FOOD OF CORMORANTS *Phalacrocorax carbo sinensis* WINTERING IN BAVARIA, SOUTHERN GERMANY

THOMAS KELLER

ABSTRACT Following the spectacular population increase in continental Cormorants, numbers of wintering birds on lakes and rivers in Bavaria, southern Germany, have risen sharply. Because of a growing concern among commercial fishermen and anglers, a diet study has been carried out at two major roosts: one at a lake (lake Chiemsee) and one at a dammed river (lower Inn river). Main prey species were cyprinids (Rudd, Roach, Chub and Bream), but at lake Chiemsee the commercially most important Whitefish also appeared in the diet during spawning in December/January. Mean daily intake per bird increased in the course of winter, because of larger specimens taken. Possible causes and effects of this phenomenon are discussed. Assuming an average daily uptake of 400 g fresh mass, it was estimated that at lake Chiemsee 3.3% of the total annual fish production was taken by Cormorants (vs. 28% by commercial fishermen). The total catch of Whitefish by Cormorants amounted to a mere 3.2% of the total commercial catch of this species. Larger proportions were scored for Eel (22.3%) and Pike (6.2%). At the lower Inn river it was estimated that Cormorants took 21% of the total annual fish production. Both in view of species composition in the Cormorants' diet and of the consumption estimates specified above, it is considered unlikely that the birds impose a serious threat to commercial fisheries. Interference with recreational angling (e.g. for Grayling) may, however, occur.

Weinbergstrasse 9, D-97753 Karlstadt-Stetten, Germany.

INTRODUCTION

As a consequence of the increase of the Cormorant *Phalacrocorax carbo sinensis* as a breeding bird in NW-Europe since the early 1980s (Van Eerden & Gregersen 1995), the numbers of wintering individuals in Bavaria (southern Germany) have increased substantially. Details on the development of this wintering population are presented by Wüst (1981), Leibl & Vidal (1983), Bezzel & Engler (1985), Zach (1987), Franz & Sombrutzki (1991) and Bezzel (1989, 1992). This increase has caused concern among both commercial fishermen and anglers. Food studies in the wintering regions of the Cormorant have mainly been carried out in other areas within Europe, i.e. Switzerland (EAWAG 1975, 1979, Ruhlé 1985, Imfeld et al. 1986, Müller 1986, Bundesamt für Umweltschutz 1987, Morel & Hausmann 1989, Suter 1991a, b, c, d), France (Im & Hafner 1984), in The Netherlands (Marteijn & Dirkse 1991, Platteuw et al. 1992, Dirksen et al. 1995) and in Austria (Trauttmansdorff 1992). Most of these have shown cyprinids to be the main prey items. This paper provides a brief overview of the food choice of the birds from two of the major Bavarian roosts, based on the analysis of pellets.

STUDY AREA AND METHODS

The two roosts were selected for their suitability for pellet collection. One of them was located on the smallest of three islets in lake Chiemsee (47°52’ N, 12°25’ E), the largest Bavarian lake (79.9 km²), the other on the banks of the lower Inn river (48° 18’ N, 13° 11’ E), which is dammed for power generation (Fig. 1). At each of the two roosts pellets were collected on five consecutive
days each month throughout the winter of 1990/91 (November-February at lake Chiemsee, December-February at the lower Inn river). Pellet collection always took place in the early morning, before scavengers could get at them, and only fresh and complete ones were taken. A total of 1758 pellets from both roosts were analysed. The numbers of Cormorants present at the roosts were recorded in the evenings before the pellet collections. At lake Chiemsee additional counts were made in October and March.

All identifiable fish remains (otoliths, pharyngeal bones, opercula, eye lenses, vertebrae, etc.) were separated and analysed (for methods see EAWAG 1975, 1979, Jonsson 1979, Müller 1986, Worthmann & Spratte 1987, Morel & Hausmann 1989, Marteijn & Dirksen 1991, Zijlstra & Van Eerden 1995). No attempt for correction of wear was made.

RESULTS

At lake Chiemsee the average monthly numbers of Cormorants were 244 in November, 255 in December, 231 in January and 165 in February. In October and March 150 birds were recorded (Lohmann pers. comm.). At the lower Inn river the numbers of Cormorants were somewhat higher; average monthly Cormorant numbers being 288 in December, 302 in January and 211 in February. No counts were made in October, November and March. As the counts of the winter before (1989/90) showed very similar results (Franz & Sombrutzki 1991), the numbers of October 1989 (185), November 1989 (327) and March 1990 (95) were used for calculation of bird days.

Identifiable fish remains were found in 62% of all pellets \( (n = 1758) \), 20% only contained unidentifiable remains, while about 18% were completely empty. A total of 2303 individual prey items was found, belonging to 22 different species of fish (Table 1). The length spectrum of the fish caught ranged from 3 cm cyprinid fry to 70 cm Eel Anguilla anguilla (corresponding to a mass spectrum of 1-900 g). The food composition of the Cormorants was quite similar at the two roosts, consisting mainly of cyprinids (50-76% in numbers, 31-64% in biomass at lake Chiemsee and 64-90% in numbers, 58-82% in biomass at the lower Inn river; Fig. 2). At lake Chiemsee the most important cyprinid species were Rudd Scardinius erythrophthalmus, Roach Rutilus rutilus and Chub Leuciscus cephalus. At the lower Inn river mainly Bream Abramis brama and Roach were caught. The economically very important Whitefish Coregonus spp. were only
Table 1. Prey species of Cormorants in the winter of 1990/91 at lake Chiemsee and the lower Inn river, southern Bavaria.

<table>
<thead>
<tr>
<th>Fish length, cm</th>
<th>Fish mass, g</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Min</td>
</tr>
<tr>
<td><strong>Anguilla anguilla</strong></td>
<td>45.6</td>
<td>23.2</td>
</tr>
<tr>
<td><strong>Salmo trutta fario</strong></td>
<td>24.5</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>Oncorhynchus mykiss</strong></td>
<td>24.6</td>
<td>11.2</td>
</tr>
<tr>
<td><strong>Coregonus spp.</strong></td>
<td>28.6</td>
<td>13.0</td>
</tr>
<tr>
<td><strong>Thymallus thymallus</strong></td>
<td>27.5</td>
<td>13.2</td>
</tr>
<tr>
<td><strong>Rutilus rutilus</strong></td>
<td>27.3</td>
<td>9.3</td>
</tr>
<tr>
<td><strong>Leuciscus leuciscus</strong></td>
<td>24.7</td>
<td>18.2</td>
</tr>
<tr>
<td><strong>Leuciscus cephalus</strong></td>
<td>25.4</td>
<td>16.9</td>
</tr>
<tr>
<td><strong>Leuciscus idus</strong></td>
<td>19.3</td>
<td></td>
</tr>
<tr>
<td><strong>Scardinius erythrophthalmus</strong></td>
<td>24.5</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Aspius aspius</strong></td>
<td>37.2</td>
<td>32.7</td>
</tr>
<tr>
<td><strong>Tinca tinca</strong></td>
<td>27.4</td>
<td>25.2</td>
</tr>
<tr>
<td><strong>Chondrostoma nasus</strong></td>
<td>34.1</td>
<td>27.4</td>
</tr>
<tr>
<td><strong>Barbus barbus</strong></td>
<td>30.3</td>
<td>28.8</td>
</tr>
<tr>
<td><strong>Alburnus alburnus</strong></td>
<td>18.0</td>
<td>16.2</td>
</tr>
<tr>
<td><strong>Blicca björkna</strong></td>
<td>22.7</td>
<td>18.6</td>
</tr>
<tr>
<td><strong>Abramis brama</strong></td>
<td>23.5</td>
<td>16.7</td>
</tr>
<tr>
<td><strong>Cyprinidae, not identified</strong></td>
<td>15.2</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Esox lucius</strong></td>
<td>37.3</td>
<td>25.2</td>
</tr>
<tr>
<td><strong>Lota lota</strong></td>
<td>29.8</td>
<td>17.9</td>
</tr>
<tr>
<td><strong>Perca fluviatilis</strong></td>
<td>13.3</td>
<td>6.8</td>
</tr>
<tr>
<td><strong>Stizostedion luciperca</strong></td>
<td>20.7</td>
<td>8.3</td>
</tr>
<tr>
<td><strong>Gymnocephalus cernua</strong></td>
<td>13.1</td>
<td>11.9</td>
</tr>
</tbody>
</table>

Consumed in their spawning period at lake Chiemsee during the months of December and January (up to 29% in numbers, 41% in biomass; Fig. 2). Consumption of Eel (another economically important species) was also virtually restricted to lake Chiemsee, where only in November some large individuals (6% in numbers and 31% in biomass) were taken (Fig. 2). Grayling *Thymallus thymallus*, an important recreational species for anglers, were found at both sites, but only in January and February at the onset of their spawning period (Fig. 2). In the latter month their proportion reached up to 23% in numbers (21% in biomass) at lake Chiemsee and up to 8% in numbers (15% in biomass) at the lower Inn river. The only other species reaching a proportion of over 10% (either in numbers or in biomass) in any month were Perch *Perca fluviatilis* (in November 12% in numbers, 6% in biomass at lake Chiemsee and in December 23% in numbers, 9% in biomass at the lower Inn river; Fig. 2) and Burbot *Lota lota* (in November 12% in biomass, 4% in numbers at lake Chiemsee). Two other species of recreational importance to anglers, Pike *Esox lucius* and Pikeperch *Stizostedion luciperca*, were never found in proportions exceeding 1% of the prey items. Thus, except for the absence of the typically pre-
Fig. 2. Food composition (number and biomass) of Cormorants at lake Chiemsee and the lower Inn river in the winter of 1990/91.

alpine lake dwelling Whitefish in the diet of Cormorants of the lower Inn, there were only minor differences in the food choice of both roosts.

Seasonal changes in food composition suggest that in lake Chiemsee cyprinids are partially substituted by Whitefish during the latter’s main spawning period in December and, to a lesser extent, January. When Whitefish disappears from the diet by February, the proportion of cyprinids does not recover its original November level, since it is now being replaced by Grayling, which start their spawning period by then. At the lower Inn river a sharp decrease in the proportion of Perch between December and January was compensated for entirely by an increase in the proportion of cyprinids. Marginal increases between January and February in the proportions of Perch and Grayling were accompanied by a slight decrease in cyprinids.

The estimated mean fish mass per pellet, usually considered to be the individual bird’s mean daily food intake (cf. Voslamber 1988, Dirksen et al. 1995, Veldkamp 1995), was 273 g. The frequency distribution of fish mass per pellet was skewed towards the upper end (Fig. 3). Two overall tendencies have been found: an increase in the mean fish mass per pellet in the course of the winter (values for January and February well above those for November and December) and a decrease in the numbers of individual fish per pellet. Furthermore, an increase occurred throughout the winter in the mass of individual fish consumed and pellets containing one to three prey items (279 g) occurred more often than those with more than three (161-236 g).

Using the bird numbers of each month (recalculated to bird days) and an individual daily food ration of 400 g/day, the total fish consumption was estimated. At lake Chiemsee the Cormorants
consumed about 14,522 kg of fish (36,306 bird days) during the winter (October-March). From data on diet composition it was calculated, that they mostly took cyprinids (7150 kg). The proportions of the commercially important Whitefish, Eel and Pike were about 2300 kg, 1679 kg and 270 kg respectively. If only considering the lake area of 7990 ha, the predation pressure was calculated to be 1.8 kg/ha. This figure will be too high, as the birds sometimes use the adjacent rivers Alz, Traun, Tiroler Ache and Inn as additional foraging areas. Especially Grayling must have been taken from the rivers, as this is a very rare species in the lake. The Cormorants consumed about 864 kg of it during the winter. At the lower Inn river the Cormorants took about 17,075 kg of fish (42,688 bird days). Again, they mostly consumed cyprinids (11,369 kg). The proportions of the recreationally important Pike, Pikeperch, Eel and Grayling were 1185 kg, 806 kg, 879 kg and 1100 kg. During their stay, the birds use a stretch of 80 km of the river (Reichholf 1988), with an area of approximately 2730 ha. Thus, their predation pressure was calculated to be 6.3 kg/ha (213.4 kg/km). As the birds additionally forage in some smaller gravel lakes and some rivers, flowing into the river Inn (e.g. Rott, Mattig, Salzach), during some weeks of the winter, the predation pressure on the river Inn will be somewhat lower in reality.

**DISCUSSION**

Prey species composition as well as the seasonal changes in it found in this study, agree very well with earlier findings in Swiss lakes and dammed rivers (EAWAG 1975, 1979, Imfeld et al. 1986, Müller 1986, Suter 1991a, b, c, d). A similar study carried out in summer in Schleswig-Holstein, however, revealed a completely different prey composition (Worthmann & Spratte 1987). In this case, Eel was preyed upon with much higher frequency. Although sufficient knowledge about fish densities, fish ecology and fish behaviour at lake Chiemsee and the lower Inn river is lacking, the prey composition found suggests that serious damage to either commercial fisheries or anglers is unlikely to occur, but there might be some competition between anglers and birds. At lake Chiemsee, commercially interesting species as Whitefish and Eel are only caught by Cormorants at very restricted periods of time.

In 1990 the total commercial catch was 122,946 kg. This figure was quite low compared to the five year average (1986-1990) of 152,159 kg. The Cormorants consumed 11.8% of the commercial catch. Lohmann (1991) estimated an annual fish production of 55 kg/ha for the lake. Comparing this figure to predation pressure and commercial catch, it is found that the Cormorants consumed about 3.3% (1.8 kg/ha) of the annual fish production, whereas the fishermen took 28% (15.4 kg/ha) of it. Unfortunately, there is no information available on angling yields. Considering the commercially important Whitefish, it is found that Cormorants took only 3.2% of the commercial catch (1990: 72,012 kg). Eel (not native to the lake) and Pike are not equally important to fisheries. The commercial catches were 7524 kg and 1682 kg in 1990 respectively, of which the Cormorants consumed 22.3% and 6.2%.
The annual fish production of the lower Inn river was estimated to be about 30 kg/ha (Kainz, pers. comm.). The Cormorants consumed about 21% (6.3 kg/ha) of it. Also in this case only very few data are available on angling yields, because a variety of German and Austrian angling associations fish in the river and also some private fishing occurs. The only data available came from one fishing association that uses about 1700 ha of the river Inn, issuing 1035 annual licenses. As there are quite some additional anglers in the same stretch of the river, which are not registered in that particular association, the available data were multiplied by an estimated correction factor of 1.25 in order to get an idea of the total angling yield. Thus, the anglers took about 32 646 kg of fish in 1990, that equals 19.2 kg/ha (64% of the annual fish production). According to the predation pressure found (6.3 kg/ha), the Cormorants consumed about 33% of the angling yield.

Comparing the yield to the species composition in the Cormorants’ diet, it was found that both anglers and birds go for pretty much the same species. The estimated angling yield of cyprinids was 22 855 kg and Cormorants consumed about 31% of it (values from diet composition data, calculated down to the 1700 ha the angling association uses). But there was one interesting difference. Within the cyprinid family the anglers took mostly carp (12 125 kg), whereas the birds took virtually none of it. Considering Pike, Pikeperch and Eel, Cormorants consumed about 26.3%, 75.1% and 17.8% of the yield (Pike: 2805 kg, Pikeperch: 668 kg, Eel: 3079 kg). For the endangered Grayling, it was found that it is taken only at the very end of the Cormorants’ stay, which coincides with the onset of the Graylings’ spawning. From the data of the angling yields, it is obvious that the Cormorants do not catch their Graylings in the river Inn. There the proportion of Grayling in the angling catch was only 0.3% (104 kg) compared to an average of 8% in the Cormorants’ diet. Furthermore, Kainz (pers. comm.) reported 100-150 Cormorants feeding on Grayling for about two weeks in February 1991, at the small Austrian river Mattig, which is a tributary of the river Inn and only 12 km away from the roost of the Cormorants.

When comparing the situations at lake Chiemsee and the lower Inn river to similar Swiss waters, it is seen that much higher numbers of Cormorants than those recorded at either study site, did not have appreciable negative impacts on fish stocks present (Suter 1991b). However, for more exact predictions of impact of Cormorants on fish stocks more extensive studies on fish are needed. Once again, it has become apparent that Cormorants do not show any clear species preference, but take whatever prey species present at its fishing grounds. Judging by the range of lengths found (Table 1), the size of the fish does not seem to impose a real problem either. Within the piscivorous waterbirds, Cormorants should thus be considered generalists, able to exploit the most abundant stocks of any fish species.

Daily food intake by individual Cormorants in Bavaria in winter, as estimated by mean fish mass per pellet, seems to be low in comparison with the value of 500 g generally proposed (Deufel 1984, Imfeld et al. 1986, Müller 1986, Worthmann & Spratte 1987). A lower value (330 g), however, was also found by Voslamber (1988), while Reichholf (1990) even estimated it to be a mere 100-150 g. The finding that fish mass per pellet was higher in pellets containing only few individual prey items suggests that birds, lucky enough to catch some big fish at the beginning of their day’s foraging, satisfy their needs earlier than less fortunate ones. Thus, it can be argued that fish mass per pellet for pellets containing the remains of many small fish is more likely to represent the minimum daily needs of the individual bird (cf. Van Dobben 1952). On the other hand, the bird catching larger prey items may have the advantage of putting on body reserves. This could be an explanation for the higher daily rations found at the end of the winter, when the birds should be preparing for the return journey and the following breeding season. The possibilities of catching larger prey later in winter may be greater too, since the lower water temperatures at
this time are likely to reduce the maximum swimming speed of all fish (Wardle 1975). Thus, the larger specimens (generally the faster swimmers; Wardle 1977), which earlier might have been too quick to be caught, only become available to the Cormorants at lower water temperatures.

ACKNOWLEDGEMENTS

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SAMENVATTING


Mogelijke oorzaken en gevolgen van dit verschijnsel worden besproken. Uitgaande van een gemiddeld dagrantsoen van 400 g verse vis en het aantal berekende vogeldagen, was de schade op Chiemsee 3.3% van de totale jaarlijkse visproductie van 55 kg/ha door Aalscholvers weggevangen (tegen maar liefst 28% door de beroepsvisserij). De predatiedruk van de vogels werd hier geschat op maximaal 1.8 kg/ha. Op de rivier de Inn bedroeg de predatiedruk 6.3 kg/ha, waarmee naar schatting 21% van de totale jaarlijkse visproductie door de vogels werd geconsumeerd.

Vooral vanwege de soortsamenstelling van de prooien en de bovengenoemde schattingen lijkt het onwaarschijnlijk dat Aalscholvers de beroepsvisserij in de bestaande situatie aantoonbare schade berekken. Wel is het niet uit te sluiten dat sportvissers en Aalscholvers concurreren, met name bij de visserij op Vlagzalm.