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Creation and development of the subcolony in Cormorant *Phalacrocorax carbo sinensis* at the Jeziorsko reservoir, Central Poland

Proces powstawania i rozwój kolonii satelitarnej kormorana *Phalacrocorax carbo sinensis* na zbiorniku Jeziorsko, Polska Centralna

SUMMARY

The research was conducted at Jeziorsko reservoir (51°73'N, 18°63'E) in Central Poland during the years 2004–2007. In 2005, a small subcolony of Cormorants (41 breeding pairs) was created about 1 km away from the main colony (370 breeding pairs). This year, the mean clutch size in the subcolony was lower than in the main colony and the fraction of small clutches (2–3 eggs) in the subcolony was significantly higher (57.1% vs. 37.1%). Although in 2005 breeding success was unusually low in the main colony, the number of fledglings raised per nest and per successful nest were significantly higher in the main colony in comparison to the subcolony. This followed the higher losses of whole clutches/broods recorded in the subcolony (68.6% vs. 39.5%). In the following year (2006), the number of pairs breeding in the subcolony increased over 4-fold (165 pairs) and was only slightly lower than in the main colony (220 pairs). The values of all breeding parameters recorded in the subcolony were significantly higher than in the previous year and were similar to those in the main colony. In 2007 the number of fledglings raised per successful nest in the subcolony was significantly higher in comparison to the main colony. The obtained results suggest that probably young and inexperienced birds limited by the availability of the nest sites were mainly involved in the creation of the subcolony. The growth of the breeding parameters recorded in consecutive years in the subcolony could be connected with the subsequent movement of higher-quality birds from the main colony and shows the advantages of occasional abandonment of overexploited colony location.

STRESZCZENIE

Badania prowadzono na terenie zbiornika Jeziorsko (51°73'N, 18°63'E) w latach 2004–2007. W roku 2005 w odległości około 1 km od kolonii głównej kormoranów na zbiorniku (370 par lę-

gowych) powstała niewielka kolonia satelitarna (41 par lęgowych). W roku tym średnia wielkość zniesienia ptaków w kolonii satelitarnej była niższa od wartości wykazywanych w kolonii macierzystej, a procentowy udział małych zniesień (2–3 jaja) w kolonii satelitarnej był istotnie wyższy (57,1% vs. 37,1%). Mimo stosunkowo niskiego sukcesu lęgowego w kolonii macierzystej w roku 2005 (najniższa wartość w okresie objętym badaniami) liczba odchowanych w niej podlotów przypadających na parę oraz na parę z sukcesem była istotnie wyższa niż w kolonii satelitarnej. W kolonii satelitarnej ptaki istotnie częściej traciły całe lęgi (68,6%) niż w kolonii macierzystej (39,5%). W kolejnym roku (2006) liczba par podejmujących lęgi w kolonii satelitarnej zwiększyła się ponad czterokrotnie (165 par) i była niewiele niższa od liczby par gniazdujących w kolonii macierzystej (220 par). Wartości wszystkich badanych parametrów lęgowych w kolonii satelitarnej były wyższe niż w roku poprzednim i jednocześnie nie wykazywały istotnych różnic w porównaniu z kolonią macierzystą. W roku 2007 liczba odchowanych z sukcesem podlotów na parę była istotnie wyższa w kolonii satelitarnej niż w kolonii macierzystej. Powyższe wyniki sugerują, że w proces tworzenia się kolonii satelitarnej zaangażowane były głównie ptaki młode i niedoświadczone, ograniczane dostępnością miejsc gniazdowania w kolonii macierzystej. Sukcesywny wzrost wartości parametrów lęgowych notowany w kolejnych latach w kolonii satelitarnej był najprawdopodobniej związany z sukcesywnym przepływem ptaków o wyższej jakości z kolonii macierzystej i wskazywał na istotne korzyści płynące z porzucenia miejsca gniazdowania narażonego na wieloletnią eksploatację.

K e y w o r d s: Cormorant, *Phalacrocorax carbo sinensis*, subcolony, breeding parameters

INTRODUCTION

Cormorant *Phalacrocorax carbo* is a colonial species of bird which breeds in the vicinity of various types of waterbodies. Since the 70's of the 20th century, the population of Cormorant has been rapidly growing in numbers across the whole of Europe. In this period, some populations of the continental subspecies of Cormorant *P. c. sinensis* showed the annual increase rate in the number of breeding birds at the level of 30% (13). Cormorant profited mainly from its legal protection introduced in the majority of European countries at that time. General increase in the fish productivity recorded in European waters which was caused by the processes of eutrophication was also essential for the maintenance of the growing population (14). Extensive development of Cormorant population was manifested by the growth of already existing colonies and by the appearance of new breeding locations, which created favourable conditions to investigate spatial changes in the expanding colonies. As a number of studies have shown, the spatial modifications in the structure of growing colonies can be complicated and not necessarily limited to the mere increase in the area occupied by the breeding birds. Such spatial processes as the division of the main colony into several distinctive sections and creation of entirely new subcolonies were recorded in expanding colonies of Cormorant (8). Since different parts of colony are likely to be subjected to different environmental and biotic factors, a spatial variation in the breeding parameters may consequently arise within a colony (2). An investigation on the variation in the breeding parameters of Cormorant during the process of creation and development of a new subcolony at Jeziorsko reservoir is the aim of this paper.

MATERIAL AND METHODS

The research was conducted at Jeziorsko reservoir (51°73'N, 18°63'E) in Central Poland during the years 2004–2007. Cormorants started nesting at the reservoir in 1991, when a colony of approximately 90 pairs was found (7). Afterwards, there was a constant increase in the number of breeding pairs at the reservoir throughout the 90's and the colony size reached 400 pairs at

the beginning of the 21st century. During the years 2004–2007, the main colony of Cormorants at the reservoir was located at the level of Mikołajewice village next to the old Warta riverbed. Additionally, in 2005, a subcolony of Cormorants appeared at a distance of about 1 km from the main colony and was situated within the mixed colony of Grey Herons *Ardea cinerea* and White Egrets *Egretta alba*. Both colonies were located in the similar habitat of willow shrubs with the domination of White Willow *Salix alba* and Grey Willow *Salix cinerea*. Both colonies were visited from the middle of March until the beginning of July. The colonies were visited every one or two weeks. The time-schedule of visits was arranged so that the estimations of breeding parameters were most possibly accurate. All the nests were individually marked. During the visits, the number of eggs/pullies was recorded either directly by ladder or with the usage of a mirror attached to the top of a 4 meter high stick. In the main colony, nests were located at a height from 1 to 9.5 m (on average 4.5 m), and in the subcolony from 3 to 11 m (on average 6 m), which allowed effective checks of the majority of nests. The number of fledglings in the highest nests was recorded with binoculars from the surrounding trees.

Frequency distributions of clutch size were compared between colonies with Maximum-Likelihood *Chi*-square tests. Interannual differences in breeding parameters were tested with the ANOVA and *post-hoc* Tukey test. Differences in breeding parameters between colonies were tested with the t-test. All statistical analyses followed Zar (15).

RESULTS

In 2004, there were 420 pairs of Cormorants nesting at the reservoir, all in the main colony. In 2005, the total number of breeding pairs at the reservoir was similar, however, 41 pairs moved to the newly created subcolony. In the subcolony, the number of breeding pairs was constantly increasing and reached 240 pairs in 2007. That year the number of pairs breeding in the subcolony exceeded the number of pairs in the main colony (220 pairs).

In 2005, the frequency distribution of clutch sizes differed between both colonies (χ^2=11.93, df=5, p=0.036). Fraction of small clutches (2–3 eggs) was significantly higher in the subcolony comparatively to the main colony (57.1% vs. 37.1%, χ^2=4.43, df=1, p=0.035). In the subcolony, clutches higher than 4 eggs were not recorded and in the main colony they comprised 13.9% of all clutches. In 2005, all breeding parameters recorded in the newly created subcolony were lower in comparison to the main colony (clutch size 3.18 vs. 3.60, t=2.33, df=400, p=0.020, Fig. 1; the number of fledglings per nest 0.46 vs. 1.63, t=4.50, df=374, p<0.001, Fig. 2; the number of fledglings per successful nest 1.45 vs. 2.70, t=4.18, d=214, p<0.001, Fig. 3). The differences between colonies appeared to be significant, even though the number of fledglings raised per nest in the main colony were the lowest among all the years of the study (Tukey: p<0.001 for all interannual differences). The lower number of fledglings raised per nest in the subcolony was connected with the higher rate of losses of all clutches in comparison to the main colony (68.6% vs. 39.5%, χ^2=10.97, df=1, p<0.001). In 2006–2007, the frequency distributions of clutch size did not differ between colonies (2006: χ^2=9.71, df=5,

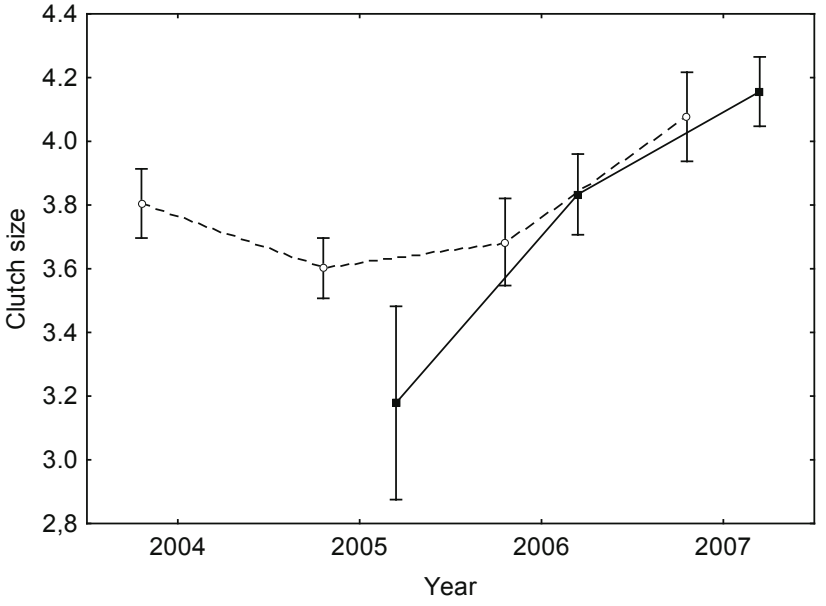

Fig. 1. Clutch size of Cormorants breeding in the main colony (dashed line) and in the subcolony (solid line). Central point – mean, error bars – 1.96*SE

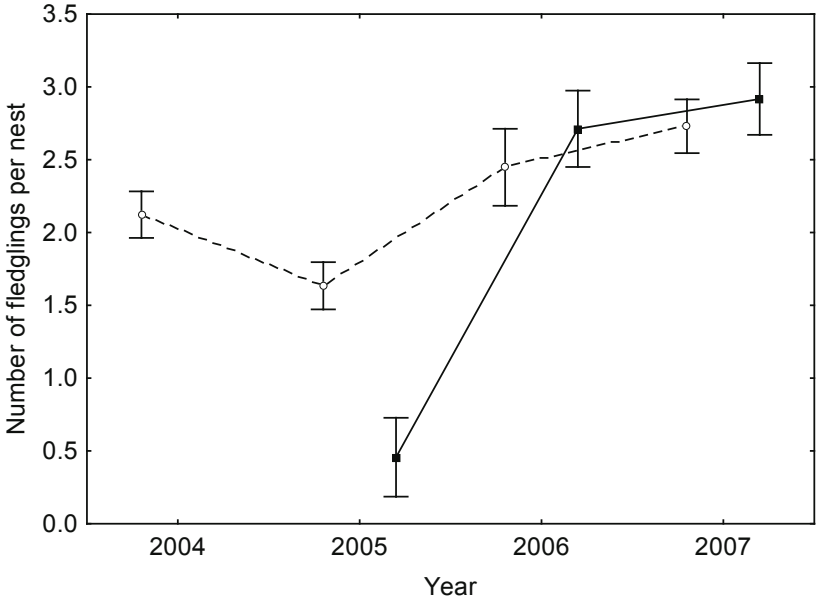

Fig. 2. Number of fledglings raised per nest in the main colony (dashed line) and in the subcolony (solid line). Central point – mean, error bars – 1.96*SE

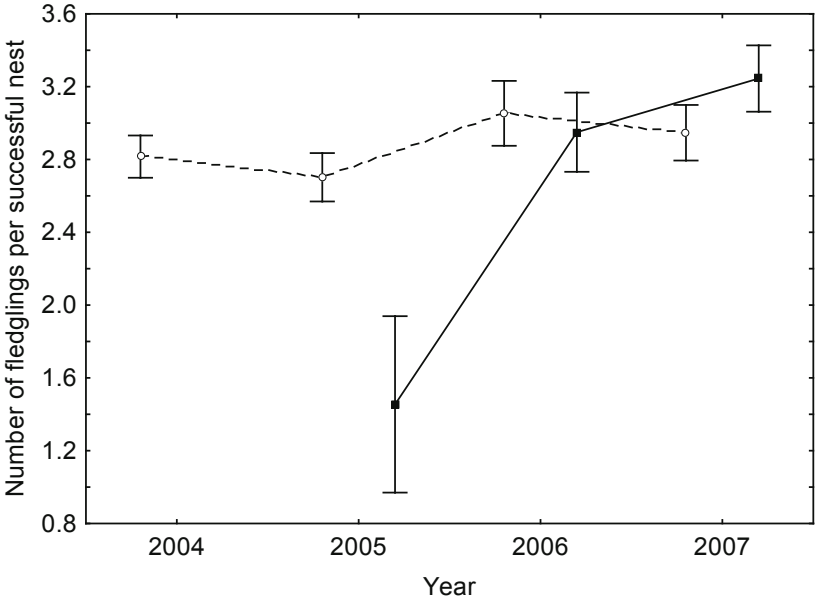

Fig. 3. Number of fledglings raised per successful nest in the main colony (dashed line) and in the subcolony (solid line). Central point – mean, error bars – 1.96*SE

p=0.084; 2007: χ^2=2.83, df=4, p=0.59). In 2006, all recorded breeding parameters in the subcolony were significantly higher than in the previous year (Tukey: clutch size p=0.005, number of fledglings per nest p<0.001, number of fledglings per successful nest p<0.001). Moreover, none of the breeding parameters recorded in the subcolony differed from the mean values in the main colony (clutch size 3.83 vs. 3.68, t=1.57, df=266, p=0.12; number of fledglings per nest 2.71 vs. 2.45, t=1.36, df=201, p=0.17; number of fledglings per successful nest 2.95 vs. 3.05, t=0.73, d=171, p=0.47). In 2007, there was a further increase in the clutch size in the subcolony (Tukey: p=0.002). Furthermore, the number of fledglings raised per successful nest in the subcolony was higher than in the main colony this year (3.24 vs. 2.95, t=2.43, d=247, p=0.016).

DISCUSSION

All breeding parameters recorded in the subcolony of Cormorants at Jeziorsko reservoir during the year of its creation were found to be lower than in the main colony. This observation suggests that the quality of birds which founded the subcolony was lower in comparison with the individuals breeding in the main part of the colony. The quality of birds can be manifested by such aspects as their

age, breeding experience or physical condition (10, 12). All these intrinsic factors so far proved to affect the breeding performance of Cormorants (1,3). Therefore, lower clutch sizes and numbers of fledglings raised in the subcolony could be attributed to the breeding of younger and less experienced birds. Such conclusions are consistent with other studies conducted in the colonies of Cormorants. Similar variation in breeding parameters between newly and formerly occupied sections of the colony was also found, for example, in Kąty Rybackie at the Baltic coast (8). High frequency of younger birds in the newly created parts of the colony was also found in Vorsø, Denmark. The theory on the development of waterbird colonies confirms the above observations. The subcolonies are likely to be created when the size of the main colony is limited by availability of nesting sites, and inferior birds should be rather expelled from the new unfamiliar areas (8). On the other hand, lower breeding success in the subcolony during the year of its appearance may result from unfamiliarity of birds to the newly occupied area. Breeding-site fidelity is known to yield certain advantages in terms of fitness and a long-term familiarity with a nesting site positively affect breeding success in the majority of studied bird species (4).

In consecutive seasons, all breeding parameters recorded in the subcolony were gradually increasing and finally, in 2007, the number of fledglings raised per successful nest in the subcolony exceeded the value recorded in the main colony. At the same time, the number of pairs breeding in the subcolony was constantly growing at the expense of the main colony. The main colony at Jeziorsko reservoir was exploited by breeding Cormorants for several years before the appearance of the subcolony. Preference of *sinensis* subspecies to nest on trees means that its colonies are often not permanent and that they have to occasionally change their location due to overexploitation of the nesting sites and the consequent decline in their quality. The impact of piscivorous bird colonies on the phytocoenosis mainly results from the deposition of nitrogen compounds found in the excreta and depends on the size of the colony and the density of nests (11, 16). The floristic composition of phytocoenosis also determines its resistance for the damage coming from the presence of breeding birds. After the period of exploitation, trees may become heavily damaged and stop providing safe sites for nesting (6). Under such circumstances, birds may decide to relocate the colony to the adjacent unimpaired areas. The physical structure of colonies so far proved to change with their age and to affect the breeding success of Cormorants (5, 9). Thus, it cannot be excluded that progressing deterioration of the breeding habitat in the main colony contributed to the creation of the subcolony at Jeziorsko reservoir and its further development. In fact, prior to the creation of the subcolony, the quality of trees in the center of the main colony became poor and the rate of nests falling down during the breeding season was unusually high (personal observations).

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