*Journal of Biological Research* **7**: 51 – 57, 2007
*J. Biol. Res.* is available online at http://www.jbr.gr
Indexed in: CAS (Chemical Abstracts Service) and DOAJ (Directory of Open Access Journals)

# Diet of the great cormorant (*Phalacrocorax carbo* L. 1758) at two Greek colonies

VASILIOS LIORDOS* and VASSILIS GOUTNER

*Department of Zoology, School of Biology, Aristotle University, GR-54124 Thessaloniki, Greece*

Received: 28 December 2006 Accepted after revision: 1 May 2007

The diet and commercial value of prey of the great cormorant (*Phalacrocorax carbo* L. 1758) were studied at two Greek colonies: the Axios Delta and the lake Mikri Prespa, through the analysis of regurgitated pellets. A variety of fish taxa were found in the samples, but only one or two dominated in the great cormorant's diet. Prussian carp (*Carassius gibelio*) dominated in the Axios Delta, whereas pumpkinseed (*Lepomis gibbosus*) and Prussian carp were the most important in the lake Mikri Prespa. Differences in diet found between the areas are probably due to differences in prey species richness and diversity. Fish of high commercial value contributed in low proportions to the great cormorant's diet. The small overlap between the bird's diet and the valuable prey suggests minimal competition with fisheries.

**Key words:** Great cormorant, pellet analysis, Axios Delta, lake Mikri Prespa, Greece.

## INTRODUCTION

The great cormorant (*Phalacrocorax carbo* L. 1758) is a widespread waterbird that feeds almost entirely on fish (Cramp & Simmons, 1977; Johnsgard, 1993). Its populations have been increasing (although stabilised recently) since the 1970s throughout its European range (Debout *et al*., 1995; Van Eerden & Gregersen, 1995; Marion, 2003; Volponi & Addis, 2003), mainly attributed to the legal protection and increase in fish productivity due to eutrophication of aquatic habitats (Russell *et al*., 1996). As a consequence, severe conflicts with angling and fisheries interests have been risen in many countries (Russell *et al*., 1996; Cowx, 2003). Therefore, much research on great cormorant's diet, energetics, and impact on fish populations has been conducted, especially during the last ten years (e.g. Grémillet *et al*., 1995; Keller, 1995; Veldkamp, 1995a, b; Goutner *et al*., 1997; Lorentsen *et al*., 2004). Subsequently, management and control plans were formulated and applied (Kirby *et al*., 1996; Bildsøe *et al*., 1998; Marion, 2003).

The great cormorant numbers have also been increasing in Greece since the 1970s. The breeding population of 550 pairs counted in 1971 (Handrinos & Akriotis, 1997) soared to an all-time high (5,360 pairs) in 2002 (Liordos, 2004). The bird's fish-eating habits along with its population explosion prompted an urgent need for studies on great cormorant's diet and its impact on fish populations and fisheries. Five studies on the diet of the great cormorant have been carried out in Greece. Goutner *et al*. (1997) reported the diet of nestlings in the Axios Delta in 1993 and 1994 and Liordos *et al*. (2002) reported the diet of wintering great cormorants at the Amvrakikos Gulf. Dimitriou *et al*. (2003) examined the effects caused by great cormorant depredation on commercial fish at Bouka lagoon, Messolonghi, while Kazantzidis & Naziridis (2003) studied the effect of great cormorants on fishery in the lake Kerkini. Liordos & Goutner (2007) compared the bird's diet in three wintering areas.

In this essay we: (1) describe, for the first time in Greece, the diet of great cormorants in two major Greek colonies through the analysis of pellet contents; (2) compare diet composition between areas; and (3) evaluate the commercial value of the fish consumed.

* Corresponding author: tel.: +30 210 4113703, fax: +30 22960 83652, e-mail: liordos@yahoo.com

## MATERIALS AND METHODS

The study was conducted in the Axios Delta and at lake Mikri Prespa colonies (Fig. 1), both of them designated as Wetlands of International Importance under the Ramsar Convention. The Axios Delta (40° 27′ – 40° 38′ N, 22° 33′ – 22° 52′ E) belongs to a large wetland complex covering a total of 68.7 $km^2$, situated near the city of Thessaloniki (Athanasiou, 1990). The breeding colony included three heron species and was located on an islet at a riverine forest of tamarisks (*Tamarix hampaena*), common alders (*Alnus glutinosa*), and willows (*Salix* sp.) (Kazantzidis *et al*., 1997). Lake Mikri Prespa (40° 44′ N, 21° 04′ E) in the far northwestern Greece, along with lake Megali Prespa, is situated at an altitude of 853.5 m a.s.l. Of its surface (47.35 $km^2$), 92% belong to Greece and the rest to Albania. Great cormorants are nested on the Vidronissi island, at a stand of ancient juniper (*Juniperus foetidissima*) trees.

Great cormorants regurgitate an indigested material (e.g., bones, scales, otoliths) in the form of pellets almost daily (Van Dobben, 1952; Zijlstra & Van Eerden, 1995). They are egested early in the morning and are thought to reflect the complete diet of the previous day (Zijlstra & Van Eerden, 1995). Only complete and fresh pellets were collected, early in the morning, soon after the birds departed from their colony. Upon collection, the specimens were individually sealed in a plastic bag and tagged with an identification number, and then stored in a freezer at –20°C. Pellets were thawed on the day of analysis and processed according to Carss *et al*. (1997). Our samples were rather egested by breeding adults, or possibly non-breeding individuals, as suggested by Veldkamp (1995b) for the great cormorant and Harris &

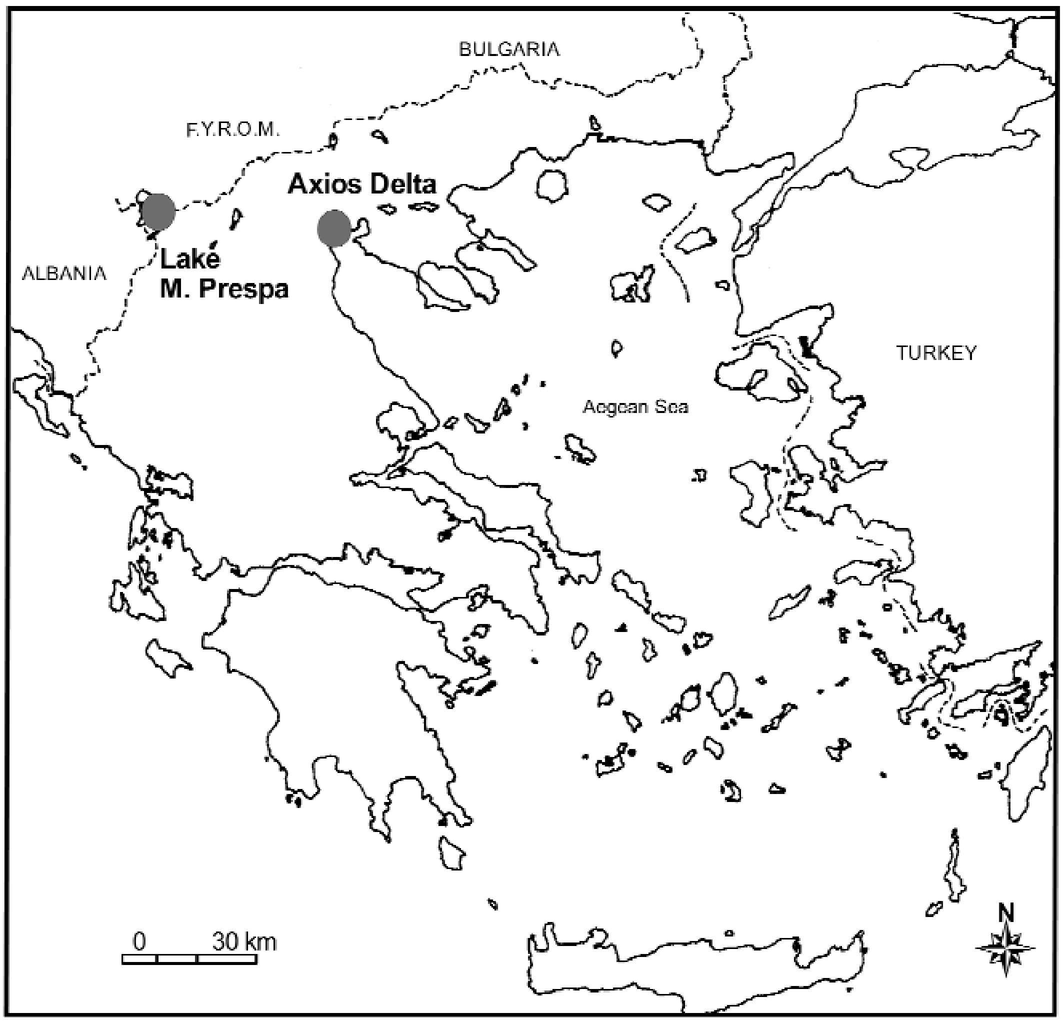


FIG. 1. The study areas in Greece.

Wanless (1993) for the shag (*Phalacrocorax aristotelis*). Great cormorant nestlings do not produce pellets before fledging, up to the age of about eight weeks (Trauttmansdorf & Wassermann, 1995), thus pellets cannot be used for studying their diet.

Otoliths and Cyprinidae chewing pads were mainly collected from the pellets. Cyprinidae are hard to be identified to the species level, because otoliths, mainly, and chewing pads are very small and similar among different species (Veldkamp, 1995a). Otoliths and chewing pads found in the pellets were identified according to Härkönen (1986) and Veldkamp (1995a) in combination with our own reference collection. Other remains, such as scales and pharyngeal bones were not measured, but were used for identification. Each otolith and chewing pad was measured (maximum length and width) to the nearest 0.1 mm using a dissecting microscope. Otoliths and chewing pads were paired, assuming that those differing less than 0.2 mm originated from the same fish.

Pellet contents were analysed by relative abundance by numbers (numbers of each prey type in the sample) and frequency of occurrence (number of samples containing each prey type). Relative abundance by biomass could not be estimated, due to lack of regressions estimating fish length and mass from chewing pads. Spatial variation in diet composition was analysed using $G$ test (Zar, 1999). Species evenness and diversity were also calculated for each area using the Pielou's evenness $J'$, Margalef's $d$, and Shannon-Weaver $H'$ diversity indices (natural logarithm based, Brower *et al*., 1997).

Fish prey taxa were classified according to their commercial value, following Goutner *et al*. (1997) and our own local markets' research (Table 1), and then contribution of each class in the diet was calculated.

## RESULTS

The diet of the great cormorant was composed of at least 10 fish species, belonging to five families (Tables 1 and 2).

In the Axios Delta, the most important of seven prey types found, both by numbers and frequency of occurrence, was Prussian carp (*Carassius gibelio*), followed by Mugilidae (Table 2). Another five fish species were found in pellets in frequencies $< 20\%$ and numbers $< 5\%$. The average number of fish from 16 pellets was $6.0 \pm 2.5$ (SD) ($n = 96$, range 2-14 fish).

In lake Mikri Prespa, four fish species were identified in pellets, of which pumpkinseed (*Lepomis gibbosus*) was the most numerous and frequent prey, followed by Prussian carp, whereas Cyprinidae and *Chalcalburnus belvica* were less important (Table 2). The average number of fish from 35 pellets was $5.5 \pm 5.2$ ($n = 194$, range 1-27 fish).

The composition of the diet presented a significant spatial variation ($G_9 = 217.12$, $p < 0.001$). Only one out of 10 prey types, the Prussian carp, was found, although in high proportions, in the great cormorant's diet in both the Axios Delta and the lake Mikri Prespa. Specific diversity and evenness indices for both areas are given in Table 2.

Prey types of medium and low commercial value dominated in the great cormorant pellets (Tables 1

TABLE 1. Fish species found in the pellets of the great cormorant. Commercial value of prey is also given (1: high; 2: medium; 3: low). Common and scientific names are taken from FishBase online (www.fishbase.org)

| Common names | Scientific names | Commercial value |
|---|---|---|
| | Carangidae | |
| | *Trachurus* spp. | 3 |
| | Centrarchidae | |
| Pumpkinseed | *Lepomis gibbosus* | 3 |
| | Cyprinidae | 2 |
| Bleak | *Alburnus alburnus* | 3 |
| Prussian carp | *Carassius gibelio* | 2 |
| | *Chalcalburnus belvica* | 3 |
| Carp | *Cyprinus carpio* | 1 |
| Roach | *Rutilus rutilus* | 2 |
| | Moronidae | |
| Bass | *Dicentrarchus labrax* | 1 |
| | Mugilidae | 2 |

TABLE 2. Percent relative abundance by numbers and frequency of occurrence of the prey found in the pellets of the great cormorant breeding in the Axios Delta in 1999 and in the lake Mikri Prespa in 2002. Number of pellets analysed as well as total fish numbers ($n$) collected from each area are also given

| Fish taxa | Axios Delta | | lake Mikri Prespa | |
|---|---|---|---|---|
| | % numbers | % frequency | % numbers | % frequency |
| Mugilidae | 7.3 | 25.0 | – | – |
| Cyprinidae | – | – | 13.4 | 34.3 |
| Prussian carp | 81.3 | 93.8 | 20.6 | 62.9 |
| Roach | 2.1 | 12.5 | – | – |
| Bleak | 1.0 | 6.3 | – | – |
| Carp | 3.1 | 18.8 | – | – |
| *Chalcalburnus belvica* | – | – | 11.9 | 40.0 |
| Bass | 2.1 | 12.5 | – | – |
| Pumpkinseed | – | – | 54.1 | 65.7 |
| *Trachurus* spp. | 3.1 | 6.3 | – | – |
| Total | $n = 96$ | 16 pellets | $n = 194$ | 35 pellets |
| Number of taxa | 7 | | 4 | |
| Margalef's $d$ | 1.315 | | 0.596 | |
| Shannon-Weaver $H'$ | 0.785 | | 1.180 | |
| Pielou's evenness $J'$ | 0.403 | | 0.851 | |

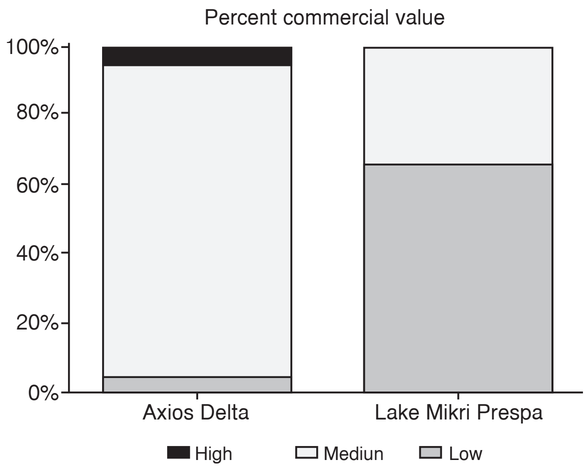


FIG. 2. Commercial value of fish prey of the great cormorant in the Axios Delta and in the lake Mikri Prespa.

and 2, Fig. 2). Fish of medium commercial value dominated in the diet at the Axios Delta, mainly due to the increased presence of Prussian carp. In contrast, fish of low commercial value were most important in the lake Mikri Prespa, where pumpkinseed and small Cyprinidae dominated. Carp (*Cyprinus carpio*) and bass (*Dicentrarchus labrax*) were the only prey of high commercial value that contributed to the great cormorant diet in the Axios Delta, although in low proportions (about 5%). Valuable fish species were not found in the lake Mikri Prespa pellets.

## DISCUSSION

Pellets are easy and quick to collect, with little or no disturbance to the birds, and give good information on the species of fish preyed. On the other hand, several sources of error are involved in the analysis; erosion of fish remains, under-representation of small species due to complete weathering of otoliths and other remains (Carss *et al*., 1997). Therefore, pellet analysis is considered an appropriate method for the qualitative analysis of avian diet, but should not be used for the calculation of daily food intake rates because its disadvantages lead to underestimation of total prey biomass consumed (Carss *et al*., 1997). The lack of regressions estimating fish length and mass from Cyprinidae chewing pads made impossible the calculation of even rough approximations of daily food intake from our samples.

Although several species were included in great cormorant's prey, only a few of them composed the bulk of its diet. Prussian carp dominated in the Axios Delta, whereas pumpkinseed and Prussian carp were the most important in the lake Mikri Prespa. This agrees with other studies (Boldreghini *et al*., 1997; Goutner *et al*., 1997; Martyniak *et al*., 2003; Lorentsen *et al*., 2004; Liordos & Goutner, 2007) and is due to the opportunistic foraging behaviour of the great cormorant (Johnsgard, 1993). Great cormorants are thought to target prey patches of very high density (Grémillet *et al*., 2001) and the link between foraging performance and prey abundance is considered to be stronger than in any other species of diving bird (Grémillet & Wilson, 1999). This leads to the preponderance of these prey types, which are mostly available and abundant in a particular area and season (Grémillet & Wilson, 1999; Grémillet *et al*., 2001). The high contribution of freshwater fish, mainly Prussian carp, but also carp, roach (*Rutilus rutilus*) and bleak (*Alburnus alburnus*) to the birds' diet in the Axios Delta suggests that great cormorants were foraging mostly along the river and probably in other freshwater bodies (lakes Koronia, Volvi and Kerkini). On the other hand, horse-mackerel species (*Trachurus trachurus* and *T. mediterraneus*), found in the great cormorant's pellets, are among the most abundant species in the depth zone of 0-50 m in the Thermaikos Gulf (Papaconstantinou *et al*., 1994, 1997; Kallianiotis *et al*., 2004). Great cormorants can dive to depths more than 40 m, but they are usually feeding in waters of less than 10 m deep (Johnsgard, 1993) and appropriate research on fish abundance at the foraging grounds of the great cormorant is therefore needed.

Pellets were scarce and relatively hard to find in our colonies, being much fewer than those expected by the high number of birds present. Harris & Wanless (1993), Trauttmansdorf & Wassermann (1995), and Veldkamp (1995b) observed a similar situation and suggested that the pellets were produced by adult birds (breeding or non-breeding). Black goby (*Gobius jozo*) and round sardinella (*Sardinella aurita*) in the Axios Delta and *C. belvica* in the lake Mikri Prespa dominated numerically in the diet of great cormorant nestlings in 1999-2002 (Liordos, 2004). The difference in the diet between the nestlings (Liordos, 2004) and the adults (this study) found in Greece has been also observed in The Netherlands by Veldkamp (1995b) for the great cormorant and in Scotland by Harris & Wanless (1993) for the shag. They stressed that part of the differences found could be due to differences in sampling methods (nestling regurgitates and pellets) but suggested that certainly a difference occurred in the diet between young and adult birds. Harris & Wanless (1993) found that shags feed their chicks almost entirely with lesser sandeels (*Ammodytes marinus*), whereas adults were also taking for themselves fish species of lower calorific values compared with lesser sandeels. They concluded that shags select the higher energy value lesser sandeels during the chick-rearing season to meet the increased energy requirements. Our results, compared with Liordos (2004), showed that nestlings were fed with different, preferably smaller-sized, fish species than adults. The calorific value of the great cormorant prey found in this study is not known but a possible explanation for the difference observed could be that, although they can easily handle fish of more than 200 mm fork length (Cramp & Simmons, 1977; Johnsgard, 1993), parent birds more often select large assemblages usually formed by smaller fish. In doing so, they secure plentiful food in short time in order to meet the higher energy requirements during chick-rearing. However, final conclusions cannot be drawn before further research is conducted on the diet composition and prey sizes of young, breeding and non-breeding adult great cormorants, as well as on fish population dynamics and behaviour.

The average number of fish per pellet (6.0 in the Axios Delta and 5.5 in the lake Mikri Prespa) was within the range found in other areas (Italy 6.4: Martucci & Consiglio, 1991; Germany 5.5: Keller, 1995; Switzerland 6.4: Suter, 1991). Diet composition varied considerably between the Axios Delta and the lake Mikri Prespa, with Prussian carp being the only of 10 prey taxa found in both areas, reflecting the spatial variation in species composition. The higher species richness found in the Axios Delta diet reflects the considerable habitat richness of an estuarine environment (Zalidis & Mantzavelas, 1994). Specific diversity is higher in the Axios Delta when only species richness is taken into account (Margalef's $d$, see Table 2). In contrast, when both species richness and evenness are considered, specific diversity is higher in the lake Mikri Prespa than in the Axios Delta, due to the more even distribution of individuals among the species in the former (Shannon-Weaver $H'$, see Table 2). Goutner *et al*. (1997) found 24 fish taxa in great cormorant nestling regurgitates in the Axios Delta, reflecting the differences of the method used in the analysis of the diet.

Several studies (Rae, 1969; Suter, 1991; Keller, 1995; Veldkamp, 1995b; Mellin & Krupa, 1997) have found a small participation of commercial fish in the diet, suggesting low economic damage. On the other hand, serious economic impact may occur in small areas of high fish concentrations such as intensive aquacultures, wintering ditches, small lakes, and reservoirs (Moerbeek *et al*., 1987; Cornelisse & Christensen, 1993; Kirby *et al*., 1996; Russell *et al*., 2003). In this study, the participation of commercially important fish in the diet of the great cormorant was very low. Nevertheless, due to occasional sampling and small sampling size of pellets, no assessment can be made on the potential impact of cormorants on fisheries.

This work was a first attempt to describe the diet of adult great cormorants during the breeding season in Greece, based on pellet analysis. Results presented a "snapshot" of the bird's diet, from which two important patterns emerged: (i) spatial variation in diet composition; and (ii) small overlap between the great cormorant diet and valuable prey. These patterns are to be confirmed by future research involving more samples throughout the breeding season and assessment of the locality specific impact size through the estimation of fish stock levels and total prey biomass removal (Davies *et al*., 2003).

## ACKNOWLEDGEMENTS

We are grateful to Prof. P.S. Economidis who helped us in identifying fish prey taxa. We also express our gratitude to the following people for their assistance in the field: S. Kazantzidis, P. Menounos, F. Passios, and P. Vafeidis.

## REFERENCES

Athanasiou H, 1990. *Wetland habitat loss in Thessaloniki plain, Greece*. M.Sc. Dissertation, University College London.

Bildsøe M, Jensen IB, Vestergaard KS, 1998. Foraging behaviour of cormorants *Phalacrocorax carbo* in pound nets in Denmark: the use of barrel nets to reduce predation. *Wildlife biology*, 4: 129-136.

Boldreghini P, Santolini R, Pandolfi M, 1997. Abundance and frequency of occurrence of fish-prey in the diet of cormorants *Phalacrocorax carbo* in the Po River Delta (Northern Italy) during the wintering period. *Ekologia polska*, 45: 191-196.

Brower JJ, Zar JH, Von Ende CN, 1997. *Field and laboratory methods for general ecology*. McGraw-Hill, USA.

Carss DN, Bevan RM, Bonetti A, Cherubini G, Davies J, Doherty D, El Hilli A, Feltham MJ, Grade N, Granadeiro JP, Grémillet D, Gromadzka J, Harari YNRA, Holden T, Keller T, Lariccia G, Mantovani R, McCarthy TM, Mellin M, Menke T, Mirowska-Ibron I, Muller W, Musil P, Nazirides T, Suter W, Trauttmansdorff JFG, Volponi S, Wilson B, 1997. Techniques for assessing cormorant diet and food intake: towards a consensus view. Proceedings IV European Conference on Cormorants. *Supplemento alle richerche di biologia della selvaggina*, XXVI: 197-230.

Cornelisse KJ, Christensen KD, 1993. Investigation of a cover net to reduce southern cormorant (*Phalacrocorax carbo sinensis*) fisheries depredation in a pound net. *ICES journal of marine science*, 50: 279-284.

Cowx IG, 2003. *Interactions between fish and birds: Implications for management*. Fishing News Books, Blackwell Science Ltd., Oxford.

Cramp S, Simmons KEL, 1977. *Handbook of the birds of Europe, the Middle East and North Africa. The birds of the western Palearctic, Vol. I*. Oxford University Press, Oxford.

Davies JM, Holden T, Feltham MJ, Wilson BR, Britton JR, Harvey JP, Cowx IG, 2003. The use of a Monte Carlo simulation model to estimate the impact of great cormorants *Phalacrocorax carbo* at an inland fishery in England. *Vogelwelt*, 124: 309-317.

Debout G, Røv N, Sellers RM, 1995. Status and population development of Cormorants *Phalacrocorax carbo carbo* breeding on the Atlantic coast of Europe. *Ardea*, 83: 47-59.

Dimitriou E, Kapareliotis A, Acovikiotis K, Pergantis F, Perifanos M, Tsagarakis E, 2003. Injured fishes due to great cormorants' attacks at Bouka Lagoon. *Proceedings of the 11th Panhellenic Ichthyologists Conference*. Preveza, Greece: 215-218.

Goutner V, Papakostas G, Economidis PS, 1997. Diet and growth of great cormorant (*Phalacrocorax carbo*) nestlings in a Mediterranean estuarine environment (Axios Delta, Greece). *Israel journal of zoology*, 43: 133-148.

Grémillet D, Wilson RP, 1999. A life in the fast lane: energetics and foraging strategies of the great cormorant. *Behavioral ecology*, 10: 516-524.

Grémillet D, Schmid D, Culik B, 1995. Energy requirements of breeding great cormorants *Phalacrocorax carbo sinensis*. *Marine ecology progress series*, 121: 1-9.

Grémillet D, Wanless S, Carss DN, Linton D, Harris MP, Speakman JR, Le Maho Y, 2001. Foraging energetics of arctic cormorants and the evolution of diving birds. *Ecology letters*, 4: 180-184.

Handrinos G, Akriotis T, 1997. *The Birds of Greece*. Christopher Helm (Publishers), London.

Härkönen TJ, 1986. *Guide to the otoliths of the bony fishes of the northeast Atlantic*. Danbiu ApS, Hellerup.

Harris MP, Wanless S, 1993. The diet of shags *Phalacrocorax aristotelis* during the chick-rearing period assessed by three methods. *Bird study*, 40: 135-139.

Johnsgard PA, 1993. *Cormorants, darters, and pelicans of the world*. Smithsonian Institution Press, Washington.

Kallianiotis A, Vidoris P, Sylaios G, 2004. Fish species assemblages and geographical sub-areas in the North Aegean Sea, Greece. *Fisheries research*, 68: 171-187.

Kazantzidis S, Naziridis T, 2003. The effect of cormorant *Phalacrocorax carbo sinensis* (Linnaeus, 1758) on fishery at Lake Kerkini, Greece. *Proceedings of the 11th Panhellenic Ichthyologists Conference*. Preveza, Greece: 235-238.

Kazantzidis S, Goutner V, Pyrovetsi M, Sinis A, 1997.

Comparative nest site selection and breeding success in 2 sympatric Ardeids, Black-crowned Night-Heron (*Nycticorax nycticorax*) and Little Egret (*Egretta garzetta*) in the Axios Delta, Macedonia, Greece. *Colonial waterbirds*, 20: 505-517.

Keller T, 1995. Food of cormorants *Phalacrocorax carbo sinensis* wintering in Bavaria, southern Germany. *Ardea*, 83: 185-192.

Kirby JS, Holmes JS, Sellers RM, 1996. Cormorants *Phalacrocorax carbo* as fish predators: an appraisal of their conservation and management in Great Britain. *Biological conservation*, 75: 191-199.

Liordos V, 2004. Biology and ecology of great cormorant (*Phalacrocorax carbo* L. 1758) populations breeding and wintering in Greek wetlands. Ph.D. Dissertation, Aristotelian University of Thessaloniki. In Greek with English summary.

Liordos V, Goutner V, 2007. Spatial patterns of winter diet of the great cormorant in coastal wetlands of Greece. *Waterbirds*, 30: 103-111.

Liordos V, Papandropoulos D, Zogaris S, Alivizatos C, Vrettou E, Arapis T, 2002. *Great cormorant at Amvrakikos Gulf – Research on the conflict between fish-eating birds and fishermen*. Intermediate Report LIFE project.

Lorentsen SH, Grémillet D, Nyomen GH, 2004. Annual variation in diet of breeding great cormorants: does it reflect varying recruitment of gadoids? *Waterbirds*, 27: 161-169.

Marion L, 2003. Recent development of the breeding and wintering population of Great cormorants *Phalacrocorax carbo* in France – Preliminary results of the effects of a management plan of the species. *Vogelwelt*, 124: 35-40.

Martucci O, Consiglio C, 1991. Activity rhythm and food choice of cormorants (*Phalacrocorax carbo sinensis*) wintering near Rome, Italy. *Gerfaut*, 81: 151-160.

Martyniak A, Wziatek B, Szymanska U, Hliwa P, Terlecki J, 2003. Diet composition of Great cormorants *Phalacrocorax carbo sinensis* at Katy Rybackie, NE Poland, as assessed by pellets and regurgitated prey. *Vogelwelt*, 124: 217-225.

Mellin M, Krupa R, 1997. Diet of Cormorant, based on the analysis of pellets from breeding colonies in NE Poland. Proceedings IV European Conference on Cormorants. *Supplemento alle richerche di biologia della selvaggina*, XXVI: 511-516.

Moerbeek DJ, Van Dobben WH, Osieck ER, Boere GC, Bungenberg de Jong CM, 1987. Cormorant damage prevention at a fish farm in The Netherlands. *Biological conservation*, 39: 23-38.

Papaconstantinou C, Politou CY, Caragitsou E, Stergiou KI, Mytilineou C, Vassilopoulou V, Fourtouni A, Karkani M, Kavadas S, Petrakis G, Siapatis A, Chatzinikolaou P, Giagnisi M, 1994. Investigations on the abundance and distribution of demersal stocks of primary importance in the Thermaikos Gulf and the Thracian Sea (Hellas). National Centre for Marine Research, Athens, Greece, Technical Report, North Aegean Series 4/1994.

Papaconstantinou C, Politou CY, Caragitsou E, Mytilineou C, Vassilopoulou V, Fourtouni A, Karkani M, Kavadas S, Petrakis G, Lefkaditou E, 1997. Fishing status of the demersal populations with commercial importance along the north coasts of Hellas. *Proceedings of the 5th Hellenic Symposium on Oceanography and Fisheries*: 79-82.

Rae BB, 1969. The food of cormorants and shags in Scottish estuaries and coastal waters. *Marine resources*, 1: 1-16.

Russell IC, Dare PJ, Eaton DR, Armstrong JD, 1996. Assessment of the problem of fish-eating birds in inland fisheries in England and Wales. *Report to the Ministry of Agriculture, Fisheries and Food, project number VC0104*. MAFF, London.

Russell IC, Dare PJ, McKay HV, Ives SJ, 2003. The potential of using fish refuges to reduce damage to inland fisheries by cormorants, *Phalacrocorax carbo*. In: Cowx IG, ed. *Interactions between fish and birds: Implications for management*. Fishing News Books, Blackwell Science Ltd., Oxford: 65-71.

Suter W, 1991. Food and feeding of cormorants *Phalacrocorax carbo* in Switzerland. In: Van Eerden MR, Zijlstra M, eds. *Proceedings workshop 1989 on Cormorants Phalacrocorax carbo*. Rijkswaterstaat Directorate, Flevoland, Lelystad: 156-165.

Trauttmansdorff J, Wassermann G, 1995. Number of pellets produced by immature Cormorants *Phalacroxorax carbo sinensis*. *Ardea*, 83: 133-134.

Van Dobben WH, 1952. The food of the Cormorant in the Netherlads. *Ardea*, 40: 1-63.

Van Eerden MR, Gregersen J, 1995. Long-term changes in the northwest European population of Cormorants *Phalacrocorax carbo sinensis*. *Ardea*, 83: 61-79.

Veldkamp R, 1995a. The use of chewing pads for estimating the consumption of cyprinids by Cormorants *Phalacrocorax carbo*. *Ardea*, 83: 135-138.

Veldkamp R, 1995b. Diet of Cormorants *Phalacrocorax carbo sinensis* at Wanneperveen, The Netherlands, with special reference to bream *Abramis brama*. *Ardea*, 83: 143-155.

Volponi S, Addis P, 2003. Great cormorants *Phalacrocorax carbo sinensis* in two key Italian wintering areas. *Vogelwelt*, 124: 93-98.

Zalidis CG, Mantzavelas AI, 1994. *Inventory of Greek wetlands as natural resources (first approximation)*. Greek Biotope/Wetland Centre, Thessaloniki.

Zar JH, 1999. *Biostatistical analysis*. *4th Edition*. Prentice Hall International, Upper Saddle River, NJ.

Zijlstra M, Van Eerden MR, 1995. Pellet production and the use of otoliths in determining the diet of Cormorants *Phalacrocorax carbo sinensis*: trials with captive birds. *Ardea*, 83: 123-131.