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# Exploitation by the Grey Heron of Fish Regurgitated by Cormorants

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**Abstract.**—Foraging by Grey Herons (*Ardea cinerea*) on fish regurgitated by Great Cormorants (*Phalacrocorax carbo*) was investigated in large mixed colony (ca. 10,000 pairs of cormorants and 700 pairs of herons) at Kąty Rybackie (north Poland). Experiments with displaying fish in different parts of the mixed and monospecific colonies were carried out. Herons took fish only within the area of mixed nests. Herons foraged on regurgitated fish during the whole breeding season but most intensively (up to 18% of all birds) in the fledging period. The main foraging area of herons (the Vistula Lagoon) has abundant food and is situated close to the colony. The fish regurgitated by cormorants constituted an important source of food for fledglings in the critical period after leaving the nest and was an alternative or supplementary food for adult birds during a period of bad weather. Extra food available in the colony could be responsible for high breeding success of the herons in the mixed colony at Kąty Rybackie. Received 6 July 2004, accepted 30 december 2004.

**Key words.**—Grey Heron, *Ardea cinerea*, Great Cormorant, *Phalacrocorax carbo*, mixed colony, fish regurgitation, feeding.

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Cormorants, like many piscivorous birds, readily regurgitate food when alarmed. It is believed that the birds regurgitate in order to scare or divert the attention of their aggressors and predators. Once relieved of food, the bird is lighter and more mobile and is thus able to defend itself or escape more easily (van Dobben 1952; Owen 1955; Temple 1969). The mixed colony at Kąty Rybackie is the largest colony of the Grey Heron (*Ardea cinerea*) (716-879 nests in 1999-2002) and Great Cormorant (*Phalacrocorax carbo*) (7,197-9,191 nests in 1999-2002) in Poland and in Europe. The size of the colony makes regurgitated fish an abundant food source taken by mammals visiting the colony (Red Fox [*Vulpes vulpes*], Raccoon Dog [*Nyctereus procyonoides*] and Wild Hog [*Sus scrofa*]) as well as by the Jay (*Garrulus glandarius*). Irregular earlier observations in Kąty Rybackie showed that herons also foraged on regurgitates, although they are not usually scavengers. Their staple food consists of fish and also of mammals, amphibians, reptiles, invertebrates and birds (Dementiev and Gladkov 1951; Milstein *et al.* 1970; Cramp 1998). The aim of this study was to estimate the importance of food regurgitated by cormorants for adult and fledgling herons.

## STUDY AREA

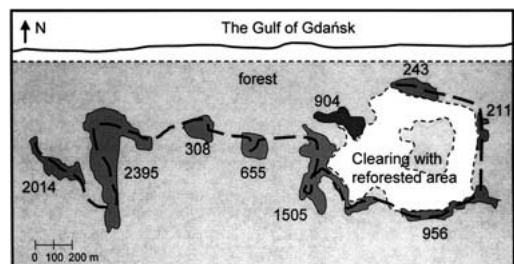
The study colony is situated at the Kąty Rybackie reserve on the Vistula Split (54°21'N, 19°14'E), 100 m

from the Gulf of Gdańsk (the Baltic Sea), Poland, and 2 km from the Vistula Lagoon (the main feeding ground for herons). The nests are in Scot's Pine (*Pinus sylvestris*) in a coastal pine forest. The colony is formed of a few sub-colonies, called sectors in this paper (Fig. 1). Herons nests in one sector of the colony, which they share with cormorants.

## METHODS

Each 7-10 days, all herons present along the plotted transect (total length 2 km), situated in parts of colony occupied by cormorants, were counted at dawn, before noon (only in 2002), in afternoon and before the sunset. In total, the transect was checked 31 times (13 in 2001 and 18 in 2002) during the whole breeding season (March-July). During each control check, the activity of observed herons (foraging, food finding) was noted.

Three breeding season periods were distinguished as: I—incubation and stage of small chicks, II—stage of medium and large chicks (21-38 days of life), i.e., the period of the most intensively growth and development of nestlings (Owen 1955; Marion 1979) and III—fledging period (>38 days of life).



**Figure 1.** The study area, location and the number of Great Cormorant nests in 2002 in subcolonies occupied by cormorants (light grey patches) and Grey Herons (dark grey patch) are indicated. Dashed bold line is the route of the transect.

Experiments with fish were performed in 2002. Fish were placed in three areas: 1) in the part of colony occupied exclusively by cormorants, 2) in the heronry, 3) outside the colony, in a large clearing surrounded by sectors of colony occupied by herons and cormorants. In each experiment, ten whole or cut 15-cm pieces of the fish species recorded in the Vistula Lagoon [Silver Bream (*Blicca bjoerkna*), Perch (*Perca fluviatilis*), Roach (*Rutilus rutilus*), Ruffe (*Gymnocephalus cernuus*) and Herring (*Clupea harengus*)] were placed in all three places. Fish were placed in a line ca. 3-4 m apart, so that detection of the next fish by herons was likely to be accidental. To avoid learning by herons, the fish were placed in different parts of three study areas each time. Fish placements along the plotted line were checked every 1-4 hours. Fifteen experiments were carried out at 7-10 days intervals from the incubation period up to fledging of the chicks (April-July).

Due to differentiated time of exposition and number of displayed fish, the rate of decrease of fish was measured by fish decrease ratio:

$$\frac{\text{Number of fish at start} - \text{Number of fish remaining at end}}{\text{Duration of exposition} * 100}$$

To determine if herons foraged on fish deposited in other heronries, three all-day experiments with were carried out during the chick rearing period of 2002 in the heronry at Kierszy (53°57'N, 19°28'E, situated in small wood, ca 100 km from Kały Rybackie, which had 277 occupied nests), which lacked cormorants. Fish was displayed there in the heronry and outside the colony, in the same way as at Kały Rybackie.

The number of Grey Heron and cormorant chicks that were present in the colony in consecutive periods was calculated on the basis of the number of eggshells found under the nests. Eggshells were collected each 7-10 days on the sample plot (170 heron nests and 541 cormorant nests). The percentage of herons feeding on regurgitated food was calculated on the basis of data from one sector where all herons were visible to the observer (flat ground). These data were extrapolated to other sectors. In the last period (fledging), the number of fledglings able to fly was added to the number of adults.

## RESULTS

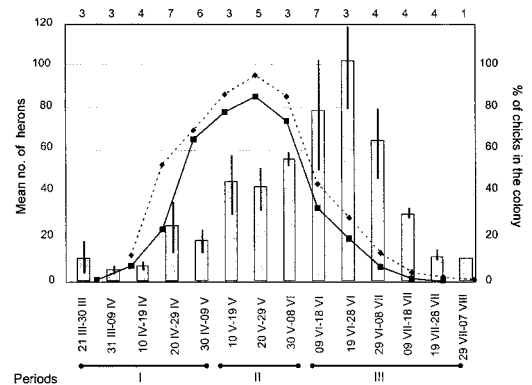
Heron were seen foraging on food regurgitated by cormorants in the sectors of colony occupied by cormorants during the whole breeding season. However, their number was low at the beginning of the season. A considerable increase was observed during the period with medium and large chicks (II), and the maximal numbers were observed in the fledging period (III), after which the numbers decreased markedly (Fig. 2). In both seasons, the number of observed herons during the incubation and small chicks periods was significantly lower than in the other periods (Kruskal-Wallis test; in

2001,  $H_{2,31} = 16.7$ ,  $P < 0.005$ ; in 2002,  $H_{2,53} = 20.7$ ,  $P < 0.005$ ; Dunn test,  $P < 0.05$ ; Fig. 3). The highest number of herons per 1 control of the plotted transect was recorded in both seasons in the fledging period, 27 June 2001 (145 individuals) and 17 June 2002 (153 individuals). These numbers constitute ca 28% of all herons breeding at Kały Rybackie colony and ca 18% the total number of adults and fledglings (assuming two adult birds and mean 3.2 fledglings per nest; Jakubas 2003).

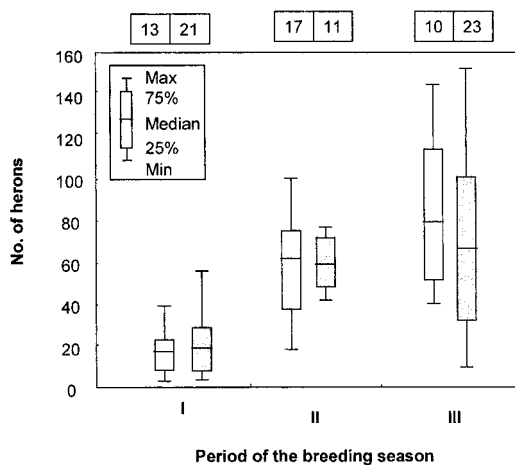
In both seasons, the number of herons observed was similar during the controls in various parts of the day. Only in 2002, when the transect was checked four times a day, the number of herons observed before noon was higher. However, differences among checks were not significant (Kruskal-Wallis test;  $H_{2,40} = 1.13$ , n.s. in 2001, and  $H_{3,50} = 5.20$ , n.s. in 2002).

The number of herons observed feeding in particular cormorant sub-colonies increased together with the size (number of nests) of the sector (for whole breeding period 2002, Spearman R correlation coefficient  $r_s = 0.62$ ,  $N = 448$ ,  $P < 0.001$ , for the 2002 chick rearing period (periods II and III)  $r_s = 0.73$ ,  $N = 272$ ,  $P < 0.001$ ).

In all sample plots (excluding those outside the colony), the values of fish decrease ratios increased in the course of the breeding season, reaching the maximum in the fledging period. In the sectors of the colony occupied exclu-



**Figure 2.** The number of the Grey Herons observed during three counts per day in sectors of the colony occupied by Great Cormorants (histogram, mean  $\pm$  SD), the number of Grey Heron (dotted line) and Great Cormorant (solid line) chicks present in the colony in 2002.



**Figure 3.** The number of Grey Herons observed in sectors of the colony occupied by cormorants during three distinguished periods (I—incubation and small chicks period, II—medium and large aged chicks period, III—fledging period) in 2001 (white) and 2002 (grey). Sample sizes (number of counts) are given in the squares above graphs.

sively by cormorants, the fish decrease ratio in the period I was significantly lower than in other periods (Kruskal-Wallis test  $H_{2,52} = 17.92$ ,  $P < 0.005$ ; Dunn test,  $P < 0.05$ ). Similar situation was recorded in the area occupied by herons (Kruskal-Wallis test,  $H_{2,49} = 19.22$ ,  $P < 0.005$ ; Dunn test,  $P < 0.05$ ). The value of fish decrease ratio was very low during the whole season in the sample plot situated outside the colony and was significantly lower than in the colony areas both occupied by cormorants and by herons (Kruskal-Wallis test,  $H_{2,154} = 24.67$ ,  $P < 0.001$ , Dunn test,  $P < 0.05$  (Fig. 4).

Herons from the single-species colony at Kiersity only sporadically exploited fish placed on the ground below the nests. In the chick rearing period, the fish decrease ratio recorded at Kiersity was significantly lower than in the heronry at Kały Rybackie (U Mann-Whitney test,  $Z = 3.65$ ,  $P < 0.001$ ). Values noted in the sample plot situated outside the colony at Kiersity was lower than in similar situated plot at Kały Rybackie (U Mann-Whitney test,  $Z = 2.54$ ,  $P < 0.05$ ).

## DISCUSSION

Herons feeding on fish dropped or regurgitated in the cormorant colony were ob-

served during the whole breeding season. The total biomass of fish regurgitated by cormorants in the colony at Kały Rybackie was estimated in 2000 to 12.9 tonnes per season (Kozłowska 2001), in 2002—13.4 tonnes (assuming that amount of dropped fish increased with the size of the cormorant colony). This estimate based on fish collected on sample plots during the daylight time and did not taken into account unknown fish biomass consumed by mammal scavengers mainly at night. Total food ingestion by herons breeding in that colony during the whole season amounted to ca 105 tonnes (Jakubas 2003). This extra food could maintain ca 13% of herons food needs. The highest recorded number of herons feeding on that food observed during single control of the plotted transect (III period, 2002) represented 18% of total number of herons able to fly (adults and fledglings). Mean proportion of herons feeding in the colony amounted to 1% (period I), 4% (period II) and 6% (period III) of their total number. These results indicate that regurgitated fish was an important, additional food source for the heron fledglings in the critical period soon after leaving the nest. Fledglings appeared in the vicinity of heronry about ten days after leaving the nest and then dispersed (van Vessem and Draulans 1987). Additionally, regurgitated fish was an opportunity to avoid death by nestlings that had precocially left the nest or were rejected by aggressive siblings (siblicide was the most important reason of the chick mortality at Kały Rybackie; Jakubas, 2003). At least 8% of individually marked, flightless chicks found on the ground survived at least 5 days ( $N = 120$  birds; Wojczulanis, unpublished data). The youngest chicks observed feeding on fish regurgitated by cormorants were 28-32 days old. Dropped fish was also an important supplementary food for adult birds, especially during unfavorable weather, within the period of the highest food demands (21-27 days-old nestlings).

Due to strong the coincidental hatching of the heron and cormorant eggs (Fig. 2), the period of highest food demands of chicks occurred at the same time. As a result, abundant amounts of fish were dropped by cormorants

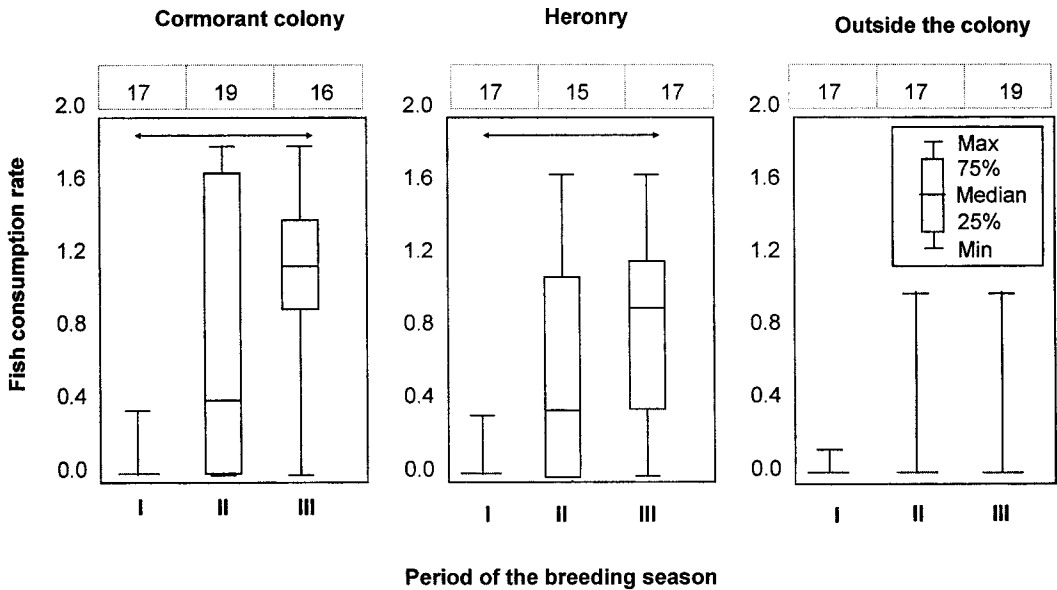


Figure 4. Values of fish consumption rates in distinguished periods of the breeding period in three studied places in 2002 (arrows indicate significant differences, Kruskal-Wallis and Dunn test,  $P < 0.05$ ). Sample sizes (number of experiments) are given in the squares above graphs.

at the most advantageous time for herons. Regurgitated food is accessible for herons beyond the cormorants' nesting period, because young cormorants return to nest to be fed longer than herons (40-50 days in cormorants vs 10-20 days in herons; Cramp 1998).

The highest mean number of herons observed feeding on dropped fish in the morning could be caused by the large number of cormorants returning from feeding grounds at that time (Brylski 2002).

The higher ratio of fish decrease observed within the colony, and the lower ratio outside the colony, suggest that foraging in the cormorant colony was not accidental. Very low ratios recorded in the control single species heronry at Kiersity showed that long-term coexistence and appreciable amounts of extra food are needed for herons to learn to utilize it and to develop this type of commensal relationship.

Mean number of feedings per nest and mean breeding success of herons were higher in Kąty Rybackie than in two other colonies in northern Poland (Jakubas 2003). Availability of food and distance between the colony and feeding areas are important factors that modify the number of chick feed-

ings and breeding success of wading birds (Hafner 1997; Frederick and Spadling 1994; Simpson *et al.* 1987; Frederick and Collopy 1988). Extra food available in the colony, in the form of cormorant regurgitates, could be an important factor in increasing the breeding success of herons at Kąty Rybackie.

#### ACKNOWLEDGEMENTS

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