg clutches was about 7 % greater. The difference between the mean volumes of eggs from 5- and 6-egg clutches reached 4 % and was not statistically relevant (t-Student test, $t = -1.40$, $n_1 = 26$, $n_2 = 24$). Eggs from both these groups differed only in breadth: eggs from 5-egg clutches were narrower (t-Student test, $t = -2.02$, $n_1 = 26$, $n_2 = 24$) (Table 1).

Eggs from earlier clutches were significantly broader than eggs laid later in the season (t-Student test, $t = 3.85$, $n_1 = 38$, $n_2 = 22$). Egg volume was also significantly higher in the earlier clutches (Cochran-Cox test, $c = 3.02$, $n_1 = 38$, $n_2 = 22$). Differences in length were not statistically significant (t-student test, $t = 0.33$, $n_1 = 38$, $n_2 = 22$) (Table 2).

Eggs from clutches with 100 % hatching success were significant broader than those from clutches with partial hatching success (t-Student test, $t = 2.9$, $n_1 = 46$, $n_2 = 14$). They were also bigger (t-Student test, $t = 2.16$, $n_1 = 46$, $n_2 = 14$). Egg length in these two groups did not different significantly (Cochran-Cox test, $c = 0.54$, $n_1 = 46$, $n_2 = 14$) (Table 2).

In nests considered "big" (n = 6) eggs were significantly shorter (Cochran-Cox test, $c = -2.1$, $n_1 = 32$, $n_2 = 25$), narrower (t-Student test, $t = -4.91$, $n_1 = 32$, $n_2 = 25$) and smaller (Cochran-Cox test, $c = -4.43$, $n_1 = 32$, $n_2 = 25$) in comparison to eggs from "small" nests (n = 4) (Table 2).

Eggs from clutches found in the central part

Table 2

The characteristic of Kestrels eggs in Warsaw according to several factors
LT – laying time, HS – hatching success, NL – nest location, NS – nest space, C – center, Ex – suburbs. For estimation of early and late laying dates as well as definition the big and small nest spaces see Methods.
Характеристика яєць боривітра у Варшаві за рядом факторів

Egg characteristic	LT		HS		NL		NS	
	early	late	100 %	partly	C	Ex	big	small
Breadth (mm)	32.4 ± 1.4	31.1 ± 1.1	32.2 ± 1.3	31.0 ± 1.6	32.0 ± 1.2	31.6 ± 1.9	31.4 ± 1.2	32.5 ± 1.5
Length (mm)	39.5 ± 2.4	39.3 ± 1.9	39.6 ± 1.6	39.0 ± 3.6	39.2 ± 1.3	39.9 ± 3.4	39.4 ± 2.0	39.5 ± 2.5
Egg volume (cm^3)	2.1 ± 0.3	1.9 ± 0.2	2.1 ± 0.2	1.93 ± 0.3	2.0 ± 0.2	2.0 ± 0.4	2.0 ± 0.2	2.1± 0.3
N eggs measured	38	22	46	14	40	20	32	25

of the city were similar in breath (Cochran-Cox test, c = 0.96, $n_1 = 40$, $n_2 = 20$), length (Cochran-Cox test, c = –0.86, $n_1 = 40$, $n_2 = 20$) and mean egg volume (Cochran-Cox test, c = 0.08, $n_1 = 40$, $n_2 = 20$) to those from outskirts (Table 2).

DISCUSSION

Generally, European Kestrels' eggs seem to vary little in size by region (e. g. Cramp, 1980). However, some significant differences were found. For instance, eggs from Scottish populations were significantly longer and broader in comparison with English ones (Village, 1990). Pikula et al (1984) found similar phenomena when comparing urban and rural populations. In each case the larger eggs were from populations that laid earlier and had larger clutches (Village, 1990). The results obtained in Warsaw were generally similar to those collected by other authors working on Kestrels and other falcons. Ratcliffe (2000), for instance, found no evidence of geographical variation in Peregrines' (*Falco peregrinus*) egg shape between different regions of Britain and Ireland. This also was confirmed by most of the data collected by Village (1990) on Kestrels. The mean parameters of eggs studied were very similar to those from other parts of Europe – especially those obtained from Central Europe, Germany, and the Czech Republic (Table 3). Eggs collected in Warsaw seemed to be significantly shorter only in comparison with those collected in Scotland and Southern Europe. Eggs from Warsaw were also slightly narrower than those from Belarus (Table 3).

The length and breadth of the eggs measured in Warsaw have included some of the lowest and highest measurements collected thus far (see Village, 1990, for references). Such a wide range is probably due to the sample size. However, it could also be caused by other factors. In runs of clutches from different Peregrine females over several years, a consistent tendency was found for the average size of an egg to become smaller in each clutch with time (Ratcliffe, 2000). It is also known that there is a high rate of reoccupation in towns, that is, when pairs occupy the same nest site in consecutive years (Plesnik, 1985; Salvati et al., 1999b). This phenomenon also was observed in Warsaw (Rejt, 2000b). It is possible that part of the city population is composed of older birds that have inhabited the area for several years. On the other hand, there were many one-year old Kestrels breeding in 2002 (own data), which could have laid larger eggs. These two factors together, and the fact that in urban area Kestrels were said to lay larger eggs, (what could be due to laying date, see Pikula et al., 1984) could explain such a wide differentiation in the shape of the eggs measured. It

Table 3

Parameters of Kestrels eggs in Europe and Siberia
Data from: Village (1990)[1], Hasenclever et al. (1989)[2], Cramp (1980)[3], Nikiforov et al. (1989)[4], Pikula et al. (1984)[5], Zubarovskiy (1977)[5], present study[7], oological collection of Museum & Institute of Warsaw (1867–1868)[8]. Ranges, if available are given in parentheses; N – number of eggs measured; * – sample size n = 57, ** – sample size n = 40 (only unhatched eggs).
Параметри яєць боривітра з Європи і Сибіру

Location	N	Length [mm]	breadth [mm]	weight [g]
C. Europe[1]	306	39 (34–43)	31 (29–34)	–
W. Europe[1]	51	39 (36–43)	32 (30–33)	–
S. Europe[1]	40	40 (37–42)	32 (30–34)	–
Britain[1]	100	40 (35–44)	32 (30–34)	–
Scotland[1]	73	41 (37–44)	32 (29–34)	–
England[1]	133	40 (35–43)	32 (29–34)	–
Belgium[3]	21	–	–	20 (17–22)
E. Germany[1]	258	39	31	–
W. Germany[2]	1054	39.6 (32.0–45.4)	31.9 (24.5–35.2)	–
Czech Republic[5]				
– urban	197	39.9 (36–45)	31.9 (29–35)	21
– rural	369	39.5 (35–44)	31.7 (29–35)	–
C. Poland[7]	60	39.5 (31.4–44.5)	31.9 (28.8–35.8)	20.5* (17–23)
Belarus[4]	64	39.3 (34.5–42.5)	30.8 (28.4–32.9)	20
Ukraine[6]	389	39 (35.6–43.5)	31.5 (28.7–34)	20.9** (17.5–24.2)
Siberia[8]	16	38.9 (36.5–41.6)	31.6 (30.1–34.2)	–

was also found that over 80 % of the clutches in Warsaw contained at least 5 or 6 eggs (own data). This factor could also affect egg shape, above all length, as stated by Village (1990) for the Common Kestrel or Wiebe and Bortolotti (1995) for the American Kestrel (*Falco sparverius*). A comparison between rural and urban populations done by Pikula et al. (1984) showed a significant difference in egg volume between two study plots was found – both the length and breadth of eggs was greater in the urban population.

In Warsaw, as in other urban studies (e. g., Pikula et al., 1984), there were no significant differences between egg width and length and the size of a complete clutch. However, in study on the American Kestrel done by Wiebe and Bortolotti (1995) a significant difference in mean egg volume among clutches of different sizes was found. Egg volume increased from clutches of three to clutches of five, and then declined in clutches of six. Egg breadth was found significantly different among clutches – eggs from five-egg clutches were wider. But during present study no reliable comparison can be made between eggs from clutches of different size because of the small sample size.

Pikula et al. (1984) in his study of the Eurasian Kestrel, as well as Wiebe and Bortolotti (1995) in their study on American Kestrel could not detect a relationship between laying date and egg size – both length and breadth. But egg size may vary with laying date if the food supply for females changes seasonally (Pikula et al., 1984; Village, 1990; Wiebe, Bortolotti, 1995). However, for the American Kestrel, great differences in food supply among years most probably leads to differences in clutch size rather than egg size (Wiebe, Bortolotti, 1995). Similar data was collected in

experiments using supplementary food (Soler, Soler, 1996). In Warsaw, contrary to previously cited studies, eggs from earlier clutches were larger. The results obtained in Warsaw support statements about the influence of the laying date on egg size. Zieliński and Bańbura (1998), for instance, stated that egg length was positively correlated with laying date in the Barn Swallow (*Hirundo rustica*). Pikula et al. (1984) suggested that differences in egg dimensions, if occurred, could be due to the proportion of older females to younger ones. It is known that older females reproduce earlier than younger (e. g., Newton 1979).

Wiebe and Bortolotti (1995) stated that eggs from clutches with 100 % hatching success had a higher mean egg volume when compared to those with partial hatching success or complete hatching failure. Pinowska et al. (2002) found that eggs in fully hatched clutches of the Tree Sparrow (*Passer montanus*) were broader than eggs containing dead embryo or infertile ones. The results obtained in Warsaw, despite small sample size, support these findings.

It was also interesting to find that eggs laid in larger cavities were significant narrower, shorter and had lower egg volume in comparison to those from smaller cavities. Data collected in 2002 also showed that Kestrels laid slightly more eggs in smaller nests (own data). This statement is contrary to the findings of other studies. For several hole-nesting species, studies documented larger clutches in larger cavities in both nest boxes (e. g. van Balen 1984; Rendell, Robertson, 1993; Stewart, Robertson, 1999) and tree holes (e. g. Rendell, Roberts, 1989). Also, for some species, large clutches observed in nest boxes compared with natural tree-holes have been attributed to the larger size of nest boxes compared with the average size of natural cavities (e. g. Nilsson, 1984; Robertson, Rendell, 1990). But among clutches used in the present analysis, early clutches predominated in broods from small cavities (known to be bigger in comparison to late clutches). Why were bigger eggs laid in small cavities? Is earlier laying only possible explanation? It is difficult to answer this question based on the data from such small sample size. A larger sample size may allow to focus this question.

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