Riding on the crest of the wave

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RIDING ON THE CREST OF THE WAVE: POSSIBILITIES AND LIMITATIONS FOR A THRIVING POPULATION OF MIGRATORY CORMORANTS *Phalacrocorax carbo* IN MAN-DOMINATED WETLANDS

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ABSTRACT This paper summarises the general findings of the scientific contributions to this special issue of Ardea on Cormorant biology in Europe. After a brief historical introduction setting the main traditional questions that arise whenever man and a species of a free-living animal compete for the same resources in the same habitat, an overview is given of how Cormorant populations have recovered after protective measures were taken over most of Europe. This recovery, particularly spectacular in the continental population, has brought the species once again into direct conflict with human interests. Research has been aimed at unravelling the principal natural factors limiting population growth. Surface area, productivity and accessability of fishing grounds for breeding birds seem to set the extent to which the population may increase but the end of the population growth seems not yet to be at hand. Because of their migratory behaviour birds spread all over western Europe outside the breeding season, showing often site tenacity to stop-over sites as well as predictable migration patterns. Factors influencing the non-breeding distribution include age, sex and probably individual experience of the birds concerned. Local conflicts between human interests and breeding as well as non-breeding Cormorants seem impossible to cope with satisfactorily on a local level, without consideration of the population as a whole. Not every possible impact of Cormorants on fish stocks is bound to be treated as negative: recent studies tentatively indicate that the birds may serve as an 'aid' to fisheries management, keeping eutrophic waters free from dense Bream stocks. Finally, the position of top-predator that Cormorants occupy in aquatic ecosystems, makes them vulnerable to the accumulation of micropollutants. These may hamper breeding success in various ways and, in larger concentrations, may even cause death. Monitoring breeding success as well as pollutant contents in adult and juvenile Cormorants as well as in their eggs may serve as a means to check on trends in environmental quality of aquatic ecosystems.

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INTRODUCTION

Of old, Cormorants *Phalacrocorax carbo* and man have been inhabiting the coastal as well as the inland wetland habitats of the European continent together. Since they both utilise the fish resources of these areas, the fear for competition has caused a traditionally hostile attitude of man towards the Cormorant, as expressed for example by one of the first popular Dutch ornithologists Dr. Jac. P. Thijsse (1903), who called it "literally and figuratively the *bête noire* of the fisherman". As a consequence of this attitude and by means of progressively more effective measures of

Cormorant population control by man, the breeding population of European Cormorants had become very small and localised by the middle of the 20th century. Only then, the preoccupation of the emerging lobby of conservationalists, resulting in the safeguarding of the last remaining colonies within the remains of nature reserves, has managed to stop the alarming decrease and to prevent the species from becoming extinct.

In the second half of the 20th century, it became increasingly frequent among field biologists to focus their attention on traditionally supposed interferences between human interests and the activities of free-living animals in a more objective way. Before jumping hastily to the conclusion that a certain species of animal was seriously jeopardising man's interests and had, therefore, to be subjected to severe population control measures, detailed impact studies were undertaken with the intention of quantifying the amount of overlap between the animal's exploitation of its environment and the interests of man. In the case of the Cormorant, this changing attitude has led to a great number of detailed studies on food choice, food consumption and general feeding ecology, one of the greatest pioneers in this field being W.H. Van Dobben, with his classical study at the Wanneperveen colony in The Netherlands. The first results of these investigations as well as the generally increasing interest of man in nature conservation have contributed to the ecological knowledge and have later on led to protective measures taken in most European countries.

Also the fascination for the species' behaviour was apparent among some biologists, long before ornithology became an honourable branch of science. The work of Portielje (1927) was followed by that of A. Kortlandt who pioneered with an ingeniously constructed watch-tower in the duck decoy of Lekkerkerk which resulted in one of the first individual based behavioural field studies on the species and on birds in general. We appreciate the contributions of both authors in this issue, more than 50 years after most of their research on Cormorants was carried out

POPULATION DEVELOPMENTS

Continental Cormorants *Ph. c. sinensis*, probably having profits from both the legal protection they nowadays enjoy and an overall increase in fish productivity in European waters due to eutrophication, have managed to increase their inland breeding population again from the mid 1970s onwards. The recovery seems to have begun in The Netherlands, where the last important strongholds were found in the mid 1950s. Then, with the Dutch population still fully on the increase, numbers started rising simultaneously all over Denmark, southern Sweden, Germany and Poland, and in the early 1990s the species has begun to colonise the Baltic states. This increase became possible because of the acquired legal state of protection in most of the countries concerned. Renewed human persecution has only had some (slight) regional influence in Poland, where the growth rate of the breeding population may have been consequently lower than elsewhere.

Another race of the Cormorant *Ph. c. carbo*, more bound to marine environments, occurs along the coasts of Norway, Iceland, the British Isles and the French Atlantic coast. Parallel to the developments of the continental European Cormorants, these populations have shown far less marked fluctuations. Norwegian birds have shown local increases, partly masked by temporary and local food shortages resulting in population drops. British birds, however, are generally on the increase, albeit that the rate of population growth is considerably lower (3% per year) than on the European mainland (10-25% per year). Furthermore, it appears that Britain has been colonised also by members of the continental race, establishing breeding nuclei in inland colonies in Essex.

NATURAL LIMITATIONS OF POPULATION GROWTH

As a consequence of the rapidly increasing Cormorant population in continental Europe, the old discussion about interference with human fisheries' interests has risen once again (Moerbeek *et al.* 1987, Zimmerman & Rutschke 1991, Muselet 1990, Staub *et al.* 1993). Since the traditional population control measures like systematically destroying nests at colonies have become very unpopular in present-day society, recent studies are focusing on the factors that have permitted the rapid increase and are, thus, eventually likely to be those that determine the population size. The results presented in this volume identify surface area of fishing grounds, fish production of these waters, turbidity of the fishing grounds and, thus, detectability of the fish and proximity of these waters to breeding colonies with good nesting opportunities as important factors determining colony size and breeding success. In fact, it appears that in the western range of the continental Cormorant population (in The Netherlands), where the spectacular increase originated, numbers are now levelling off, and the most recent data on the Danish situation suggest the same tendency. Recent observations show a decline in the number of successful pairs as well as the reduction of the number of fledged young per successful pair. However, unless other factors become limiting, given the presence of largely unused areas of shallow water in these countries as well as in northern Germany, the population is supposed to be able to double its size as far as food availability is concerned. Up to which point a continuing increase and range expansion of the Cormorant further eastwards, in Poland and the Baltic states, is likely to occur, largely dependends on whether man will permit the undisturbed establishment of new colonies, on the degree of eutrophication of the fishing grounds (a stimulus for fish production) and on the extent of pollution of the aquatic environments there.

FACTORS INFLUENCING MIGRATION ROUTES AND WINTER DISTRIBUTION

Most continental Cormorant populations, breeding in the coastal plains of northwest Europe and the southern Baltic, are completely migratory. Wintering quarters are found all over the Mediterranean basin, along the Atlantic shore as well as inland. Lower numbers winter also close to the breeding area along the southern North Sea banks. The first results of extensive colour-ringing projects show that birds from the westernmost populations (The Netherlands) mainly winter in France and the western Mediterranean, only a few passing by the Swiss lakes. Danish birds may winter along the southern North Sea, but many of them go further south, stopping over in Switzerland, and winter from the Swiss lakes south all through Italy until Tunisia. Migration routes of more easterly populations are less well-known, but these are likely to winter largely along the eastern Mediterranean and the Black Sea shores (see Van Eerden & Munsterman 1986). Migration routes as well as the timing of the movements are, at least in some individuals, remarkably predictable over consecutive years. These birds may show a distinct affinity for a certain roost but even for one particular perch within a larger roost. This site and perch fidelity tends to increase with age, thus suggesting that fixed sites and perches imply advantages to individual birds that may only be acquired with experience. Similarly, adult birds and especially males tend to winter at higher latitudes than juveniles, the pattern being influenced by the severity of the winter. All this evidence strongly supports the hypothesis that, throughout the non-breeding season, Cormorant distribution and abundance are determined by habitat quality, with birds competing for the most profitable sites. One of the driving forces behind the tendency observed in part of the birds to winter close to the breeding grounds is the necessity to be back in the colony as early as possible (breeding success).

Traditionally, Cormorants of the nominate race *Ph. c. carbo* are much less migratory. Norwegian birds frequent more or less the same fishing grounds all year round, while British and Irish birds may travel as far south as the French Atlantic coast, some even reaching the west coast of the Iberian Peninsula. As a consequence of the

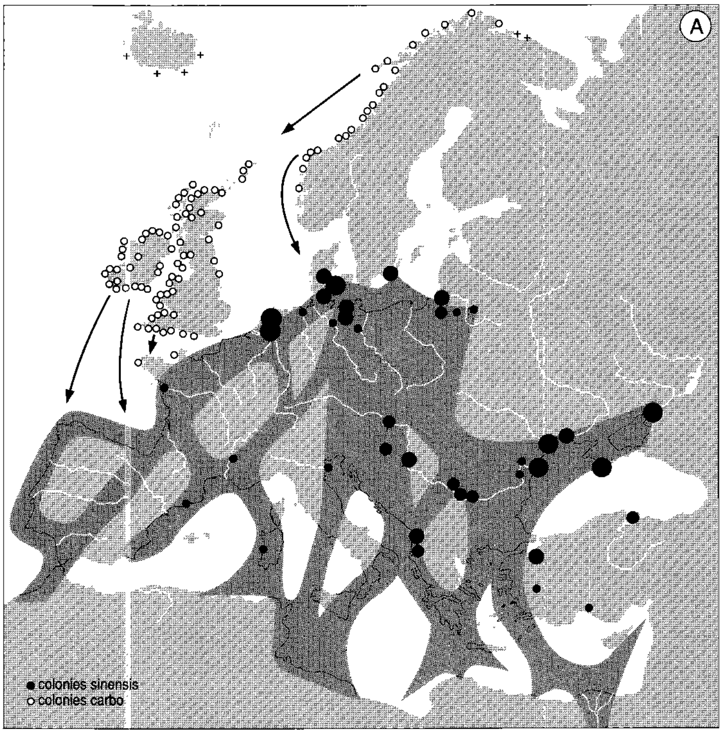

Fig. 1A. Main colonies and supposed migratory flyways of Cormorants in Europe. The coastal breeding *Ph. carbo carbo* from the British Isles, Ireland and Norway perform only a limited migration whereas the continental *Ph. carbo sinensis* is a clear but partial migrant throughout its range. The situation for the Black Sea and eastern Mediterranean is only indicative and based on scattered information only.

increase in wintering continental Cormorants in western France, competition for the best fishing grounds there is likely to have become more severe recently. At least locally (along rivers and in small estuaries), the generally smaller continental birds might be better adapted to the local fishing conditions than the larger and more marine Atlantic birds. Since at the same time increasing eutrophication of British inland waters has enhanced fish availability during winter, there is a distinct trend for British Cormorants to winter more at inland sites in Britain rather than along the French Atlantic coast. An obvious goal for future work is to bring together data about colour-ringed birds from different populations in order to unravel the effects that different wintering areas and migration strategies have on individual survival.

FOOD, FORAGING AND IMPACT ON FISH STOCKS

The Cormorant is an opportunistic feeder. Birds of the continental race feeding in freshwater during the breeding period may winter in marine habitat and vice versa. The habit of mass fishing in *sinensis* is only a recent phenomenon, thought to have evolved in response to turbid underwater conditions with a high stock of pelagic fish. By

Fig. 1B. Black areas show shallow water areas (< 50 m water depth) indicating potential wintering areas in relation to the 0, 5 and 10 °C isotherms in January. Redrawn from Van Eerden & Munsterman (1986).

foraging in shallow waters, but up to depths of 20 m, the Cormorant is adapted to inshore foraging at sea as well as over a wide variety of estuarine and inland waters. The response to changes in aquatic habitats caused by human interference (eutrophication, over-fishing, habitat destruction or recreation) are acting upon this top-predator. Food studies in the species are made by using regurgitated fish in the colony or by reconstruction of fish species and size from otoliths, pharyngeal bones and chewing pads collected in both colonies and roosts. Although these attempts are not without methodological difficulties, they clearly show the great spectrum of fish prey taken, *grosso modo* reflecting the composition of the fish population under consideration. Little information has been published about changes in diet composition parallel to changes in the fish community. Repeated studies in the same waters have shown considerable differences in diet composition in Schleswig-Holstein (Knief 1994) and Denmark (Hald-Mortensen 1994). Although largely unexplored, these differences are more likely to follow fluctuations in species' abundance rather than examples of prey-switching.

Impact studies showing detrimental effects of fish predation by Cormorants in natural waterbodies are scarce. The effect of bird predation on fish stocks is reviewed by Suter (1991) who found no evidence for a great impact in natural ecosystems. More direct effects are reported in fish ponds or artificially stocked lakes or rivers where high densities of fish are reared. Both in summer and winter the predation by Cormorants may be responsable to a 20-50% loss of production, in Carp *Cyprinus carpio* rearing basins, in extreme cases leading to the complete failure of the yield of individual ponds.

In natural waters where fish stock assessment and knowledge about fish ecology seem to be bottlenecks in evaluating the birds' impact. Already Van Dobben (1952) showed the preponderance of *Ligula* infested Roach *Rutilus rutilus* in the diet of the birds. Recently Veldkamp suggested an ecological effect by preying upon dense stocks of Bream *Abramis brama* in NW Overijssel, The Netherlands. It is suggested that Cormorants may thus actually be beneficial to the water management which aims at restoring a natural aquatic ecosystem complete with transparent water and submerged vegetations. Similar results were obtained by Leah *et al.* (1980) comparing two small waterbodies, not differing in nutrient load but different in the degree of isolation to other watersystems. Cormorant predation, resulting in a drastic reduction of planktivorous fish led to a clear water phase in the isolated lake, whereas immigration of fish from the surroundings repopulated the other lake which remained turbid. The eutrophic waterbodies with their large populations of cyprinid fish are thought to be in a stable phase, the Bream and Roach efficiently depressing the zooplankton which in turn is unable to graze down the developing algae (Andersson 1981, Blindow *et al.* 1993, Lammens *et al.* 1990). As the argument goes, the great turbidity caused by algal blooms further prevents aquatic macrophytes to develop which is a key factor for predatory fish such as Pike *Esox lucius*. The fact that Cormorants, as avian predators able to take larger cyprinids than Pike, may effectively locate both winter shoals during the annual clear water phase and prey in turbid waters by social fishing in summer, suggest that they might be an important factor of the aquatic system. The ecological effect Cormorants might have on natural waterbodies remains a matter of further research.

CORMORANTS AS INDICATORS OF ENVIRONMENTAL QUALITY

Although as early as the early 1970s J.H. Koeman and his co-workers had already established links between the levels of some heavy metals and organic micropollutants taken up with fish from polluted water bodies and lethal and sub-lethal effects on Cormorants and other piscivorous birds (Koeman *et al.* 1972, 1973), this matter received remarkably little attention until the end of the 1980s. Then it became apparent that, while Cormorant numbers were rising quickly, quite a few new colonies were being established along the entire range of Rhine and Meuse in The Netherlands whereas breeding success in the different colonies varied markedly, according to the exact location. By this time contaminant loads of the water of Rhine and Meuse had decreased considerably with respect to the 1960s and the 1970s, but some of the older sediments in the lower basins of these rivers (still containing the high levels of pollutants), like for example in the Biesbosch, were still in direct contact with the water, thus forming an important source of pollution for the local aquatic environment. Resident fish populations in these sedimentation areas still contained high contaminant loads, which were ingested by locally feeding Cormorants. It was shown that overall breeding success of a Cormorant colony was negatively related to the degree of contamination of the sediment of their habitual fishing grounds. The most toxic compounds were shown to be dioxins and 'dioxin-like' PCBs, causing thinning of eggshells and, more notably, pollutant-specific changes in metabolism and thyroid hormone levels, which may very well be responsible for lower hatching success as well as for retarded growth of hatchlings. Breeding success in a Cormorant colony may, therefore, be used as a relatively easily measurable index for the ecotoxicological quality of the surrounding water bodies and their sediments. However, in recent years Biesbosch Cormorants seem to be doing markedly better, which can be ascribed to a shift in food choice towards prey species with lower contaminant loads (Boudewijn & Dirksen 1993). The study of Platteeuw *et al.* has, indeed, indicated that individual variations in prey species composition, as well as individual differences in physical condition, may each account for differences in contaminant load of the liver (on lipid basis) of about a factor 2-3.

RIDING ON THE CREST OF THE WAVE

Thanks to its extreme plasticity the Cormorant has survived from mankind. As a kind of symbol for the tremendous loss of wetlands which has occurred through human intervention the Cormorant colonies, especially those of the tree breeding *sinensis* remind of an imaginative past where other colonial breeding piscivores as Dalmatian Pelicans *Pelecanus crispus*, Great White Egrets *Egretta alba*, Squacco Herons *Ardeola ralloides*, Night Herons *Nycticorax nycticorax*, Grey Herons *Ardea cinerea*, Purple Herons *Ardea purpurea* and Spoonbills *Platalea leucorodia* formed mixed colonies in The Netherlands (Vera 1988). Due to habitat fragmentation, drainage of wetlands, hunting and egg culling, four of these species became fully extinct while the remaining populations of the other species severely declined. Grey Heron and to a lesser extent Purple Heron and Spoonbill adapted to feeding in man-made ditches and other waterworks which, together with protection of breeding sites prevented them from becoming extinct, at least in The Netherlands. The continental populations of the Cormorant succesfully negociated this bottleneck. For Spoonbills and later on also Cormorants, the establishment of the first Dutch nature reserve Naardermeer in 1905 was of crucial importance (Van den Hoorn 1980). In Denmark, Vorsø (established in 1944) played a similar role (Gregersen 1982). However, it was not until protective measures were taken on a European scale in the course of the 1970s, that the population could greatly expand. Because of the rate of expansion this success story for nature protection also highlights the eutrophication problems that occur in western Europe. Symbolic for the plasticity of nature, the obvious challenge is to follow the future developments in the species, to monitor and further ecologically explain the wave of present expansion through Europe. As shown by the recent crash of the population in the IJsselmeer area in The Netherlands (for which the underlying causes are still under study), the situation may rapidly turn from a seemingly pre-programmed steady increase in breeding numbers into a dramatic fall. If the drop in numbers continues in the near future we may experience a major perturbation, reminiscent of the natural crash reported recently in American Double-crested Cormorants *Ph. auritus* which was caused by the mass die off of adults suffering from the so called Newcastle disease (e.g. Converse *et al.* 1992).

The Cormorant as an individual is riding high waves when coping with an ever changing environment where competition plays an important role. Its reproductive phase seems linked to the production, phenology and availability of fish which means an energetic *tour de force* for the parents, especially at high breeding densities. The density dependent feedback mechanisms, which are likely to operate at various periods of year as well as on different sub-groups (sex, age, geography) can be combined with other parameters into a population model.

We consider the Cormorant as a likely candidate for studies linking limnology, fisheries research and ornithology into the framework of ecosystem research emphasising mutual cause-effect relationships. The possibility to work along the line of individual based studies guarantees the eminent position this species has for future studies, both aiming at improving our knowledge about wetland functioning by monitoring studies as well as minimising the perceived conflict with human fisheries by sound ecological research.

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SAMENVATTING

Dit artikel geeft een samenvattend overzicht van de algemene bevindingen uit de wetenschappelijke bijdragen aan dit speciale nummer van Ardea over de biologie van de Aalscholver in Europa. In een korte historische inleiding worden de voornaamste knelpunten belicht die altijd weer aan de orde komen wanneer de mens en een in het wild levende diersoort dezelfde voedselbronnen in dezelfde omgeving exploiteren. Vervolgens wordt beschreven hoe de populaties Aalscholvers zich hebben hersteld, nadat bijna overal in Europa beschermende maatregelen van kracht zijn geworden. Dit herstel - vooral van spectaculaire omvang bij de continentale populatie *sinensis* - heeft de soort wederom in direct conflict gebracht met menselijke belangen. Onderzoek heeft zich dan ook vooral gericht op de factoren die limiterend zijn voor de populatiegroei.

Oppervlakte, productiviteit en toegankelijkheid van de visgronden voor de broedende vogels lijken de

omvang te bepalen van de maximaal mogelijke populatie. Op grond hiervan lijkt het einde van de toename nog steeds niet bereikt. Als gevolg van hun trekgedrag verspreiden Aalscholvers zich buiten de broedtijd over geheel West-Europa, waarbij vaak een opvallende plaatstrouw aan vaste pleisterplaatsen en voorspelbare individuele migratieroutes worden vertoond. Onder andere leeftijd en geslacht en waarschijnlijk ook individuele ervaring van de vogels hebben invloed op de winterverspreiding. Lokale conflicten tussen visserijbelangen en broedende, zowel als niet broedende Aalscholvers, lijken onmogelijk tot alle tevredenheid op te lossen op het lokale niveau, zonder de populatie als geheel in beschouwing te nemen. Recente studies lijken voorzichtige indicaties te geven dat de vogels bovendien zouden kunnen bijdragen bij bepaalde vormen van visstandbeheer, door eutrofe wateren vrij te houden van te hoge dichtheden aan Brasems.

Tenslotte maakt de positie aan de top van de aquatische voedselketens de Aalscholver kwetsbaar voor de accumulatie van microverontreinigingen. Deze kunnen de reproductie op diverse wijzen belemmeren en in hogere concentraties zelfs direct lethaal zijn. Het monitoren van broedsucces en gehalten van microverontreinigingen in vogels en eieren kan dienen als een methode ter controle op de ontwikkelingen in de milieukwaliteit van aquatische ecosystemen.