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# Reproductive parameters of Caspian Gull *Larus cachinnans* Pallas, 1811 in different habitats nearby and away fish ponds

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ABSTRACT

Reproductive performance of gulls depends on a variety of factors, but food abundance and its availability are among the most important. Clutch and egg sizes in gulls are found to be strongly influenced by food availability, thus better reproductive performance in the colony with greater fish availability (near fish ponds) was expected in that study. We compared the reproductive traits (clutch size, volume of eggs in the full clutch, relative volume of the C-egg (the third egg in gull's clutches) and hatching success) of Caspian Gull *Larus cachinnans* in five inland colonies in Poland located at a gravel pit, a lake, a river and two dam reservoirs. Differences in the clutch size between sites were found, with the lowest at a lake. We found similar clutch volume in all studied colonies. C-eggs were slightly smaller than A- and B- eggs, in all colonies and all study years, but the relative volume of C-egg in colonies located near fish ponds (<10 km) was significantly greater compared to colonies located far away. This may be explained by high fish availability in fishponds in comparison to other habitats. However hatching success (the ratio of the number of hatched chick to the number of eggs laid) was highest in the colony at the lake. This indicates that both inland habitats a gravel pit and a lake offered good food conditions for large gulls when fish ponds are nearby.

## INTRODUCTION

The Caspian Gull *Larus cachinnans* is a large gull species expanding its distribution range and increasing in numbers in central Europe and particularly in Poland in recent years (Snow and Perrins 1998, Tomiałojć and Stawarczyk 2003, Neubauer *et al.* 2006, Lenda *et al.* 2010). Due to the ongoing colonisation, breeding colonies of large gulls (Caspian, Herring *Larus argentatus*, Yellow-legged *Larus michahellis*) are now found in different inland habitats in Poland as islands on rivers, natural lakes, gravel pits, dam reservoirs, fish ponds, or sedimentation basins (Tomiałojć and Stawarczyk 2003). Ten of 30 inland colonies of large gulls were located on fish ponds or near fish ponds (Tomiałojć and Stawarczyk 2003, Sikora *et al.* 2007), which indicates the importance of this foraging habitat for breeding birds. Although large gulls are considered food opportunists, the availability of fish – their basic food – may constitute the key factor responsible for high reproductive performance and in consequence, successful colonisation of inland areas by these birds (Hüppop and Hüppop 1999, Skórka *et al.* 2005). Hüppop and Hüppop (1999) suggested that the inland breeding distribution of Herring Gull (species closely related to Caspian Gull) in Central Europe is limited by the availability of fish during the breeding season rather than by the availability of household refuse or by the lack of breeding habitats. It appeared that the occurrence of food-rich foraging areas

like fish ponds, had a crucial effect on gull's diet (Gwiazda *et al.* 2011). Both, the abundance and the availability of fish is high in fish ponds, so foraging of large gulls in this habitat is more effective and requires less energetic costs than foraging in other habitats. Moreover fish ponds are attractive foraging places because of their low depth, high fish density and fish of similar size – particular cohorts in separate ponds (Gwiazda 2010). The higher share of fish in a diet of large gulls breeding near fish ponds compared to colony away fish ponds in Poland was reported previously (Gwiazda *et al.* 2011).

Clutch and egg sizes of gulls are strongly influenced by food availability and, in turn, affect breeding success, which can therefore be good indicator of food supply (Pierotti and Annett 1990, Bukaciński *et al.* 1998). Moreover, it was found that the diet choice had major effects on the breeding performance of Herring Gull (Pierotti and Annett 1991). Additionally, the size difference between subsequent eggs in a clutch contains information on female condition, since gull females are fed by their mates before and during laying. It thus can be viewed as an indirect measure of food supply. According to Kilpi *et al.* (1996), a difference between the third egg (the terminal egg in gull's clutches, named the 'C-egg') and the first two, A- and B-eggs, of less than 10% indicates very good feeding conditions. Skórka *et al.* (2005) suggested that the management of fish may be a key factor contributing to the high breeding success of Caspian Gull.

We hypothesized that a higher fish share in the gull diet may increase their reproductive success indirectly – pre-laying females may achieve better body condition and lay bigger eggs, if they are fed with the large amount of fish by their mates. To verify this, we compared the reproductive traits of Caspian Gulls breeding in five inland colonies in Poland, differing by the distance to the nearest fish pond. In particular, we paid an attention to the relative size of the C-egg which is believed to be highly informative in respect to feeding conditions.

## STUDY AREAS

The study was carried out in five breeding sites of large gulls in Poland (Fig. 1). Breeding colonies were located at a gravel pit (Janko-

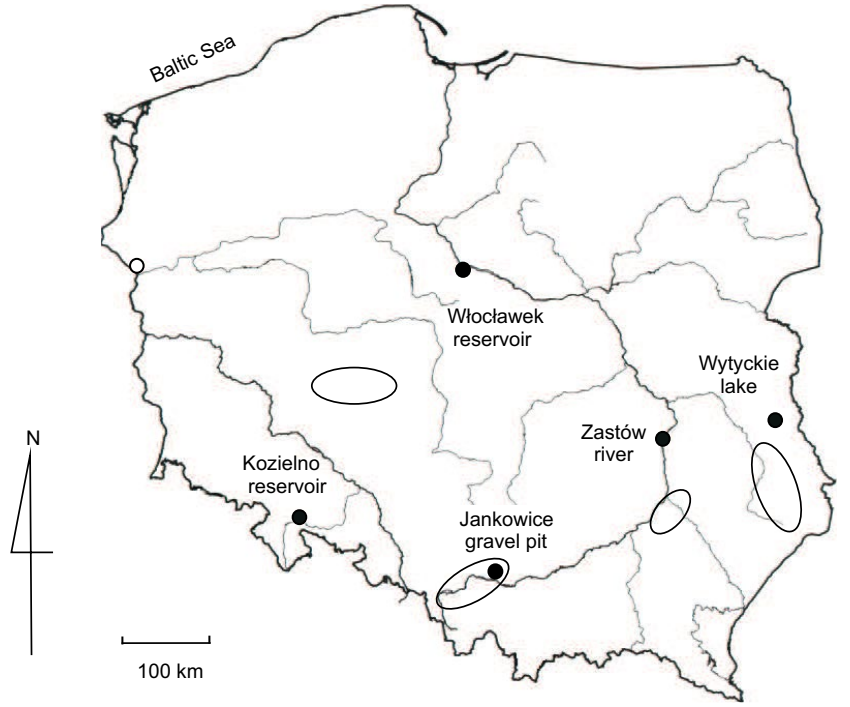


Fig. 1. Study area in Poland. Five colonies of Caspian Gull *Larus cachinnans* are marked by black dots and areas with large fish ponds complexes are marked with an ellipse.

wice), on a river island (Zastów Karczmiski), at a lake (Wytyckie), and at dam reservoirs (Włocławek Reservoir, Kozielno Reservoir).

The total area of the gravel pit in Jankowice (50°02'N, 19°26'E), hereinafter referred to as "the gravel pit", in the upper Vistula River Valley was *ca*. 62 ha. The breeding colony of Caspian Gull was established in 1999 (Faber *et al*. 2001) and is located on an island. It was covered with herbage partially mixed with willows *Salix* spp. and with shores not covered by macrophytes. Night Heron (*Nycticorax nycticorax)* bred numerously on willows. The colony of Caspian Gulls comprised 104, 119 and 250 breeding pairs in 2003, 2004 and 2014, respectively (Gwiazda *et al*. 2011). The nearest fish ponds (550 ha) are located at a distance of *c*. 1.0 km from the colony.

Włocławek Reservoir (coordinates of the gull colony: 52°39'N, 19°08'E), hereinafter referred to as "the reservoir 1", is located on the Vistula River in central Poland. The total area of this reservoir is 7040 ha, mean depth 8 m, length 59 km, and width up to 2.5 km. The breeding colony of large gulls at this reservoir was established in mid 1980's. Herring and Caspian Gulls breed here on man-made dike-cape (Zagalska-Neubauer and Neubauer 2012). The colony of large gulls comprised 135 and 143 breeding pairs in 2003 and 2004, respectively (Neubauer *et al*. 2006). The nearest fish ponds are located *c*. 27 km from colony. Because the colony is a mixed one, with Herring and Caspian gulls breeding in homospecific, heterospecific and mixed (i.e., pairs including hybrids) pairs (Gay *et al*. 2007, Neubauer *et al*. 2009, Zagalska-Neubauer and Neubauer 2012), to make comparisons with other sites meaningful, we have chosen only a subsample of pure Caspian Gull pairs and their clutches from the study years. The clutches included in the analysis were the ones, where both mates were identified as Caspian Gulls with confidence. Identification was most often based on in-hand measurements of breeding, trapped individuals (see Neubauer *et al*. 2009 for details) though in some cases, both visual identification and identification following unique colour-ring codes read (for birds trapped and marked earlier) was also possible.

The Kozielno Reservoir (50°29'N, 16°58'E), hereinafter referred to as "the reservoir 2", is located on the Nysa Kłodzka River in south-western Poland. This is a lowland reservoir with an area of 350 ha, with a mean depth of 5.0 m. The breeding colony of Caspian Gull was established in 2005. It is located on island of area 0.5 ha. Shores of island are covered by willows and central part by grass. The colony comprised *c*. 412 breeding pairs in 2014. The nearest fish ponds are located 58 km from the colony.

The breeding colony of Caspian Gull in Zastów Karczmiski (51°15'N, 21°49'E), hereinafter referred to as "the river", is located on islands in the bed of the Vistula River near Kazimierz Dolny. This site was covered with herbage. There are many sandbars and islands of different size in this part of the Vistula River. The colony of Caspian Gulls comprised *c*. 800 breeding pairs. The nearest fish ponds (50 ha) are located at a distance of *c*. 10.0 km from the colony.

Wytyckie lake (51°25'N, 23°13'E), hereinafter referred to as "the lake", is located in eastern Poland. The total area is 490 ha, mean depth 2 m (max 5.5 m). Shores are covered by abundant macrophytes (mainly *Typha* sp.). Submerged vegetation was also abundant in this lake. Island with breeding colony of Caspian Gulls was overgrown by alder and ferns. The breeding colony of Caspian Gull large comprised *c*. 175 breeding pairs. Large gulls bred there together with Black-headed Gull *Chroicocephalus ridibundus* (*c*. 700 breeding pairs). The nearest fish ponds (215 ha) are located *c*. 4.2 km from colony.

## MATERIAL AND METHODS

All colonies were monitored during egg laying: the gravel pit in 2003, 2004 and 2014, the reservoir 1 in 2003 and 2004, the reservoir 2, the river and the lake in 2014. Studied colonies were classified according to presence of fishponds nearby. The colonies at the gravel pit and at the lake were recognized as sites near fish ponds (<5 km), and the other three colonies as sites away from fish ponds (≥10 km). All nests were counted and marked; clutch size (when full, i.e., all eggs laid) was assessed for each nest. Eggs were marked with a permanent marker and their length and breadth was measured to

Table 1. Reproductive performance of large gulls in five colonies in Poland: nearby fish ponds (gravel pit, lake) and without fish ponds nearby (remaining colonies). Calculations of both the clutch volume and the relative C-egg volume were performed on a subsample of 3-egg clutches only. Clutch size is the number of eggs in a full clutch and hatching success is the proportion of eggs that hatched. All values given as means ± 1 SD.

| Year | Colony locality (local name) | Habitat | Clutch size N | Clutch volume ($cm^3$) | Relative C-egg volume | Hatching success (%) |
|---|---|---|---|---|---|---|
| 2003 | Jankowice | gravel pit | 2.9 ± 0.7 (N=105) | 253.5 ± 20.9 (N=47) | 0.97 ± 0.05 (N=46) | 84 ± 25 (N=53) |
| | Włocławek | dam reservoir | 2.9 ± 0.3 (N=15) | 260.4± 21.6 (N=15) | 0.93 ± 0.04 (N=15) | 53 ± 45 (N=15) |
| 2004 | Jankowice | gravel pit | 3.0 ± 0.4 (N=116) | 250.6 ±26.5 (N=62) | 0.97 ± 0.04 (N=59) | 85 ± 27 (N=44) |
| | Włocławek | dam reservoir | 3.0 ± 0 (N=14) | 252.5 ± 25.7 (N=14) | 0.97 ± 0.05 (N=14) | 86 ± 31 (N=14) |
| 2014 | Jankowice | gravel pit | 3.0 ± 0 (N=33) | 251.4 ± 21.3 (N=33) | 0.96 ± 0.07 (N=33) | — |
| | Kozielno | dam reservoir | 3.0 ± 0 (N=33) | 251.1 ± 15.0 (N=33) | 0.94 ± 0.05 (N=33) | — |
| | Zastów Karczmiski | river | 2.9 ± 0.29 (N=33) | 250.7 ± 17.0 (N=30) | 0.95 ± 0.05 (N=30) | 93 ± 14 (N=33) |
| | Wytyckie Lake | lake | 2.8 ± 0.38 (N=36) | 253.6 ± 14.6 (N=30) | 0.98 ± 0.05 (N=30) | 95 ± 14 (N=36) |

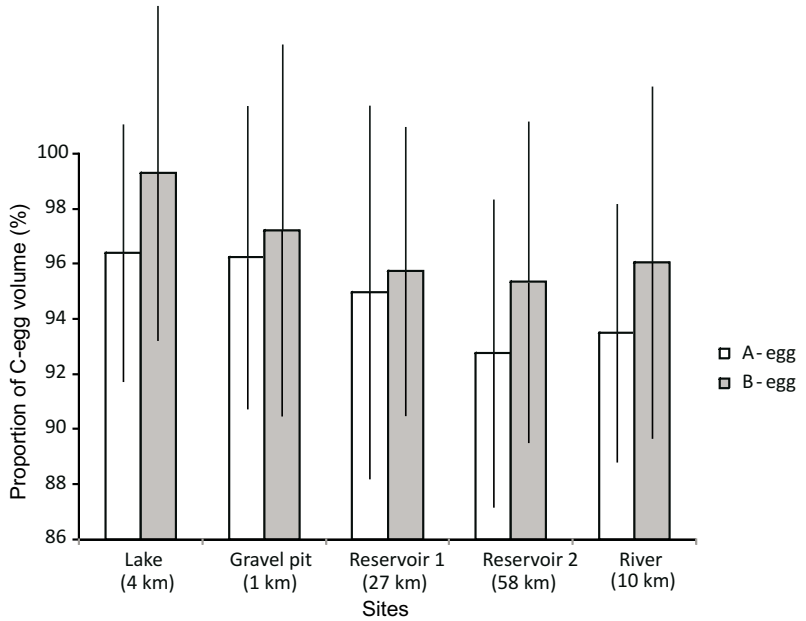


Fig. 2. Proportion of C-egg volume to A-egg and B-egg volumes in five inland colonies of Caspian Gull *Larus cachinnans* in Poland. The distance of colony to the nearest fish pond is given in parenthesis. All values given as means ± SD.

the nearest 0.1 mm with a caliper. The egg sequence was assessed during frequent visits or by the water test. Egg volumes $V$ were expressed in $cm^3$ and calculated following the formula $V = L \times B^2 \times 0.000476$, where: $L$ – egg length, $B$ – egg breadth (Harris 1964); clutch volume was obtained by summing individual egg volumes. The relative C-egg volume was expressed as a proportion of the average A- and B-eggs and calculated as: $VOL_{RelC} = VOL_C / ((VOL_A + VOL_B) / 2)$ (3-egg clutches included only). Values below 1 indicated that C-egg is smaller than average volume of A- and B- eggs in a clutch, while

values above 1 – that it is bigger. The hatching success was assessed as a ratio of the number of hatched chick to the number of eggs laid.

One-way ANOVA test was used to study the impact of colony locality on the mean number of eggs (Sokal and Rohlf 1995). The differences between volumes of C-egg and A-egg and between C-egg and B-egg were studied by t-Student test (Sokal and Rohlf 1995). Differences in the mean clutch volumes, C-egg volumes, relative C-egg volumes, and hatching success between colonies and years were assessed with the General Linear Model with locality and year as factors. We used Spearman correlation analysis to calculate the correlation coefficient between relative C-egg volume and the distance to the nearest fish pond. As data from two colonies (at the reservoir 1 and at the gravel pit) were collected during two and three years we calculated mean values and used in the correlation analysis. Statistical analyses were performed using STATISTICA 10 software (StatSoft, Inc. 2011).

## RESULTS

The mean full clutch size in studied colonies ranged from 2.8 to 3.0 egg/pair (Table 1). The number of eggs was affected significantly by locality of the colony (F = 5.53, df = 4, $P = 0.0001$). The mean clutch volumes were similar in the studied colonies and years and the differences were not significant (locality: $P = 0.68$; year: $P = 0.22$; interaction: $P = 0.32$) (Table 1). The differences in C-egg between colonies and years were not found (locality: $P = 0.18$; year: $P = 0.13$; interaction: $P = 0.99$). The mean volume of C-eggs was smaller than volumes of A- and B-eggs in the studied colonies (t = 7.17, N = 528, $P = 0.0001$; t = 4.57, N = 528, $P = 0.0001$, respectively). However, the mean C-egg volume was only 3.6 and 3.8% smaller than the mean volume of A-egg and 0.7 and 2.8% smaller than mean volume of B-egg in the colonies with nearby fish ponds – at the lake and at the gravel pit, respectively. The mean C-egg volume in other colonies was 5.0–7.2% smaller than mean volume of the A-egg and 3.9–4.7% smaller than mean volume B-egg (Fig. 2). Relative C-egg volumes depended only on the colony location (F = 3.20, df = 4, $P = 0.01$), but not on year ($P = 0.34$) and were greatest in the lake and gravel pit (Table 1). We found a negative correlation between the relative C-egg volume and distance to the nearest fish pond ($r_s = -0.873$, $P = 0.05$; Fig. 3). The differences in mean clutch volumes between colonies with presence of fishponds nearby and colonies without fishponds nearby (mean = 254.0 ± 1.39, N = 173; mean = 252.7 ± 1.90, N = 92; respectively) were not significant ($P = 0.57$), but relative C-egg was greater (F = 10.690, df = 1, $P = 0.001$) in the two colonies near fish ponds than elsewhere (mean = 0.968 ± 0.004, N = 173; mean = 0.946 ± 0.005, N = 92; respectively). The mean hatching success was 84–95% except the colony at the reservoir 1 in 2003, where was much lower (Table 1).

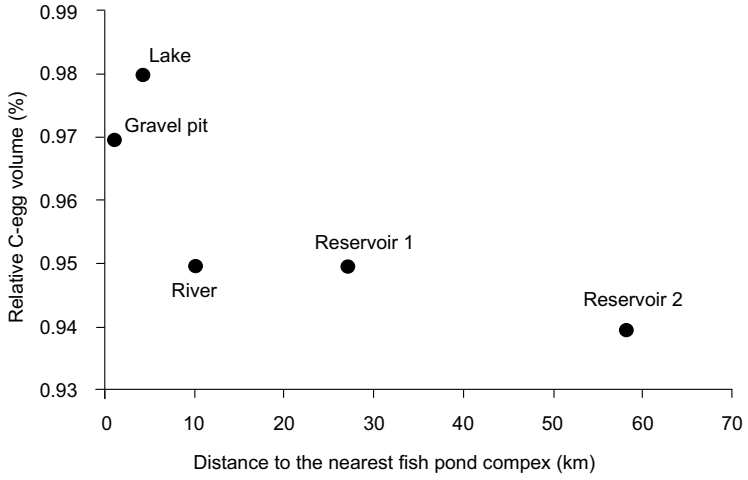


Fig. 3. Correlation between the relative C-egg volume and the distance from the Caspian Gull *Larus cachinanns* colony to the nearest fish pond.

The hatching success was affected by locality and year (locality: F = 6.73, df = 4, $P$ <0.0001; year: F = 11.67, df = 2, $P$ <0.0001; interaction: F = 4.298, df = 1, $P$ = 0.04) and was the highest at the lake (Table 1).

## DISCUSSION

Fish are regarded as the most important food for Caspian Gulls breeding inland (Cramp and Simmons 1983, Skórka *et al.* 2005, Skórka and Wójcik 2008, Gwiazda *et al.* 2011). In Poland the proportion of pellets containing fish was significantly higher in the colony at the gravel pit in Jankowice located near fish ponds than in the colony at the Włocławek Reservoir or on islands of the Vistula River located far away from fish ponds (Gwiazda *et al.* 2011). Breeding success is also a good indicator of food supply (Pierotti and Annett 1990, Bukaciński *et al.* 1998). Bukacińska *et al.* (1996) showed that the successful pairs of Herring Gull on Terschelling (The Netherlands) ate more fish.

The decreased food availability on refuse dumps in Brittany (France) caused the decline in nearly all breeding parameters as mean clutch size, egg volume in clutches and hatching success of Herring Gull (Pons 1992). Similarly C-eggs volume decreased significantly as an effect of reduced availability of refuse in the colony of Herring Gull in SW Finland (Kilpi and Öst 1998). Mean egg volume, hatching success and chick survival rates of the Yellow-legged Gull were significantly greater in colony closer to large refuse dumps than in colony farther from human food sources in France (Duhem *et al.* 2002).

In our study, we showed that some – though not all – reproductive parameters of Caspian Gull depended on the colony locality. The clutch sizes and volumes and hatching success were similar in all studied colonies and years, while the relative C-egg size negatively correlated with the distance to the nearest fish pond. The mean clutch size in the colony of Caspian Gulls in the sedimentation basin near Tarnów (southern Poland), where fishponds provided the main source of food, was 2.85 eggs (Skórka *et al.* 2005), similar as in our study. Thus, it is possible that the high density of fish and low water level in the fish ponds neighbouring studied colonies allow to limit costs of foraging and increase the probability of successful attack. Such favourable conditions can highly influence breeding success, since adult birds need less time and energy to forage and can spent more time in, e.g., direct parental care of chicks. Moreover the diet quality for breeding gulls seemed to affect intra-clutch egg size variation (Ramirez *et al.* 2011). According to Kilpi *et al.* (1996) C-egg volume was only 5% smaller than A- and B-eggs in colony of Herring Gull at Storsundsharun (northern part of the Baltic).

The small differences of C-egg volume in comparison to A- and B-egg support the view that feeding conditions are good (Skórka *et al.* 2005). In the colony near Tarnów C-egg volume was significantly smaller than eggs A (4.9%) and B (5.9%) (Skórka *et al.* 2005). It can be explained by presence of some fish ponds *c.* 4 km from colony. Our results indicate that Caspian Gull in inland habitats in Poland achieves a good reproductive performance particularly in colonies near fish ponds.

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