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CORMORANTS *PHALACROCORAX CARBO* WINTERING IN THE LAGOON OF VENICE, ITALY

ABSTRACT: Regular censuses have been carried out in the Lagoon of Venice to assess the size and trend of the local wintering population of the cormorant. Fortnightly surveys were made at the beginning and middle of each month, from October until April. A clear bimodal pattern of presence for the cormorants wintering in the Lagoon was noticed: peak counts were always noted at the beginning of December and in mid-March. The drop in the number of birds recorded mid-way through each study period is probably related to low temperatures. The cold drives a lot of fish, preyed on by the cormorants, into deeper waters of the Adriatic Sea. Besides, every year the areas in which extensive fish-farming is practised were frozen, preventing the cormorants from using them as feeding grounds.

KEY WORDS: cormorant, winter movements, temperature effects, food content, Lagoon of Venice, Italy.

1. INTRODUCTION

At 50 000 ha, the Lagoon of Venice (45°11'–45°35' N, 12°07'–12°38' E) is one of the largest coastal wetlands of the Mediterranean and the northernmost one where large numbers of cormorants *Phalacrocorax carbo* (nearly 2000 birds in 1993) settle in the winter. Both of these reasons convinced us that it was an interesting site to study wintering cormorants. Moreover, a large part of the Lagoon (8800 ha) was dammed and is currently used for fish-farming (Fig. 1); in the tidal part only traditional fishing is practised. The Lagoon is divided, therefore, into two different feeding habitats, where the possible impact of cormorants on human activities can substantially differ. The area has not yet been used by cormorants for breeding.

The general pattern of the seasonal occurrence of cormorants has recently been described on the basis of regular counts carried out between 1988–89 and 1991–92 (Cherubini et al. 1993). Figures obtained during an additional season (1992/1993) are presented here, as well as a more general description of the feeding ecology and habits of cormorants in the area.

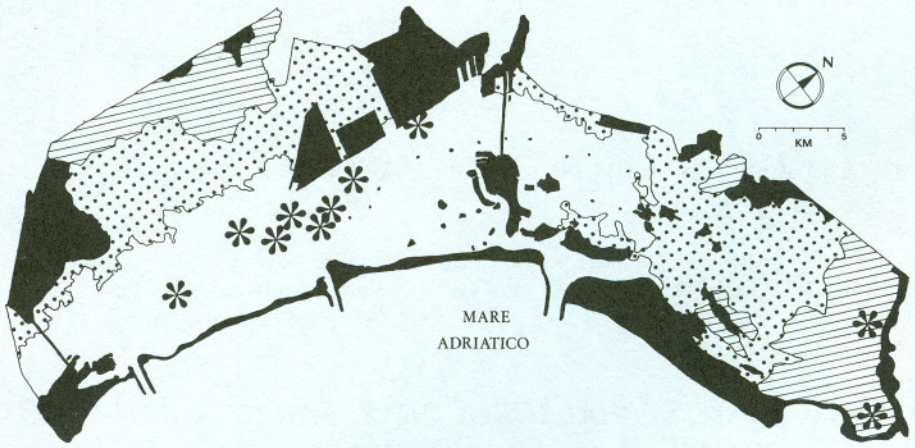

Fig. 1. The Lagoon of Venice. Dammed ponds where extensive fish–farming is practised (hatched areas), salt-marshes and mudflats (dotted areas) and night roosts of cormorants (stars) are shown

2. METHODS

Detailed investigation of the seasonal variations of the size of Venice cormorant population were carried out during the periods 1988/1989–1990/1991 by organizing fortnightly counts, at the beginning and middle of each month (October–April).

To investigate the effect of the temperature on the size of the cormorant population, we selected the five central counts of each season (mid-December to mid-February), and plotted bird numbers against mean air temperatures during 2 weeks before each value was recorded. To avoid the effect of year-to-year variation in the population size, bird numbers were expressed as a percentage of the maximum of the five counts in each winter.

The diet composition and its variation under different climatic conditions

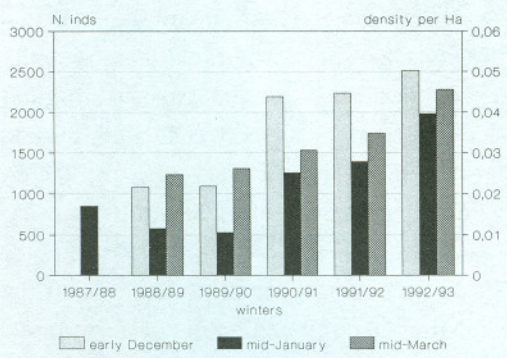

Fig. 2. Selected counts of cormorants carried out in the Lagoon of Venice from 1988 to 1993

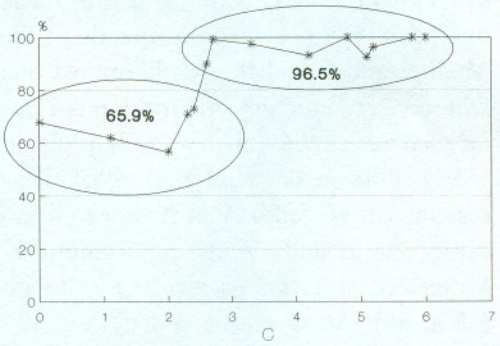

Fig. 3. The relationship between cormorant population size and average air temperature. Bird numbers are expressed as a percentage of the maximum seasonal count. Numbers in the ellipses are the means of the two count group separated by the temperature of +2.5 °C

were studied by selecting a small roost containing birds which feed in the open lagoon only. Pellets were collected on three dates in the winter of 1991–92, after setting a net under an electricity pylon where 50–80 birds used to spend the night. Only otoliths were examined, from a total of 93 pellets.

3. RESULTS

3.1. POPULATION SIZE

Fig. 2 shows the results of the regular counts conducted over the 5 seasons from 1988/89 to 1992/93, with a count for January 1988 also. It is clear that the population has increased, as seen over most of the European range (van Eerden and Zijlstra 1991). The maximum count so far (2500) was obtained early in 1992–93. Even such high counts, however, are not spectacular when the size of the site is taken into account and compared with the densities recorded at smaller coastal wetlands in central or southern Italy. Thus, in the Lagoon of Venice, the maximum density of cormorants was 0.05 ha^{-1} in December 1992, while in the main wetlands of Tuscany, Latium and Sardinia densities between 0.4–1.2 indiv. x ha^{-1} were recorded as long ago as January 1987 (Baccetti 1988). Also, in considering only areas where fish–farming is practised, a hypothetical maximum of 0.28 indiv. x ha^{-1}, which is still lower than the values recorded in central Italy.

3.2. CLIMATIC CONDITIONS

Every winter, we observed a bimodal pattern of occurrence of wintering cormorants, without any significant difference among the winters (Kendall t-test, $p < 0.01$). Strong peaks were always recorded in early December and in mid-March, while a sharp reduction in numbers was observed mid-way through each winter (cf Cherubini et al. 1993). Excluding peak figures which are probably determined by a dynamic presence of migrants, we still observed much variation between mid-December and mid-February. Minimum values were not recorded at the same time in all three winters (mid-December and mid-January in 1988/89; mid-January in 1989/90; early February and mid-February in 1990/91), suggesting a direct and short-term effect of climatic conditions rather than any link with more regular parameters.

A threshold situation seems to fall between +2 and +3 °C, as below this interval bird numbers suddenly drop by

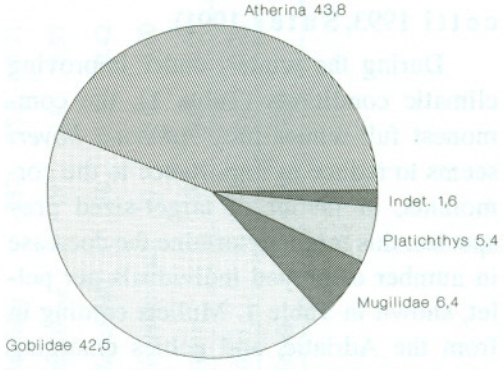

Fig. 4. Diet composition of cormorant, expressed as the number of individuals preyed upon. Numbers express percentages for each taxa. *Dicentrarchus labrax* (0.2%) and *Sparus auratus* (0.1%) are not shown

30%, while no important variations can be observed at higher or lower temperatures (Fig. 3). The two groups of counts separated by the value of +2.5 °C are significantly different (Mann-Whitney test, $p = 0.003$), averaging respectively 65.9% and 96.5% of the highest count in the season.

Below a mean temperature of +2.5 °C all the fish-farming areas freeze, as the water salinity is lower than in the open lagoon and tidal movements are prevented by dams. The extent of farmed area equates, approximately, to 16% of the whole lagoon. Their importance for cormorants, then, does not seem proportional to the surface area, as they are apparently able to affect drastically at least 30% of the population. It has to be considered, however, that severe weather may also effect food availability throughout the lagoon, driving fish into deeper and warmer waters of the Adriatic Sea.

So far, it has been impossible to estimate the importance of the different parts of the lagoon for feeding cormorants, for a variety of reasons (e.g. access to the fish-farming areas is difficult because they are private and fenced). Recording flight directions to and from night roosts did not offer very clear results, as the position of main roosts does not always allow observers to discriminate between open lagoon and fish-farming areas (Fig. 1).

3.3. FEEDING ECOLOGY

The overall diet is portrayed in Fig. 4. *Atherina boyeri* and gobies *Gobiidae* comprised 86.3% of the diet and a few (6.4%) mullets *Mugilidae* from unmanaged stocks seem the only prey with some potential commercial value. Also, in the Lagoon of Venice, as well as in many other wintering sites, the bulk of the diet is composed of only a few taxa (c.f. Boldreghini et al. 1997, Eerden and Munsterman 1986, Sarà and Baccetti 1993, Suter 1991).

During the winter, under improving climatic conditions (Table 1), the commonest full-winter prey *Atherina boyeri* seems to reduce in importance to the cormorants, in favour of larger-sized prey species: this might determine the decrease in number of preyed individuals per pellet, shown in Table 1. Mullets coming in from the Adriatic, and gobies emerging from winter burrows, apparently become more available at this time. It has to be added that four pellets, all from the January sample, contained almost exclusively shrimps *Palaemon* sp. The diet composition (considering fish only) differed significantly among the three months (c^2, $p < 0.000001$).

Unfortunately, we know relatively little about cormorant diet from inside the fish-farming areas, where more economically important fish species are reared. From the analysis of very few pellets collected in January 1990 (average temperature +2.7 °C) at a roost formed by birds coming from such areas (Table 2), quite a subtle difference seems to exist with the diet of open-lagoon feeders. More bass *Dicentrarchus labrax* and mullet are of course taken but still *Atherina* and gobies are the commonest prey.

Table 1. Monthly variation in the diet composition of cormorants feeding in open-lagoon situations in the Lagoon of Venice. Average air temperatures were calculated for the two weeks before each sample was collected. Fr = recovery frequency; i/p = individuals per pellet

Date	3 January				22 February				15 March				Totals			
Temperature	+2.7 °C				+4.5 °C				+7.3 °C							
Pellets	24				38				31				93			
Fish	N	%	Fr	i/p	N	%	Fr	i/p	N	%	Fr	i/p	N	%	Fr	i/p
Atherina	681	67.3	0.87	28.4	257	36.2	0.55	6.8	29	6.0	0.52	0.9	967	43.8	0.62	10.3
Gobiidae	232	22.9	0.71	9.7	340	47.9	0.76	9.0	365	75.3	0.81	11.8	937	42.5	0.76	10.1
Mugilidae	29	2.9	0.37	1.2	73	10.3	0.61	1.9	40	8.2	0.55	1.3	142	6.4	0.53	1.5
Platichthys	56	5.5	0.42	2.3	26	3.7	0.24	0.7	38	7.8	0.32	1.2	120	5.4	0.31	1.3
Dicentrarchus	0	0.0	0.00	0.0	1	0.1	0.03	0.0	4	0.8	0.06	0.1	5	0.2	0.03	0.1
Sparus	0	0.0	0.00	0.0	1	0.1	0.03	0.0	0	0.0	0.00	0.0	1	0.1	0.01	0.0
Indet	14	1.4	0.21	0.6	12	1.7	0.16	0.3	9	1.9	0.26	0.3	35	1.6	0.20	0.4
Totals	1012	100.0		42.2	710	100.0		18.7	485	100.0		15.6	2207	100.0		23.7

Table 2. Diet composition of cormorants feeding in fish-farming areas. Average temperature of January 1990 is shown. Fr = recovery frequency; i/p = individuals per pellet

Date		January 1990		
Temperature		+2.7 °C		
Pellets		14		
Fish	N	%	Fr	i/p
Atherina	106	65.0	0.43	7.6
Gobiidae	27	16.6	0.29	1.9
Mugilidae	14	8.6	0.64	1.0
Platichthys	0	0.0	0.00	0.0
Dicentrarchus	10	6.1	0.07	0.1
Sparus	1	0.6	0.07	0.1
Indet	5	3.1	0.07	0.4
Totals	163	100.0		11.6

4. SUMMARY

Regular censuses have been carried out in the Lagoon of Venice to assess the size and trend of the local wintering population of cormorant during three winters: 1988/89–1990/91. Fortnightly surveys were made at the beginning and middle of each month, from October until April. It is described the distribution of cormorants in the study area (Fig. 1). A clear bimodal pattern of presence for the cormorants wintering in the Lagoon was noticed: peak counts were always noted at the beginning of December and in mid-March, while in January and February the population size fell to about 50% of the maximum seasonal values (Fig. 2). The drop in the number of birds recorded mid-way through each study period is probably related to low temperatures (Fig. 3). The cold drives a lot of fish, preyed on by the cormorants, into deeper waters of the Adriatic Sea. Besides, every year the areas in which extensive fish-farming is practised were frozen, preventing the cormorants from using them as feeding grounds.

To study food contents 93 pellets collected during winter 1991/1992 were analysed. The results of this analyzis are shown in Tables 1 and 2 and on the Fig. 4.

5. POLISH SUMMARY

Regularne liczenia kormoranów zimujących nad Zatoką Wenecką prowadzone były w latach 1988/1989–1990/1991. Liczenia odbywały się od października do kwietnia na początku i w połowie każdego miesiąca. Opisano rozmieszczenie ptaków na badanym obszarze w różnych okresach zimy (rys. 1). Stwierdzono dwa szczyty liczebności – na początku grudnia i w połowie marca. W pozostałych okresach liczebność ptaków spadała o około 50% w stosunku do liczebności najwyższych (rys. 2). Wahania liczebności kormoranów wydają się być związane ze zmianami temperatury. Spadek liczebności kormoranów obserwowany w środku każdej zimy jest prawdopodobnie związany z następującym w tym okresie obniżeniem temperatury (rys. 3). Jego przypuszczalną przyczyną jest emigracja ryb z wyziębionych płytkich wód Zatoki do głębszych i cieplejszych wód Adtriatyku. Dodatkową przyczyną może być także zamarzanie wody na terenie farm rybackich co uniemożliwia kormoranom żerowanie.

W celu zbadania składu pokarmu zimujących ptaków przeprowadzono analizę 93 wypluwek, zebranych zimą 1991/1992 na noclegowisku liczącym 50–80 ptaków. Skład pokarmu kormoranów żerujących na wodach Zatoki w różnych miesiącach przedstawia tab. 1 i rys. 4. Skład pokarmu ptaków żerujących na terenie farm rybackich charakteryzuje tab. 2.

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