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VARIABILITY OF CLUTCH SIZE IN CORMORANT (*PHALACROCORAX CARBO SINENSIS*) AT THE JEZIORSKO RESERVOIR (CENTRAL POLAND) IN 2004

Abstract: The analysis of the clutch size variability in Cormorant (*P. carbo sinensis*) was based on study results in colony at the "Jeziorsko Reservoir" (central Poland) in 2004. There were used 328 broods controlled 3–5 times in the season. Number of eggs in a single clutch ranged from 1 to 7, although Cormorants mostly laid 3 to 5 eggs. Mean clutch size was 3.80 (SD = 1.00). The size of clutch depended on time of laying eggs and the part of colony where the nest with brood was localised. The clutch size was bigger for pairs that started laying eggs earlier and lower for birds bred in the part of colony where the number of nests and their density were low.

Key words: clutch size, Cormorant, central Poland

1. INTRODUCTION

Clutch size is one of the primary parameters studied in bird breeding ecology. Studies focused on its variability and factors shaping this variability are numerous and multi-dimensional (e.g. LACK 1954; PERRINS 1965; PRICE, LIOU 1989 and many others).

Recently, there is a constant increase in interest shown in the issues concerning Cormorant (*Phalacrocorax carbo*), a species which considerably interfere with human's fishing industry (e.g. VAN EERDEN et al. 1995; CARSS et al. 2003). With regard to this matter, researches allowing to objectively estimate the influence exerted by this rapidly expanding species on the ecosys-

tem, seem to be particularly vital. However, if intended to be reliable, such investigations have to reveal sufficient complexity and include several aspects of Cormorant's population ecology. Study of elementary breeding parameters is of utmost importance among them.

During the last 50 years, the size of Cormorant's breeding population, its trends and dynamics were subjected to a thorough examination (e.g. LINDELL et al. 1995; MELLIN et al. 1997; PRZYBYSZ 1997; PRZYBYSZ et al. 1997; MELLIN, MIROWSKA-IBRON 2003). Despite the postulate of performing such detailed investigations also in Poland (STEMPNIEWICZ et al. 1998), data concerning breeding parameters of Cormorant is still not abundant. This shortage of information is straightly connected with frequent inaccessibility of nests, which in case of Cormorant subspecies *P. carbo sinensis* breeding in Poland, are usually located high in the tree crowns. In consequence, obtaining any extensive data about clutch size presents a special difficulty. In Poland, such broad material was collected only in one maritime colony in Kąty Rybackie at the Gulf of Gdańsk (KOPCIEWICZ et al. 2003). The occurrence of Cormorant breeding colony in the middle part of the country is a relatively recent phenomenon. Its breeding attempts in this region were observed only since the 80s of XX century (JANISZEWSKI et al. 1991; TOMIAŁOJĆ, STAWARCZYK 2003). Nevertheless, the majority of recorded colonies occurred to be impermanent. The only big and stable colony is located at the Jeziorsko reservoir (JANISZEWSKI et al. 1998; OSIŃSKA, JANISZEWSKI 2006). The aim of this paper is to describe variation of clutch size in Cormorant (*P. carbo sinensis*), breeding in this colony in 2004.

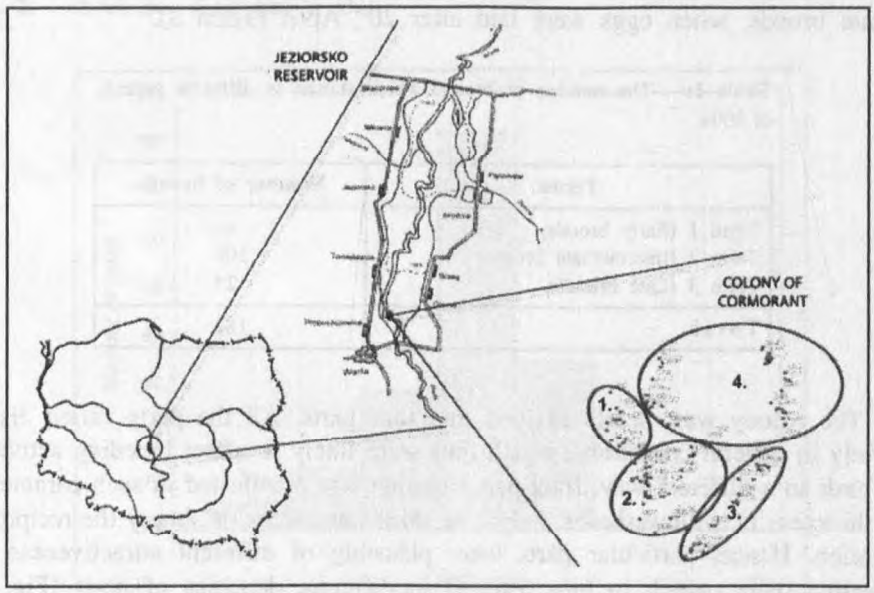
2. MATERIALS AND METHODS

Research was conducted in the colony of Cormorant, located in the 'Jeziorsko Reservoir' natural reserve, which forms the southern part of water body of the same name. Jeziorsko reservoir was constructed on the river Warta at the border between provinces of Łódź and Poznań (Fig. 1). Official exploitation of the reservoir started in the autumn of 1986. Water surface area equals 42 km^2 during the maximum water level, whereas during minimum level it does not exceed 18 km^2. Reservoir is 16,5 km long and 1.8–3.5 km wide (ORŁOWSKI 1994).

"Jeziorsko Reservoir" natural reserve is not only an important breeding area for plenty of bird species, but it is also exploited by seasonal migrants as

a suitable foraging and stop-over site (JANISZEWSKI et al. 1998; OSIŃSKA, JANISZEWSKI 2006). Cormorant's colony at the reservoir was first recorded in 1991. In 2004, the colony was set in the proximity of Mikołajewice village (51°73'N 18°63'E), next to the former Warta riverbed. It was located in the willow thicket, mainly consisting of White Willow (*Salix alba*) and Grey Willow (*Salix cinerea*). Willows in the colony were predominantly of the shrub-type, only the minor fraction was comprised of medium high trees (up to 15 meters). The whole territory of the colony was severely sectioned by the web of channels and pools. In 2004 approximately 410 pairs of Cormorant bred in the colony.

Fig. 1: Jeziorsko Reservoir with location of Cormorant (*P. carbo sinensis*) colony, and its structure (four distinctive parts) as GPS view



Material was gathered in the colony of Cormorant at the "Jeziorsko Reservoir" natural reserve during year 2004. Colony was controlled once a week in the period between the middle of March and July. Checks of the nest content were regularly performed during every control. Dates of nest checking were precisely fixed in order to maximize accuracy of egg laying onset and clutch size estimations. Therefore, nests were checked both during the building phase, as well as later, during the incubation and offspring upbringing period. Every nest was individually marked. Nest controls were carried out either directly from a ladder or with a mirror attached to the top of 4 meter high stick. The

most inaccessible nests were observed from neighbouring trees through binoculars. Relatively low location of nests in the colony (ranging from 2 to 9 meters high) permitted successful controls of almost all of them.

Approximate dates of onset of breeding were estimated during a few subsequent checks. In many cases, it was possible to define exact day of laying the first egg on the basis of two consecutive controls, provided the clutch was incomplete during the first of them. If such information was lacking, the evaluation was based on the size and the level of development of nestlings, assuming the incubation period to last for ca 4 weeks (SNOW, PERRINS 1998). Eventually, broods were divided into three categories (Table 1):

- early broods, when eggs were laid in the last decade of March (Term 1),
- intermediate broods, when eggs were laid between 1st and 20th April (Term 2),
- late broods, when eggs were laid after 20th April (Term 3).

Table 1: The number of broods which started in different periods of 2004

Terms	Number of broods
Term 1 (Early broods)	49
Term 2 (Intermediate broods)	109
Term 3 (Late broods)	24
Total	182

The colony was clearly divided into four parts. All the parts varied distinctively in general conditions, which thus were likely to affect breeding activities of birds in a different way. Inter-part variation was manifested in such parameters as thickness of willow shrubs, height of shrubs and trees or simply the reciprocal location. Hence, particular parts were plausibly of different attractiveness for breeding pairs, which in turn resulted in different densities of nests (Fig. 1). Four distinctive parts of the colony were marked out:

1. A part with diverse height and low density of nests. Thickness of willow shrubs also low.
2. A part with maximum density of nests, which were located low in the trees. Thickness of willow shrubs medium, majority of shrubs dried up.
3. A part with nests frequently placed high in the tree crowns. Such location precluded some of broods from regular controls. Thickness of shrubs medium.
4. A part separated by water channels from the rest of colony. Density of nests and thickness of shrubs diverse. Some of nests also not possible to be checked.

Comparisons between egg numbers laid in different parts of colony and during different periods were performed on the basis of variance analysis (ANOVA I) and Tukey test.

3. RESULTS

Number of eggs in a single clutch of Cormorants breeding at Jeziorsko reservoir in 2004 ranged from 1 to 7 (Fig. 2, Table 2). Nevertheless, on average, a clutch consisted of 3 to 5 eggs and the cases of bigger clutches were extremely rare – only four ones recorded in 2004.

Fig. 2: Clutch size distribution in 2004

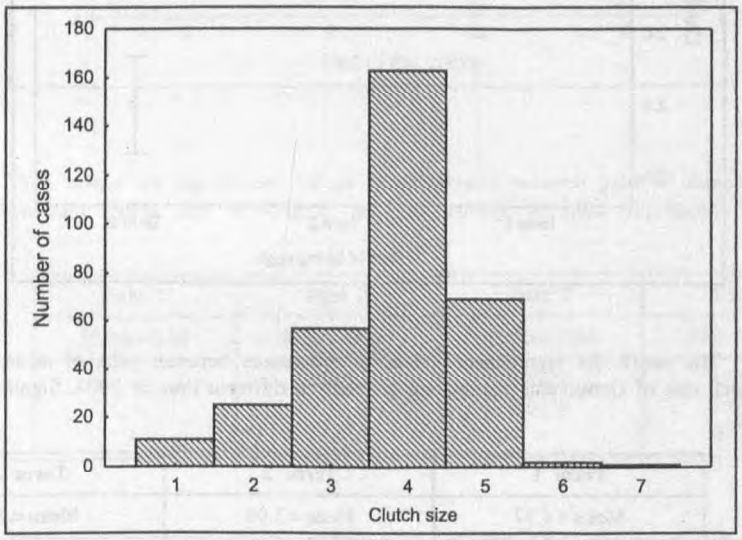


Table 2: The characteristics of distribution of eggs' number per clutch in 2004

N	Mean	SD	Skewness	SE skewness
328	3.80	1.00	–0.750	0.135

We found significant differences in the mean egg numbers laid in the successive terms of the breeding season ($F_{2;179}=40.234$, $P<0.0001$). Pairs which started laying eggs earlier had bigger clutches in comparison with those which started later (Fig. 3, Table 3).

Fig. 3: Number of eggs in three groups showing different times of breeding onset in 2004. Circles are means, error bars are 1.96 SE

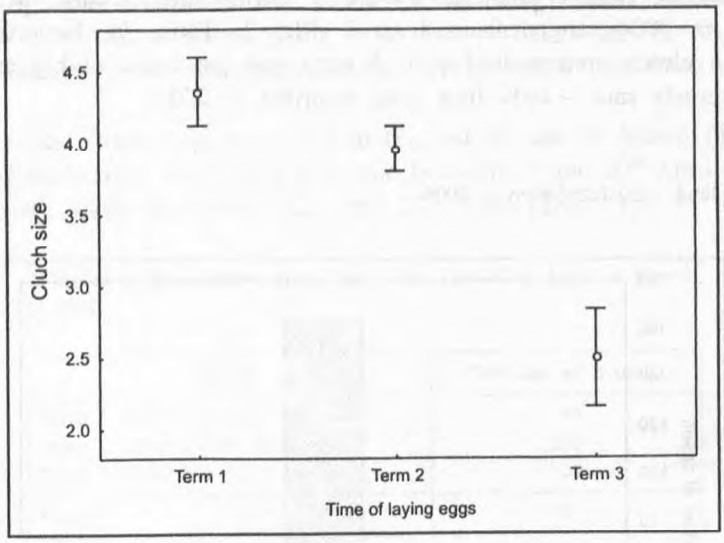


Table 3: The matrix for significance values of differences between pairs of means in Tukey test for clutch size of Cormorants that started to breed in different time in 2004. Significant values are in bold

	Term 1	**Term 2**	**Term 3**
	Mean = 4.37	Mean = 3.96	Mean = 2.5
Term 1	–	**0.0488**	**0.0000**
Term 2	–	–	**0.0000**

The results of analysis of mean clutch size diversity in relationship with the part of colony in which the brood took place are presented in Fig. 4 and Table 4. It was shown that clutch size is dependent on the nest location ($F_{3;324}=7.705$, $P<0.008$), since Cormorants breeding in the Parts 2 and 3 laid significantly more eggs than those from Part 1. Birds from Part 4 on average laid intermediate number of eggs, which did not differ significantly from clutch sizes recorded in the other parts.

Fig. 4: Numbers of eggs recorded in the four parts of colony (see Fig. 1). Circles are means, error bars are ±1.96 SE

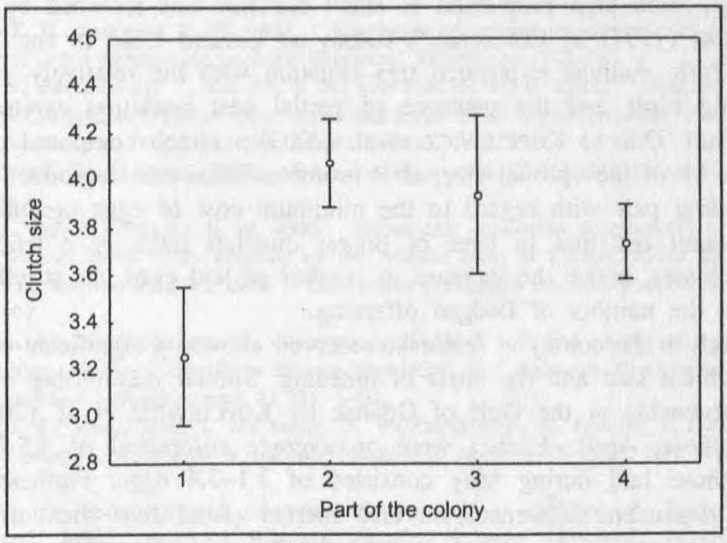


Table 4: The matrix for significance values of differences between pairs of means in Tukey test for Cormorant clutch size in different parts of colony in 2004. Significant values are in bold

	Part 1	**Part 2**	**Part 3**	**Part 4**
	Mean = 3.26	Mean = 4.08	Mean = 3.94	Mean = 3.74
Part 1	–	**0.0006**	**0.0227**	0.0973
Part 2	–	–	0.9418	0.0586
Part 3	–	–	–	0.8391

4. DISCUSSION

Clutch size is one of the major factors, which determine potential reproductive capability of the species. Analysis of this parameter did not reveal any significant difference between investigated colony and most of other European colonies. Similarly to other researches, clutches of 3 to 5 eggs were principally predominant at Jeziorsko reservoir, with clutches consisting of 4 eggs recorded most frequently. Such distribution of clutch sizes is known to be typical of Cormorants. Consequently, the clutches of 1–2 or 6–7 eggs were noted only sporadically (DEBOUT et al. 1995; van DAM, ASBIRK 1996; PRZYBYSZ 1997;

KOPCIEWICZ et al. 2003). Nevertheless, the clutches of 1 or 2 eggs are exceptionally found to comprise a considerable fraction of all the broods in the colony. Such high proportion of small clutches was recorded by PAJKERT and GÓRSKI (1997) in Cormorant's colony at Gardno Lake in the Słowiński National Park. Authors explicated this situation with the relatively young age of breeding birds and the presence of partial nest predation exerted by the Herring Gull. Due to KOPCIEWICZ et al. (2003) a clutch composed of 4 eggs appears to be of the optimal size, as it promotes maximum reproductive output of a breeding pair with regard to the minimum cost of eggs production. The authors found out that in case of bigger clutches there is a tendency for increased losses, hence the increase in number of laid eggs has strictly limited impact on the number of fledged offspring.

Research in the colony at Jeziorsko reservoir showed a significant correlation between clutch size and the onset of breeding. Similar relationship was found in Kąty Rybackie at the Gulf of Gdańsk by KOPCIEWICZ et al. (2003). Due to the authors, April clutches were on average comprised of 3.5–3.8 eggs, whereas those laid during May consisted of 3.1–3.4 eggs. Furthermore, not only time dependent differences, but also internal spatial diversification in clutch size was observed in the colony at Jeziorsko reservoir. Generally, the smallest clutches were found in Part 1, while the biggest ones in Parts 2 and 3. In Part 1 the number of nests and their density were relatively low, which implies that this area was rather suboptimal for breeding. Similar diversification was observed in Kąty Rybackie, where the smallest clutches were laid in the newly established part of colony, which was formed by relatively few nests (KOPCIEWICZ et al. 2003). On the one hand, such differences could be explained by different quality of birds, which breed in certain parts of colony. This could be manifested for example by various age, experience or condition of individuals. Beyond a doubt, there is a competition for breeding sites taking place within colony (BIRKHEAD, FURNESS 1985). Individuals of higher status are capable of occupying optimal places for breeding, whereas birds of lower status have to accept the suboptimal ones. Moreover, intrinsic features of bird mates, such as age, are likely to exert considerable influence on clutch size (CLUTTON-BROCK 1988). On the other hand, the differences can be caused by lower risk of predation in more densely inhabited parts of colony. Taking into consideration predator's traces left on the shells of destroyed eggs, tree-dwelling mammals are plausibly responsible for significant fraction of losses at the incubation stage in colony at Jeziorsko reservoir. Observations suggest that these are particularly Beech Martens (*Martes foina*), which were repeatedly noticed in the colony and even a litter was once found in the old Cormorant's nests. It cannot be excluded that martens are unable to successfully cope with robbing eggs in case of close presence and aggressive behavior of several adult Cormorants.

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