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Diet and growth of chicks of the Great Cormorant, *Phalacrocorax carbo*, at Ramsar, northern Iran (Aves: Phalacrocoracidae)

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Diet and growth of chicks of the Great Cormorant, *Phalacrocorax carbo*, at Ramsar, northern Iran

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Abstract. The diet of Great Cormorant (*Phalacrocorax carbo* Linnaeus, 1758) chicks was studied using regurgitated fish prey in a colony at Ramsar, northern Iran, in the 2003 breeding season. The development of young was analysed in terms of body mass and wing length growth. The regurgitated prey items belong to Gobiidae*,* Mugilidae*,* Atherinidae and Clupeidae, with approximately 90% of the regurgitated prey mass belonging to Gobiidae and Mugilidae. The growth rate, expressed as body mass increment per day during the period 1-30 days, ranged from 58.7 to 112.2 g/d and was independent of age ranking and brood size. The growth rate of wings was 5.5 to 8.2 mm/d and did not vary between broods of different sizes and chicks of different ages.

Key words. Great Cormorant, *Phalacrocorax carbo*, diet, chick development, daily growth rate, Ramsar, Iran, Middle East.

Introduction

Great Cormorants, *Phalacrocorax carbo* Linnaeus, 1758, inhabit costal areas as well as inland wetlands and are opportunistic feeders. Food studies in this species are made from regurgitated fish in the colony, by the reconstruction of fish species and size from otoliths, pharyngeal bones and chewing pads in pellets collected in colonies and under roosts (Van Eerden et al. 1995). The daily food intake of Great Cormorants has been studied by various methods such as pellet, regurgitated fish, or stomach content analysis, energetic models and captive bird studies (Carpentier & Marion 2003). The regurgitation method that is often used for cormorants (Veldkamp 1995) is accurate enough to measure the chicks' daily food intake (Carpentier & Marion 2003) and thus to assess the chicks' diet and its seasonal variation.

The Great Cormorant is a regular breeder in northern Iran, with breeding locations in coastal zones of the Caspian Sea, along streams and wetlands. It is the most widespread and abundant cormorant species in Iran (Scott 2007, Mansoori 2008), and has caused severe damage to fisheries in northern Iran (Monavari 1987). Nevertheless, many basic aspects of its breeding biology and diet composition are still unknown. In the present study, I therefore studied the diet of chicks using regurgitates. Chick development was monitored to determine if the brood size and chick age affect growth rate. This survey was conducted in the coastal colony of Ramsar in Mazandaran province, southern Caspian Sea, during the 2003 breeding season.

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Study area and methods

Ramsar Colony. One of the main colonies of Great Cormorants in northern Iran is located in Ramsar, Mazandaran province (35°54'N, 50°40'E) where 300-500 pairs breed regularly. This breeding population has existed since at least 1999 (BARATI 2003). Ramsar lies in the western parts of Mazandaran Province in Northern Iran, on the southern Caspian Sea. The altitude is 20 m below sea level, and the temperature was 10.4, 14.5 and 20.9°C in March, April and May, respectively, when this survey was carried out.

Data Collecting. Regurgitated food items were collected by walking through the colony causing young birds to vomit spontaneously. Samples were collected at four time intervals to monitor the changes in the species composition in the diet. All fish items were identified and measured. A total of 10 samples of regurgitated fish with altogether 158 prey items were collected. 16 nests were chosen in different parts of the colony in order to study the development of the young. It is thought that this sample is representative for the colony, including potentially young and old parts of the colony. The 16 nests had brood sizes of 1 chick (3 nests), 2 chicks (3 nests), 3 chicks (6 nests) and 4 chicks (4 nests). At the time of hatching, the chicks were marked with soft tape rings showing individual numbers. The oldest chick in each brood was defined as age-ranking 1, the second as age-ranking 2, and so on. All nests were monitored until fledging. When several chicks of a brood had hatched on the same day, criteria such as the dryness of the down and the presence of a fresh umbilical cord were used to assign hatching order according to KALMBACH & BECKER (2005). The nests were checked every 2–3 days and the chicks were weighed with a Pesola spring balance and wing length was measured with calipers. The mean of two wings was considered as wing growth. The chicks were lifted out of the nest on each occasion and measurements were made. Chicks were measured from a minimum distance of hatching, and continued up until the moment when chicks started to jump out of the nests and became impossible to catch. But only the maximum age of 30 day was taken into account. Chicks whose rank was not known were not included in the analyses in terms of hatching order, but were included in terms of brood size. The average mass gained during the period of 1-30 days was used. For comparing chick growth in terms of brood size, only those broods were included in which the number of siblings was constant at least to the age of 15 days, so two nests with a brood of three and one nest with a brood of four were excluded from the analysis because of the chick mortality. In order to detect any possible effect of age ranking within a brood and brood size on growth rate, analysis of variance was performed to determine the separate effects of age ranking and brood size. Data for some age rankings and brood sizes were pooled.

Results

Structure of the colony

Cormorants establish their colonies either on trees or on the ground. In the Ramsar colony Great Cormorants breed in trees. Most nests are on *Tilia begonifolia*, *Acer insigne, Alnus glutinosa, Fraxinus* spp., *Morus* spp. and *Prunus avium*, located at heights between 1.5 and 3.2 m (mean: 2.4, SD=0.43, n=46). Nests were generally situated at the outer end of thin branches, and some nests were therefore inaccessible for studies of chick development. The mean distance of the colony site to the water edge in the Caspian Sea is about 100 m. The mean distance to the nearest nest was 1.5 m (SD=0.2, n=38). In this colony, some other colonial birds breed in low numbers together with Great Cormorants, such as Cattle Egret (*Bubulcus ibis* Linnaeus), Little Egret (*Egretta garzetta* Linnaeus), and Black-crowned Night Heron (*Nycticorax nycticorax* Forster). The number of Great Cormorant nests was 385 and the density was 175.7 nests per hectare.

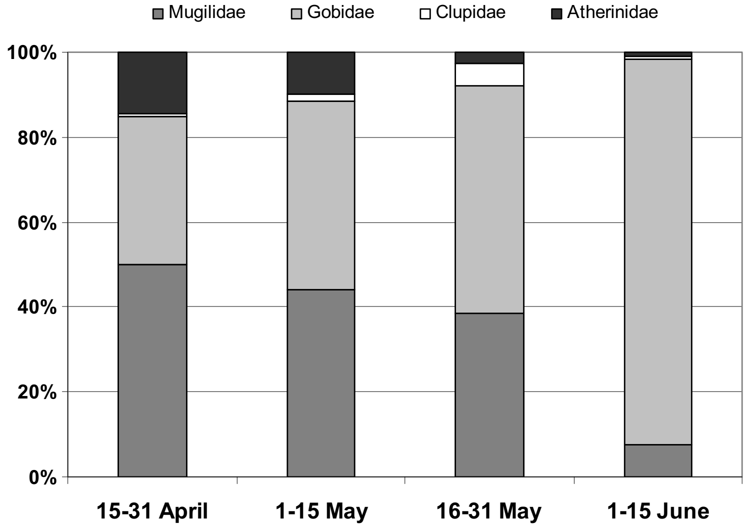


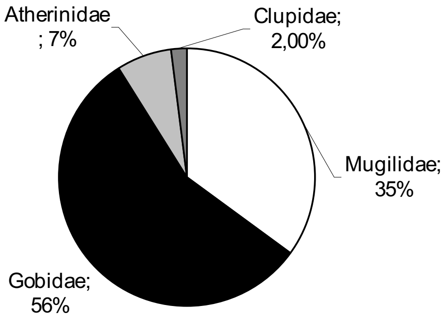
Fig. 1. Changes in the relative frequency of various fish families among the regurgitated fish by mass in the Ramsar colony in the 2003 breeding season.

Diet composition

The fish species in chick regurgitates belonged to the Mugilidae, Atherinidae, Clupeidae and Gobiidae. A comparision of the food composition in different periods was made from mid-April to mid-June. Mugilidae were the most important prey in the early stages of chick-rearing folowed by Gobiidae as the main prey in the later stages of chick development (Fig.1). Fig. 2 arranges the fish found in the chick regurgitates according to their frequency of occurrence in the samples. Expressed in term of biomass, Gobiidae and Mugilidae were the dominant families in the chicks' diet (Figs 1, 3) and made up about 90% of the whole fish mass. Atherinidae and Clupeidae formed smaller proportions of the diet. The mean weight of samples was 16.4 g (range: 4.7-130, median = 7.2, SD = 27.9, n = 158), and it was higher in the late periods of chick rearing. The measurements of the mass of fresh regurgitated fish showed that the mass category of 5-10 g was the most abundant weight class. The mean length of prey was 10.9 cm (range: 5-24, median = 9.5, SD = 4.1, n = 158). Also the most abundant length of the fish was 5-10 cm (Fig. 4).

Chick development

Measurements of the body mass changes of chicks were undertaken as soon as possible after hatching and were continued as long as the chicks cold be reached. The mean weight of newly hatched chicks was 52.2 g (SD = 5.1, n = 17). The growth rate was 86.21 g/d (range 58.7-112.2, SD = 15.4, n= 33). The rate of body mass increase was not significantly different between chicks of different age classes ($F_{2,30}$ = 0.506, p>0.05; Fig. 5). Also the brood size had no effect on chick growth ($F_{2,13}$ = 0.733, p>0.05). The combined influence of age



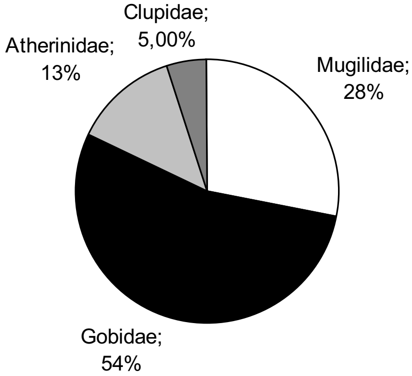


Fig. 2 (left). Frequency of fish families in the regurgitated prey by number. – Fig. 3 (right). Proportion of fish families in the diet by mass.

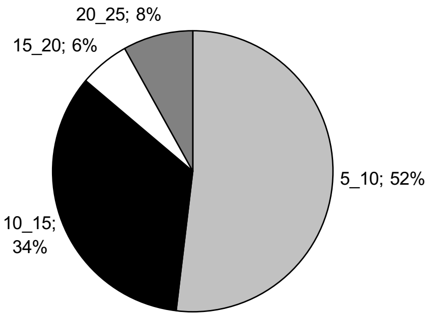


Fig. 4. Frequency of occurrence of fish families by length (cm).

ranking and brood size was not significant (p>0.05). The range of wing growth was 5.5-8.2 mm/d with a mean of 7 mm/d (Fig. 6). The mean growth was not significantly different between chicks of different ages ($F_{2,30} = 0.547$, p>0.05). The mean growth of wings in the study period in the nest with different brood size was 6.77, 7.12 and 7.46 for a brood of 1 and 2, 3 and 4, respectively (Fig. 7). The brood size also had no significant effect on wing growth ($F_{2,13} = 0.633$, p>0.05).

Discussion

At the Ramsar colony, the 158 prey items analysed from regurgitated fish at different times of the breeding season were mostly euryhaline and brackish water species. Mugilidae and Gobiidae had the highest proportions among the regurgitated fish species and formed about 90% of the biomass. Demtschenko et al. (1999) also found Gobiidae to be the main prey for cormorants in the Azov-Black Sea-region (Ukraine), with *Neogobius melanostomus*

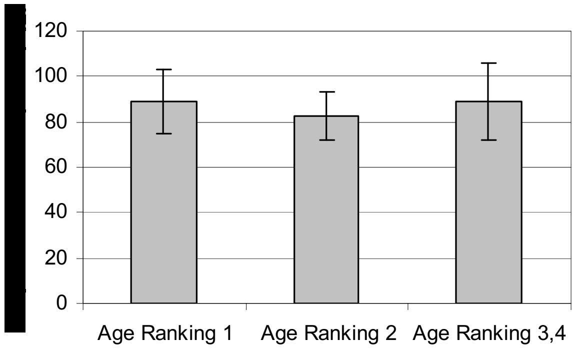


Fig. 5. Increase of body mass in young Great Cormorants of different age rankings (g/day).

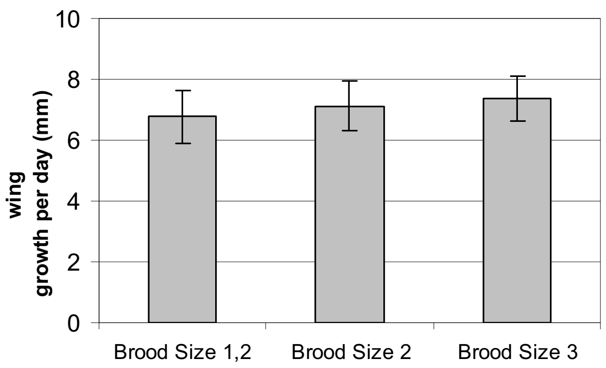


Fig. 6. Wing growth in young Great Cormorant at different age rankings.

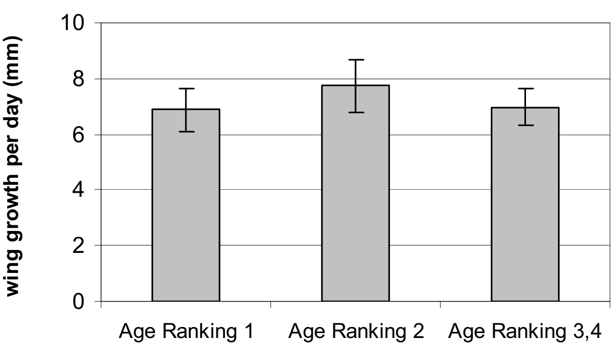


Fig. 7. Wing growth in young Great Cormorants in nests with different brood sizes.

as the dominant species. In the Ramsar colony, species such as *Clupeonella* spp. do not seem to play an important role in the diet (Figs 2-3). One probable explanation for this is the recent decline of *Clupeonella* stocks in the Caspian Sea (NEGARESTAN et al. 2001).

The main prey in the diet varied during different chick rearing periods. The most important prey in the early stages of chick rearing was the Mugilidae, followed by Gobiidae later in the season. In a diet assessment of fish-eating birds in northern Iran, BEHROUZI-RAD (1992) found Cyprinidae and Mugilidae to be the most important items in the diet of adult Great Cormorants, comprising 58% and 40% of the whole mass respectively. PRIVILEGGI (2003) in Valle Cavanta, Italy, also found the Mugilidae to be the most numerous prey in the winter diet of Great Cormorants.

VAN DOBBEN (1952) found the stomach regurgitates of nestling cormorants to be an indicator of parental diet. However, some differences in the diet of adult and nestling birds may occur.

Great Cormorants have been reported to cause damage to fisheries in northern Iran (MONAVARI 1987). In our colony, economically important fish species such as Clupeidae and Mugilidae made up about 37% of all the biomass (Fig. 3) and were more frequent in the early stages of chick rearing rather than in late stages (Fig. 1). PRIVILEGGI (2003) found these species to be more abundant during the cold season in the diet of adult Great Cormorants. More direct effects on the economically important species are reported in fish ponds or artificially stocked lakes or rivers where high densities of fish are kept (VAN EERDEN et al. 1995). It seems important to conduct a long-term survey on the diet of adult Great Cormorants, especially to determine seasonal changes.

In the Ramsar colony, the mean biomass of the prey was 16.4 g and was lower compared to the mean biomass of regurgitated fish from the Azov-Black Sea-region (Ukraine) colony in which 60.7% weighed between 30 and 81 g (DEMTSCHENKO et al. 1999). The biomass of the prey varied seasonally as a result of chick growth and increasing food requirements during the study period, or may be also because bigger fish become more available during the season.

Little information has been published about changes in the diet composition depending on changes in the fish community (VAN EERDEN et al. 1995). It will be necessary to investigate the changes in the abundance of different fish species and the occurance of these species in the diet and the relationship between these two parameters. The cormorant diet reflects the fish community of an ecosystem and also the variation in the abundance of the fish species. So it would be useful to study the differences between the diet of Great Cormorants in the breeding and wintering areas in northern Iran compared with the diet of the chicks in different breeding colonies and in different wintering areas. The daily food requirement and its changes during chick development at this breeding colony of Great Cormorants in Iran is a useful tool for monitoring the relationship between diet and the growth rate of chicks. It would be useful to determine the role of different diet compositions in chick growth.

Not only does the number of young fledged birds reflect the colony performance, but so does the quality of output: body condition of nestlings could affect survival (VAN RIJN et al. 2003). The measurements showed that the mean body mass growth is 86.21 g. per day during the period of 1-30 days of age. In a study on the effect of brood size on growth rate, PLATTEEUW et al. (1995) found the daily mass increment to be between 56.36 to 102.77 with a mean of 74.86. At the Ramsar colony, the age ranking and brood size had no effect on chick growth. So age-ranking does not seem to have any effect on wing growth in Great Cormorant chicks at this colony. PLATTEEUW et al. (1995) found growth rate to be independent of brood size, but there was a negative correlation between age rankings and growth rate.

The mean increase in wing length was 7 mm per day. Among the 13 chicks measured, wing growth was not influenced by age ranking and brood size. PLATTEEUW et al. (1995) mentioned that the average energetic requirements per nest could be reliably estimated by multiplying a chick's individual needs by brood size. In can be concluded that at the Ramsar colony the chicks were well fed so that the mean growth rate was more than in some other colonies studied (PLATTEEUW et al. 1995). It is likely that fish are more abundant at this colony site. It was also shown that body condition was strongly related to nestling mortality (VAN RIJN et al. 2003) which was relatively low at the Ramsar colony (BARATI 2003). Some important factors considered to affect the breeding success in Great Cormorants are: food and its spatial and temporal availability, the distance between nesting and feeding areas, the climate, and other environmental factors.

Because of the short distance between the nesting and feeding areas, the Ramsar colony is a favourable breeding habitat for Great Cormorants. This is one of the most important factors influencing habitat quality and breeding efficiency. Another important factor may be the peak time of hatching in which the demands of the whole colony increase and may exceed the available resources. At the Ramsar colony, due to the short distance between feeding and breeding areas and due to the large feeding area, the probability of depleting the food resources is low. In general, this colony seems to provide a favourable breeding area for the Great Cormorant in northern Iran. Research is necessary into other aspects of this species, aiming at improving our knowledge about its ecology through monitoring studies, as well as minimizing the perceived conflict with human fisheries through ecological research.

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