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THE DIET OF GREAT CORMORANTS *PHALACROCORAX CARBO* WINTERING IN SOUTHWESTERN FRANCE

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RÉSUMÉ. — *Le régime alimentaire de Grands Cormorans* Phalacrocorax carbo *hivernant dans le sud-ouest de la France*. — L'étude du régime alimentaire du Grand Cormoran *Phalacrocorax carbo* dans le sud-ouest de la France a été réalisée grâce à l'analyse de 385 contenus stomacaux issus d'oiseaux prélevés dans le cadre du plan de régulation national de cette espèce. Suite à l'augmentation des effectifs nicheurs dans le nord-ouest de l'Europe au début des années 80, le nombre d'oiseaux hivernants dans le sud-ouest de la France a fortement augmenté. Cette hausse a provoqué de vives réactions notamment chez les pêcheurs qui ont obtenu des tirs de contrôle du Grand Cormoran. Dans cette étude nous analysons les contenus stomacaux d'oiseaux provenant de différentes rivières de Midi-Pyrénées et d'Aquitaine. 22 espèces de poissons dont la taille varie de 2 à 50 cm ont été répertoriées. Les proies principales sont constituées par la famille des cyprinidés. Le gardon *Rutilus rutilus* est l'espèce ayant la plus forte occurrence, mais en terme de biomasse, le barbeau *Barbus barbus* est la proie la plus importante. Le poisson-chat *Ictalurus melas* joue aussi un rôle important dans le régime alimentaire du Grand Cormoran. Ces premiers résultats dans des rivières françaises et l'impact du Grand Cormoran sur ces milieux sont discutés.

In aquatic ecosystems, predator-prey interactions between birds and fish can play an important role in the structure and dynamics of the food-chain. Cormorants *Phalacrocorax carbo* represent top-predators and are therefore good indicators of the general health of the water environment. They are important predators of fish and they have received considerable attention in the literature. Studies on the diet and distribution of Cormorants have been done in particular during the breeding period (Warke *et al*., 1994; Veldkamp, 1995; Kirby *et al*., 1996; Musil & Janda, 1997; Grieco, 1999). Data from the non-breeding period have been published from fish farms in France (Im & Hafner, 1984), water bodies in Switzerland (Suter, 1995) and lake Ketelmeer in the Netherlands (Platteuw *et al*., 1992). Seasonal variation in the prey species are also studied all over the year (e.g. Keller 1998). In southwestern France the Cormorant was a rare species seldom seen in the early 70's (Affre & Affre, 1978). It is presently a common and regular wintering waterbird. The increasing number of regional wintering birds is highly correlated with the demographic explosion of the Danish and Dutch colonies (Bousquet, 1992; Marion, 1997). The debate about Cormorant predation of fish stock has been sufficiently strong to have resulted in reductions of Cormorant popu-

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lations by shooting. However, particularly in southwestern France, little is known about species and size composition of the diet of wintering Cormorants. In this area, commercial fisheries are few; even if some conflicts between man and fish eating birds were noticed, most of them came from interference with recreational angling.

This paper provides a brief overview of the diet of Cormorants in southwestern France, based on stomach contents analyses. The impact of wintering Cormorants on fish stock is also discussed.

MATERIAL AND METHODS

A total of 385 stomachs were analysed from 49 different sites located in Midi-Pyrénées area (Ariège, Aveyron, Haute-Garonne, Lot, Tarn and Tarn-et-Garonne) and in Aquitaine area (Dordogne, Landes, Lot-et-Garonne and Pyrénées-Atlantiques). Only the cyprinid dominant part (middle basin) of rivers were taken into account. Salmonid dominant parts will be analysed elsewhere (Santoul *et al*., in press). The main rivers of southwestern France area are represented in this study (Adour, Ariège, Aveyron, Dordogne, Garonne, Lot and Tarn).

Cormorant's diet was assessed by examining the stomach contents of birds shot under license by agent of the French Environment Minister (CSP: Conseil Supérieur de la Pêche and ONCFS: Office National de la Chasse et de la Faune Sauvage) in winter during the period 1997-2002. Only recent meals where included in the analyses. Some stomachs also contained the remains of previous well-digested meals but these were excluded, differences between relatively fresh fish and older retained items in the posterior part of the stomach are often clear. Whole fish were identified and their lengths measured. Fish lengths were converted to fresh weight by the series of regression equations we had validated (for method see Carss & Marquiss, 1997). This study aims at characterizing the global diet of wintering Cormorants in southwestern France. We do not intend to assess daily food intake. There are several reasons for this, first Cormorants where shot in the morning and as well as in the evening at roosting places, second quantifying food intakes from stomach contents analyses has several biases, quick digestion of some prey being the most obvious one (Carss & Marquiss, 1997). A percent occurrence (i.e. the percentage of individual Cormorants in which each fish species was recorded) was calculated for every fish species. We also calculated the biomass of fish items in the stomachs expressed as the mean of biomass percentages (aggregate percent).

RESULTS

Identifiable fish remains were found in 48% of all stomachs (n = 186). In all 846 identifiable individual prey items were found, belonging to 22 different fish species (Table I). Cyprinids represent 50% of the total number of species found in this study. The size range of the fish taken is considerable: 2-50 cm in length and 2-900 g in weight.

Table II shows that the dominant prey species in terms of occurrence were cyprinids. Within this family the Roach *Rutilus rutilus* (28.6%), Barbel *Barbus barbus* (24.8%) and Bleak *Alburnus alburnus* (9.7%) were the most common. Catfish *Ictularus melas* (22.7%) was also an important prey. In weight (aggregate percent biomass) cyprinids still dominate with 62.2%: Barbel (22.2%), Roach (15.5%) and Chub (5.1%) are the most important of this family. Catfish (18.8%) is also important.

Predators (Pike *Esox lucius*, Perch *Perca fluviatilis* and Pikeperch *Sander lucioperca*) account respectively for 2.1, 8.6 and 2.3% of occurrence and 1.5, 5.1 and 1.6% of mean biomass.

For the three principal species of fish caught (Roach, Barbel and Catfish), the mean size varied from 11.6 cm (4 to 25 cm) for the Roach to 22.2 cm (5 to 50 cm) for the Barbel (Table I).

DISCUSSION

The stomach contents of collected birds have been commonly used to estimate diet (e.g. Rae,1960; Carss & Marquiss, 1997; Carss *et al*., 1997). In our study, a total of 22 prey species eaten (in the cyprinid zone) reflects the great plasticity of the Cormorant foraging behaviour (Van eerden & Zijlstra, 1997). Cormorants are almost entirely piscivorous, but no high commercial or fishing value fish species were found as main prey in the present study. The fish fauna of southwestern France rivers is dominated by cyprinids which represent 50% of the fish species caught by Cormorants which most commonly take Roach, Barbel and Catfish in Midi-Pyrénées and Aquitaine area These species have been frequently

TABLE I

Prey species of wintering Cormorants in southwestern France (N = number of fish measured)

Scientific name	Name	Fish length, cm			Fish mass, g			N	%
		Mean	Min	Max	Mean	Min	Max		
Abramis brama (L., 1758)	Bream	14.6	5	23	45.9	3	125	29	3.4
Alburnus alburnus (L., 1758)	Bleak	8.6	5	13	8.2	4	22	156	18.4
Anguilla anguilla (L., 1758)	Eel	30.0			144.0			1	0.1
Barbus barbus (L., 1758)	Barbel	22.2	5	50	165.0	4	900	74	8.7
Micropterus salmoides (Lacépède, 1802)	Largemouth bass	17.7	11	28	76.5	12	240	6	0.7
Blicca bjoerkna (L., 1758)	Silver bream	11.0	11	11	15.0	15	15	3	0.4
Carassius carassius (L., 1758)	Crucian carp	16.0	12	26	58.0	20	220	25	2.9
Cyprinus carpio (L., 1758)	Carp	15.7	6	40	81.0	5	420	19	2.2
Esox lucius (L., 1758)	Pike	24.0	19	32	106.0	60	205	4	0.5
Gobio gobio (L., 1758)	Gudgeon	8.8	5	18	12.9	5	65	16	1.9
Gymnocephalus cernua (L., 1758)	Ruffe	10.0			12.0			1	0.1
Ictalurus melas (Rafinesque, 1820)	Catfish	13.1	4	27	45.4	5	210	147	17.4
Lepomis gibbosus (L., 1758)	Pumpkinseed	5.1	4	12	3.9	3	11	79	9.4
Leuciscus cephalus (L., 1758)	Chub	23.4	9	29	179.9	10	310	14	1.7
Leuciscus leuciscus (L., 1758)	Dace	24.4	23	30	186.0	150	280	5	0.6
Mugil cephalus (L., 1758)	Mullet	24.0	23	25	166.0	142	190	2	0.2
Perca fluviatilis (L., 1758)	Perch	11.6	6	25	23.3	4	120	29	3.4
Rutilus rutilus (L., 1758)	Roach	11.6	4	25	24.7	2	160	197	23.3
Salmo trutta fario (L., 1758)	Brown trout	24.0	17	31	145.1	60	280	15	1.8
Scardinius erythrophtalmus (L., 1758)	Rudd	14.7	10	20	41.7	11	89	16	1.9
Sander lucioperca (L., 1758)	Pikeperch	26.5	21	30	195.0	115	215	4	0.5
Tinca tinca (L., 1758)	Tench	20.5	12	31	133.3	23	290	4	0.5

TABLE II

Percentage occurrence and biomass of fish items in the stomachs of Cormorants wintering in southwestern France

Scientific name	Name	Occurrence of stomachs%	Mean biomass of total fish weight%*
Abramis brama (L., 1758)	Bream	8.1	4.4
Alburnus alburnus (L., 1758)	Bleak	9.7	3.1
Anguilla anguilla (L., 1758)	Eel	0.5	0.5
Barbus barbus (L., 1758)	Barbel	24.8	22.2
Micropterus salmoides (Lacépède, 1802)	Largemouth Bass	2.7	0.7
Blicca bjoerkna (L., 1758)	Silver Bream	0.5	0.5
Carassius carassius (L., 1758)	Crucian Carp	5.4	3.5
Cyprinus carpio (L., 1758)	Carp	5.4	3.2
Esox lucius (L., 1758)	Pike	2.1	1.5
Gobio gobio (L., 1758)	Gudgeon	2.2	1.3
Gymnocephalus cernua (L., 1758)	Ruffe	0.5	0.1
Ictalurus melas (Rafinesque, 1820)	Catfish	22.7	18.8
Lepomis gibbosus (L., 1758)	Pumpkinseed	4.3	2.1
Leuciscus cephalus (L., 1758)	Chub	5.9	5.1
Leuciscus leuciscus (L., 1758)	Dace	1.6	1.2
Mugil cephalus (L., 1758)	Mullet	1.1	0.7
Perca fluviatilis (L., 1758)	Perch	8.6	5.1
Rutilus rutilus (L., 1758)	Roach	28.6	15.5
Salmo trutta fario (L., 1758)	Brown Trout	5.4	5.4
Scardinius erythrophtalmus (L., 1758)	Rudd	3.8	2.4
Sander lucioperca (L., 1758)	Pikeperch	2.2	1.6
Tinca tinca (L., 1758)	Tench	1.1	1.1

* Aggregate percent (see text).

recorded in the diet of Cormorants in similar habitats (e.g. Van dobben, 1952; Cramp & Simmons, 1977; Keller, 1995; Boudewijn & Dirksen, 1997). Numerous studies have found that the main prey species of Cormorants are cyprinids, representing between 50% and more than 90% of the species found in Cormorant's diet (Keller, 1995; Van eerden & Zijlstra, 1997; Privileggi, 2003; Trauttmansdorff, 2003). Cormorants exploit a wide range of fish from 4 to 50 cm, but mainly 10-22 cm in length (mean size of 11.6 cm for the principal prey, the Roach). These sizes are also much alike those of the most frequently eaten individuals elsewhere (e.g. Keller, 1995; Martyniak *et al*., 1997).

It is difficult to make a general classification of species of value for anglers in the cyprinid zone. However within the cyprinid family anglers take mostly Carp (*Cyprinus carpio*), whereas the birds take only few (5.4% of occurrence). Predators especially Pike, Perch and Pikeperch are also highly valuable for anglers. In the stomachs analysed, the proportion of predators was quite low, especially for Pike and Pikeperch. For Perch, 8.6% of occurrence in stomachs do not seem to be a significant impact on the Perch stock which is well represented in the Adour-Garonne basin (Mastrorillo *et al*. 1998).

However, accurate estimation of fish stock is not possible in most large rivers of our study site. In order to estimate Cormorant impact on fish stock we have used an indirect method. Using recent studies from southwestern France (e.g. CSP unpublished data, Hutagalung *et al*., 1997; Santoul *et al*., 2004), we have compared principal fish (e.g. roach) present in stomachs in a given area and class size of this fish caught by gillnets. In all rivers studied no impact of Cormorants can be found on fish class structure (e.g. lack of one class). The good balance of these classes shows that fish stock seems to be strong enough to support wintering Cormorant predation in most of southwestern rivers (open wetlands).

However some Cormorants fed in adjacent wetlands of the Garonne River (e.g. gravel pits) and the proportion of birds foraging on theses places is difficult to estimate. In such closed wetlands, the impact of Cormorants seems to be higher (Santoul, 2000). Catfish often caught by Cormorants are well represented in gravel pits (Santoul, 2000). For Warke *et al*. (1994), the distribution and abundance of Cormorants was controlled by fish availability. During the wintering period they are highly mobile, they move rapidly from place to place (Kirby *et al*., 1996); these numerous wetlands, by providing numerous fish with numerous individuals, are important places for wintering Cormorants in southwestern France (Santoul, 2000). The provision of alternative prey like Catfish and Pumpkinseed with no commercial or angling value could protect river stock, even if also this has the disadvantage of increasing the total density of potential prey available to Cormorants and may result in larger numbers of birds being attracted (Draulans, 1987). In some circumstances, there may be merits in sacrificing the fish to Cormorants in one particular area (e.g. unmanaged gravel pits) in order to conserve fish stock in other areas, though this would need to be part of a wider management strategy (Kirby *et al*., 1996).

Because of our important sample size we are able to characterize globally the diet of Cormorants in southwestern France. However, more work is required to better estimate the impact of Cormorants on fish stocks in each wetland.

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