COMMISSION OF THE EUROPEAN COMMUNITIES

SHOREBIRDS AND LARGE WATERBIRDS CONSERVATION

PROCEEDINGS OF TWO WORKSHOPS
HELD AT ST AIDAN'S COLLEGE, DURHAM, UNITED KINGDOM
SEPTEMBER 17-18, 1983

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FOR INTERNAL USE — RESTRICTED CIRCULATION

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L E G A L N O T I C E

CONTENTS

FOREWORD

This publication constitutes the proceedings of two workshops held at St Aidan's College, Durham (United Kingdom) on September, 17-18 1983, under the auspices of the Commission of the European Communities, as part of the first phase of the Third Environmental Research Programme. The workshops were convened by the contact group "Conservation of wild birds" to review recent developments concerning the conservation of shorebirds and of herons, egrets and other waterbirds.

The first objective of the research activities on conservation of birds undertaken within the Environmental Protection R&D Programme is to provide the Council Directive no. 79/409/EEC of 2 April 1979 on the Conservation of Wild Birds with the necessary background information for its implementation and its application.

In view of ensuring effective conservation, influence on the use or management of areas of particular habitats for specific migratory species at certain seasons, both inside and outside the Community may be required.

It was the purpose of the two workshops to consider the habitat requirements of shorebirds, herons, egrets and other large waterbirds at different steps of their annual cycles.

I. CONSERVATION OF SHOREBIRDS

INTRODUCTION

In recent years E.E.C. DG XI has commissioned several projects, particularly from IC BP, concerned with the identification of important specific sites for birds within the Member States. Sites have been selected largely on the basis of published information, and with particular reference to species and habitats named in the E.E.C. directive on conservation of birds. Most sites contain concentrations of breeding or wintering birds.

With highly migratory species, such as many waders (shorebirds), safeguarding of species requires that we look outside E.E.C. Member States, particularly during the breeding season. Although many waders occur in large numbers in only a restricted number of localities outside the breeding season, they are often well dispersed whilst breeding. To ensure effective conservation, we may thus have to influence the use or management of large areas of particular habitats at certain seasons, both inside and outside the Member States. It is the purpose of this volume to consider the state of knowledge on the habitat requirements of waders whilst breeding, when refuelling during migration, whilst moulting, and in other non-breeding areas. Such knowledge is an essential basis for habitat management. We also need to keep in mind the question of at what season is the population of a particular species regulated, for this will indicate where to concentrate conservation efforts.

P. R. EVANS

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SESSION 1

HABITAT REQUIREMENTS AND CONSERVATION PROBLEMS IN THE BREEDING AREAS

POPULATIONS AND BREEDING SCHEDULES OF WADERS IN HIGH ARCTIC GREENLAND

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Summary

Waders are the dominating birds of the high arctic tundra of Greenland both regarding population densities and number of species. Of ten species of waders breeding regularly in Greenland, eight have their main distribution in the high arctic part. Ringed Plover *Charadrius hiaticula*, Turnstone *Arenaria interpres*, Knot *Calidris canutus*, Dunlin *Calidris alpina*, Sanderling *Calidris alba*, and Red Phalarope *Phalaropus fulicarius* are the most abundant. Their living conditions in high arctic Greenland are characterized by extremely low and often sparse vegetation, moderate snow cover and short, cool summers. Large local, regional and annual differences occur, however, and the breeding phenologies and population densities of waders vary markedly in accordance with these differences.

A strong negative correlation exist between the onset of egg-laying and the snow cover in early June. Waders breed two weeks later in areas rich in snow than in areas with little snow, i.e. areas with low precipitation and/or areas where the snow is blown off by frequent winter storms. The critical factors are probably the feeding conditions prior to egg-laying, and in snow rich areas also increasing fox predation with increasing snow cover.

Breeding densities are best correlated with the local occurrence of snow-free land with vegetation cover in early June, and even here the feeding conditions prior to egg-laying may be the most decisive factor. Although large local anomalies occur, there is a general northwards decrease in snow cover within the high arctic Greenland, and correspondingly a decrease in vegetation cover. This means that the earliest wader populations to breed are found in the extreme north, while the population densities are low here due to low productivity. Also in the more productive southernmost parts of high arctic Greenland, the wader populations are low, here due to extensive and long-lasting spring snow cover. The optimal conditions are found in between, where the combination of moderate snow cover and reasonable vegetation cover allow waders to breed relatively early and in high numbers.

Compared to other arctic areas, the population densities of waders in high arctic Greenland are moderate to low (1-7 pairs per kilometre square in most census areas). Responsible for this is above all the low productivity as compared to the extremely productive low arctic tundras of North America and Sibiria. On the other hand the limited snow cover makes it possible for the waders to breed earlier in high arctic Greenland than on most other tundras.

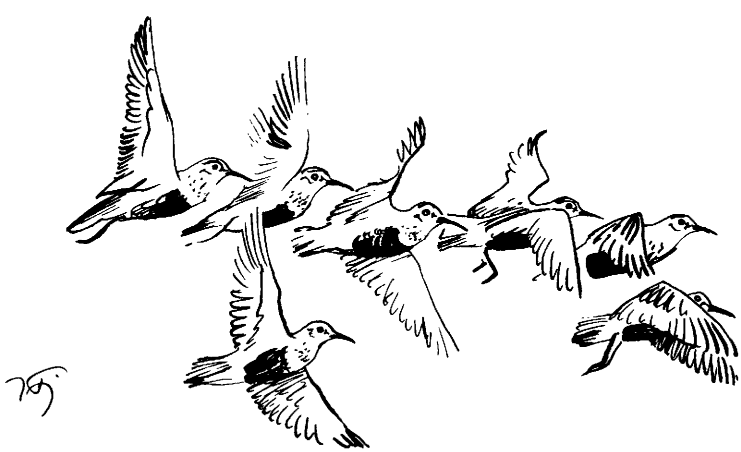
The strategy of the waders in high arctic Greenland is apparently to minimize the time spent here. They remain on their

pre-migratory fattening areas in northwestern Europe and Iceland until the very last days of May, when the thaw starts in high arctic Greenland. When and where conditions permit, they go directly to the breeding grounds and start egg-laying in early June. Relaying after failures occurs until around 1st July, at which time non-breeders and failed breeders leave their territories and form post-breeding flocks. After a short period of pre-migratory fattening, they leave for western Europe, progressively followed by the breeders, of which most have gone by early August. The feeding prospects sharply decrease in most areas by that time, and the adult waders furthermore benefit from going to temperate or tropical areas and start their moult as early as possible. Juveniles follow about a month later, after a period of development and fattening along the arctic coasts, which become ice-free in August.

The total population estimates, derived from breeding density data, deviate considerably from the estimates made of the same populations in the Old World in winter. Using the estimated ratio between the species on the breeding grounds, and the 350,000 nearctic Knots counted on the West European wintering grounds, the corresponding totals of the other species should be: Ringed Plover 200,000 (wintering in West Africa); Turnstone 250,000 (wintering mainly in northwestern Europe); Dunlin (ssp. arctica) 20,000 (wintering in West Africa); and Sanderling 130,000 (wintering mainly in West Africa). Especially the number of Turnstones differ significantly from what is counted in western Europe in winter (32,000). It must be stressed, however, that these estimates only are very rough first attempts to quantify these populations.

No safe estimates exist as to the carrying capasity of the breeding grounds or the extent to which they are saturated. Subjective judgements together with impressions of population fluctourations may suggest that the habitats for Ringed Plover and perhaps also for Dunlin and Sanderling are saturated, while it is possible that the populations of Turnstone and Knot at least partly are regulated on the wintering grounds.

The full paper, which is a comprehensive account of the annual cycle of the waders of the high arctic Greenland, will be published in "Meddelelser om Grønland. Bioscience".



Discussion

Myers (USA) remarked that the relationship between date of snow melt, vegetation cover and densities of breeding waders in Alaska appears similar to that in Greenland. Early snow melt in the Alaskan interior leads to lower population densities using the coastal areas. Populations fluctuate widely at Point Barrow (on the coast) since the extent of sea-ice also affects the rate of loss of snow cover there. Densities of breeding waders in Alaska are 10x those in Greenland. Myers questioned whether the Greenland nesting areas are full. In reply, Meltofte (DK) considered that Alaskan waders were opportunistic breeders but Greenland birds more conservative. Perrins (UK) questioned whether removal experiments had been attempted in Greenland. Meltofte replied that they had not. Oelke (FRG) asked about the accuracy of figures of wader densities in different habitats. Meltofte confirmed accuracy of counts, but said that no measure of habitat quality had yet been obtained. Oelke also questioned whether arctic foxes were regulated by wader densities or vice versa. Meltofte assured him that the foxes were not regulated in that way. Pienkowski (UK) quoted a letter from Tomkovich (USSR) that densities of waders settling to breed in parts of Arctic Russia were related to density of foxes already present and not only to food resources.

RECENT POPULATION CHANGES OF WADERS IN FINLAND AND THEIR CAUSES

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In 1979 at Nordic Ornithological Congress in Norway, I gave a talk entitled "The population changes and present status of waders in Finland" (Hilden, O. & Hyytiä, K. (1981), Proc. 2nd Nordic Congr. Ornithol. 1979: 19-37. Stavanger). This is a shortened version of that paper, with more emphasis on the reasons for change.

The main sources for my review are the well-known work by Merikallio "Finnish birds, their distribution and numbers" (1958), the new handbook of Finnish birds "Pohjolan linnut värikuvin" by v.Haartman, Hilden, Linkola, Suomalainen & Tenovuo (1963-72), and the bird atlas work carried out in 1974-79. In addition, recent faunistic reports and unpublished data have been used.

We have 28 species of waders, which breed or have bred permanently in Finland. Of these, 13 have increased during the last 30 years, either definitely or probably, seven have decreased, and two at first increased and expanded strongly but have shown a declining trend in more recent times. For the remaining six species no certain population changes can be demonstrated.

Let us first take a glance at these groups of species, with short comments on the most striking changes.

1. Species definitely increased: Charadrius dubius, Pluvialis apricaria, Limosa limosa, Haematopus ostralegus, Arenaria interpres, Tringa totanus, Xenus cinereus, Philomachus pugnax.

The eight species belonging to this group include birds of quite different distribution and habitats. The Golden Plover and the Ruff are northern species, which have greatly increased and expanded to the south in recent times. The Little Ringed Plover is a southern species that has extended its range towards the north. The Oystercatcher, Turnstone and Terek Sandpiper are coastal birds, whose populations have slowly increased since the 1950s. The Redshank, another coastal bird, has colonized the SW inland during the last 25 years. The Black-tailed Godwit, finally, is a new breeding species in Finland since the late 1950s.

2. Species probably increased: Capella gallinago, Limosa lapponica, Actitis hypoleuca, Tringa ochropus, Phalaropus lobatus.

For these five species, the evidence of increase or range extension is not as convincing as for the previous group, but all facts known support the idea of an increasing trend.

3. Species that first increased and expanded, but then decreased: Vanellus vanellus, Calidris alpina schinzii.

Up to the 1960s, the Lapwing represented one of the most successful bird species in Finland. In the course of about a hundred years it colonized almost the whole country and increased enormously in numbers. But after that it has rapidly decreased in numbers and disappeared from the marginal habitats; the present population has been estimated at less than 20% of its size 20 years ago. The southern subspecies of the Dunlin colonized the SW and W coasts of Finland since the 1930s, and had a population of about 200 pairs in the mid-1960s. But since then the population has been greatly reduced, and many of the former breeding localities are now without Dunlins.

4. Species definitely decreased: Capella media, Charadrius hiaticula, Numenius arquata, Calidris temminckii.

The Great Snipe, at the end of the past century still a locally common breeding bird in Finland, has almost completely disappeared. Only one nesting record has been reported since 1950, and only a few passage migrants are seen annually. The coastal population of the Ringed Plover has declined catastrophically since the 1960s, and from many areas the species has totally disappeared. In the Curlew population a considerable decrease has taken place during the same time, especially in the southern parts of the country. In Temminck's Stint, a marked decrease has been proved on the coasts and in most parts of Lapland during the last few decades.

5. Species probably decreased: Numenius phaeopus, Tringa glareola, T. nebularia.

For these species, the information is scanty and the suggested decrease is partly deduced from the destruction of habitats.

6. No certain population changes can be demonstrated: Eudromias morinellus, Scolopax rusticola, Lymnocryptes minimus, Tringa erythropus, Calidris maritima, Limicola falcinellus.

Lack of information on any population trends in these species does not mean that no changes would have occurred, only that they have not been demonstrated.

The reasons for long-term changes in bird populations are always complicated. In general, the changes are due to several factors, some of them operating on the breeding grounds, others during migration or in the wintering areas. The most conspicuous factor need not always be the most important one. Moreover, the factors may affect reproductive as well as mortality rates, or both. A reliable analysis of the reasons for the population trends of a certain species would thus presuppose detailed information on the ecology of the species throughout the year, its population dynamics, dispersal, relation to different environmental factors, etc. Usually we do not have all this information, only some pieces of it.

This reasoning also holds for waders. For several species we do know factors that certainly have affected their status, but we cannot claim that these factors would be the only ones responsible for their increase or decrease. For some species, the reasons for their population changes remain quite obscure. In the following, I will list the main factors which seem to have affected the wader populations in Finland.

1. Climate Some decades ago, long-term changes in climate were believed to explain most changes in the distribution and numbers of birds. In Finland, Kalela and Siivonen were well-known proponents of this view. Nowadays, the significance of climate is not considered as important as it used to be, and most population trends are believed to result from alterations in environment, caused directly or indirectly by man.

This new idea is supported also by the population trends in waders. The list of increasing and decreasing waders includes both southern and northern species, which suggests that climatic factors have not played any important role. The Lapwing is a classical example of species, whose expansion to the north has been explained in terms of amelioration of the climate. But, as stressed by v. Haartman, the northward expansion has been much greater than the northward movement of the isotherms, which thus suggests some other explanation.

As far as I can see, the climatic factors cannot be regarded as the main reason for the recent changes for any wader species in Finland.

2. Ditching and drainage of wetlands. This is certainly one of the most detrimental factors for waders all around the world. In Finland, about half of the wetlands have been drained, which means a total area of more than 50 000 km^2, and in the southern part of the county there are regions where 80 to 90% of all wetlands are ditched. This, of course, has greatly reduced the habitats available for a number of waders. In spite of this, some species (most clearly the Ruff) have been able to increase and expand, which shows that they had not utilized completely the sources available. One species, the Golden Plover, seems to have benefited by the ditching of peatland, as it prefers rather dry moors; this may, in fact, be one reason for its rapid increase.

On the whole, draining of wetlands has not had such a detrimental influence on wader populations in Finland as in Central and Southern Europe, simply because we still have extensive areas of wetlands left.

3. Regulation of water courses. About half of the total area of all our thousands of lakes and rivers in Finland nowadays are regulated. In addition, huge water reservoirs have been built in Northern Finland, the largest covering an area of 400 km^2.

These colossal changes in land use, among the most criticized in Finland, have had a two sided effect on waders. The big reservoirs have flooded important nesting grounds of all the peatland species, but at the same time they have created new suitable habitats for some other waders (*Charadrius hiaticula*, *Actitis hypoleucos*, *Calidris temminckii*, *Phalaropus lobatus*). Lowering the level of lakes, clearing river beds, building of power stations, etc., have also benefited the Common Sandpiper and both the Ringed Plovers.

4. Extensive clear-cut areas in N. Finland, the largest one covering no less than 100 km^2, represent another dramatic, sharply criticized measure in Finnish land use. In general it has caused a considerable impoverishment of the bird fauna, but two wader species have successfully colonized these tundra-like habitats, namely the Golden Plover and the Whimbrel.

5. Effects of the modern agriculture. It should be known to everyone how rapidly the methods used in agriculture have changed in recent times, in Finland probably more dramatically than in Central Europe. The ever growing use of pesticides and artificial fertilizers, new heavy machines instead of horses, cessation of grazing on shore meadows, much earlier mowing of the hay, destroying of many weeds important for birds, draining of fields, larger areas of monocultures, and so forth, all this has totally changed the ecological conditions in rural areas.

Among the waders, the Lapwing, Curlew, Redshank, Dunlin, Ruff and Temminck's Stint have definitely suffered from the cessation of grazing, as they all prefer short-grass meadows and avoid tall and dense vegetation. On the other hand, the Snipe seems to have benefited by this factor. However, only with respect to Temminck's Stint, Dunlin and Curlew can this factor have effected the populations more than locally, as the other species breed mainly in other habitats. The alarming decrease of the Curlew and the recent crash of the Lapwing population must be connected with the general rapid decline of almost all farmland birds in Finland since the 1960s. The Partridge and the Kestrel are rarities nowadays, the Stock Dove has almost totally disappeared from most parts of its range, the Starling population has crashed to a fragment of its former size, and the colonies of the Black-headed Gull have greatly reduced in size. During the last couple of years even populations of the Whinchat and Ortolan Bunting have declined catastrophically.

Some weeks ago Pentti Linkola, a noted Finnish ornithologist, writer and philosopher, published a long, shocking article entitled "The hara-kiri of the Finnish agriculture", where in a convincing way he connected the recent crash of our farmland birds with the rapid changes in modern agriculture, particularly the use of chemicals. It will certainly provoke a heated debate, which - I hope - will result in intensified research into these questions.

6. Modern land use. Gravel pits, filled-in areas, dumps, industrial sites, etc., have created new artificial nesting habitats for the Little Ringed Plover. Nowadays most of the population breeds in such man-made habitats, and this must be the main reason for the recent increase and expansion of the species. To a lesser extent also the Ringed Plover, Common Sandpiper and Terek Sandpiper have benefited by this factor.

7. Factors operating outside the breeding range. The above factors can, at least partly, explain some of the recent changes in the populations of Finnish waders. But for many species the causes remain obscure. Why, for example, has the Black-tailed Godwit colonized the west coast of Finland during the last 25 years, why has the Ruff greatly increased and enlarged its range, and why has the Ringed Plover population crashed? It is impossible to demonstrate any changes in the breeding habitats of these birds in Finland, which could explain these trends.

In such cases the reasons must be sought among the factors operating outside Finland, either in the more central parts of the breeding range or during migration. For instance, draining of wetlands in W Europe may have caused dispersal to more northern areas. This could explain the colonization and increase of the Black-tailed Godwit and Dunlin in Finland in the 1950-60s, as both species are known to have decreased in W Europe during the same period. Mortality outside the breeding season, caused by hunting, pollution of resting and wintering grounds, adverse weather, etc., is likely to have caused the steep decline in the Finnish population of the Ringed Plover. Unfortunately, our knowledge of these factors is very limited.

Discussion

Myers (USA) emphasized the threats to sub-arctic breeding grounds in the New World from oil exploitation. Fortunately there are no such threats (yet) in Scandinavia. Beintema (NL) remarked that the changes in habitats in Finland appear to parallel those that took place earlier, and more slowly, in the Netherlands. Hilden confirmed that the conversion from wetland to woodland, through extensive drainage, began in the 1950's. Beintema supported Hilden's interpretation that most changes in breeding populations resulted from human activities and not climatic change. He commented that the Black-tailed Godwit expansion in Finland in the 1950's coincided with a period when the species was still increasing in the Netherlands. Langslow (UK) asked whether the increase in Golden Plovers following drainage was likely to be only temporary and Hilden agreed that this was so if drained areas were afforested.

THE IMPACTS OF AFFORESTATION ON BREEDING SHOREBIRDS AND RAPTORS IN THE UPLANDS OF BRITAIN

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Summary

Nearly half of the area of Great Britain is unenclosed uplands which support important breeding bird communities of species such as golden eagle, merlin, hen harrier, golden plover, greenshank, dunlin, raven and red grouse. Afforestation with alien conifers is having a deleterious effect on some of these species. Afforestation not only has a direct impact on the planted ground but also affects the adjacent land and, particularly, streams and lakes. Blanket afforestation has caused the decline of ravens and golden eagles in Galloway, merlins in Northumberland and golden plovers in many areas. Unplanted ground within new forests supports few birds. Breeding waders have an uneven and patchy distribution on British moorlands. The long term conservation of most of the existing breeding wader populations in the uplands depends upon large areas of high quality for waders being left unplanted and a strategy to conserve birds of prey which avoids blanket afforestation.

1. THE UPLAND ENVIRONMENT IN BRITAIN

Great Britain occupies about 230 000 km^2 and nearly half of this area is unenclosed uplands. The uplands of Britain are defined more by climate and topography than by altitude and consist of montane and sub-montane grasslands and heaths often associated with extensive peatlands. The distribution of breeding golden plover in Britain (1) roughly indicates the extent of upland habitat except in Wales and south west England where golden plover are much scarcer than their apparently suitable habitat.

The upland environment in Britain is characterised by relatively low temperatures associated with high altitude, heavy precipitation and high atmospheric humidity. The extreme oceanicity of the British mountains involves an altitudinal depression of typical vegetation zones through the severity of wind and the lack of summer warmth. Hence, in north west Scotland, montane conditions come down nearly to sea-level whilst in the eastern Highlands they are found about 600 metres above sea-level. A more detailed description of the uplands of Britain can be found in the Nature Conservation Review (2).

Large areas of the uplands in western and northern Britain were formerly covered by pine and birch forest of which only remnants now remain. Most of the upland forests had been cleared by the beginning of the nineteenth century and were replaced by grasslands and dwarf-shrub heaths (especially *Calluna vulgaris* dominated heath). The grasslands and heathlands are interspersed with extensive areas of peatlands, mostly blanket mires with limited areas of soligenous mires (2). The British uplands comprise the largest area of semi-natural habitat in Britain and, like most semi-natural habitats, are under inexorable pressure from the intensification of human activities. Virtually all these areas have been subject to heavy grazing and burning of the vegetation for many decades and this has led to a wide range of biological consequences.

The British uplands support important breeding bird communities which include species such as golden eagle, hen harrier, peregrine falcon, merlin, golden plover, dunlin, curlew, greenshank, dotterel, teal, red grouse and ring ouzel. Turdus torquatus. For some of these species Britain holds a substantial proportion of the European breeding population. The more intensive use of these uplands for agriculture, forestry or hunting has a range of impacts on the flora and fauna which usually causes the loss of species abundance or richness or both.

2. HUMAN IMPACTS ON THE UPLANDS

There are four principal types of human impact:

(1) Afforestation with alien conifers such as lodgepole pine Pinus contorta and sitka spruce Picea sitchensis:

(2) Changes in sheep husbandry accompanied by land drainage, ploughing and reseeding of land formerly under semi-natural vegetation.

(3) Changes in the management of the red deer Cervus elaphus including the advent of 'deer farming'.

(4) Reduction in the extent of dwarf-shrub heath through change from intensive management for red grouse to that for grazing animals especially sheep.

3. ECOLOGICAL IMPACTS OF AFFORESTATION

The afforestation of upland heaths and grasslands causes major short-term and long-term ecological changes both on the ground planted and in adjacent areas and occurs over huge areas of the uplands. Initially the area to be planted is fenced to exclude sheep, deer and goats and then deep-ploughed. The vegetation within the enclosure grows much taller than the grazed moorland outside the fence. Fertilisers and pesticides are often applied. Gradually as the young trees grow the canopy of the new forest closes and shades out the herb layer. When between 30 and 50 years of age the forest is cut down and a second planting of trees takes place. The flush of ground vegetation which is so characteristic of the first rotation is normally absent on the second rotation. Commercial forestry plantations support little wildlife as they are dense, and often impenetrable, monocultures with minimal structural variation; they are totally unlike semi-natural woodlands.

The growing of conifers on originally poor soils (usually the case for afforestation in Britain) tends to further lower the fertility of the soil. Miles (3) has reviewed both British and Continental studies and found three trends within the soil following afforestation:

1. Greater surface accumulation of organic matter

2. Increased acidity of surface organic and mineral horizons

3. Increased rate of podsolisation

The increased acidity produced by the needle fall increases the acidity of the water run-off. The acidity of the water reaches concentrations which are high enough to damage the eggs of salmonid fish and to lead to the loss of other aquatic organisms. There is a correlation between the age of the conifers and the level of acidity; a substantial reduction in fish catches along the river Fleet in Galloway is correlated in time with the expansion of afforestation in the catchment. Acid waters from afforested catchments are high in dissolved metal ions and concentrations of aluminium toxic to fish have been recorded (4).

Following the initial ploughing, the rate of water run off increases greatly with an accompanying increase in sediment load. Erosion of the stream bed increases and, together with settling of the coarser sediments, this can damage the spawning areas for salmonid fish (5). The total run-off from a planted area decreases as the plantation grows to become lower than that on the unplanted ground (6).

The other important effect on water quality is eutrophication. Fertiliser is added to promote tree growth and a proportion is lost in the water run-off (7). Enhanced release of nutrients, with parallel effects on adjoining lakes, has also been observed after clear-felling conifer stands.

Thus afforestation causes a complete change in the flora and fauna of an area and has impacts which stretch well beyond the limits of the planted ground. Thus research programmes to quanitify and understand the impacts need to take account not only of the direct effects within the plantation but also the effects outside on land management practices and on water quality.

4. RESEARCH STRATEGY TO STUDY THE EFFECTS OF AFFORESTATION AND OTHER LAND USE CHANGES ON UPLAND BIRDS

In response to these pressures on native wildlife, the Nature Conservancy Council is carrying out a series of research projects to study the impact of these land use changes on the flora and fauna. Birds form an important, interesting and highly visible component of the ecosystem and many also have relatively large territories. Hence they have been widely used as indicator species to study environmental changes.

A series of research programmes was planned to examine the impact of these environmental changes on wildlife. The work includes studies on both bird communities and individual species. The major aims of the programme of ornithological research may be summarised:

(1) To determine the density of breeding shorebirds and ducks in sample areas of the uplands throughout Great Britain.

(2) To relate the density and species richness of the bird community to the vegetation and topographic features of these areas.

(3) To investigate the impacts of afforestation both within the planted ground and on land adjacent to it.

(4) To carry out in depth studies of key species such as golden eagle and golden plover.

5. THE UPLAND BIRD COMMUNITY

In this brief description of characteristic upland bird communities, I shall only consider non-passerines. The non-passerines such as golden eagle and golden plover are restricted solely to this environment and are the most vulnerable to changes in the upland environment. The non-passerines of the uplands are listed in Table I. Note that several species are restricted to the highlands of Scotland and hence these areas have a more varied moorland bird community.

Both dotterel and ptarmigan are montane species found only above the altitudinal limit of tree planting; both dunlin and golden plover are often associated with them. The latter two species are far more numerous on the gently sloping peatlands and moorlands of the sub-montane zone; here they are typically associated with greenshank, snipe, curlew, redshank, red grouse, teal, hen harrier, merlin and short-eared owl. The more rugged uplands are the typical haunt of golden eagle and peregrine along with one important passerine, raven Corvus corax.

Golden eagles and peregrines occupy large home ranges and are spread fairly evenly throughout suitable upland habitats. This is not so with breeding waders whose distribution is very patchy. Both the species richness and abundance of waders varies markedly between similar sites in the Caithness and Sutherland in northern Scotland (8 and 9). The relationship between the number of species of breeding non-passerines and the site area is illustrated in figure 1 and the enormous variation between sites is obvious. Densities vary greatly as well; figure 2 shows the density of breeding golden plover on a series of sites whose area varied from 300 to 900 hectares. Hence the precise position of new plantations can have a marked effect on the proportion of the local population whose breeding habitat is destroyed. The patchiness of their distribution is an important factor when considering the conservation of breeding wader populations in the uplands.

TABLE I

The non-passerines typical of upland bird communities in Great Britain

+Red-throated Diver	Gavia stellata
Teal	Anas crecca
Wigeon	Anas penelope
Golden Eagle	Aquila chrysaetos
Hen Harrier	Circus cyaneus
Peregrine	Falco peregrinus
Merlin	Falco columbarius
Red Grouse	Lagopus lagopus scoticus
+Ptarmigan	Lagopus mutus
Black Grouse	Lyrurus tetrix
Golden Plover	Pluvialis apricaria
Dotterel	Eudromias morinellus
Snipe	Gallinago gallinago
Curlew	Numenius arquata
+Wood Sandpiper	Tringa glareola
Redshank	Tringa totanus
+Greenshank	Tringa nebularia
Dunlin	Calidris alpina
Short-eared Owl	Asro flammeus

+ only found in the highlands of Scotland

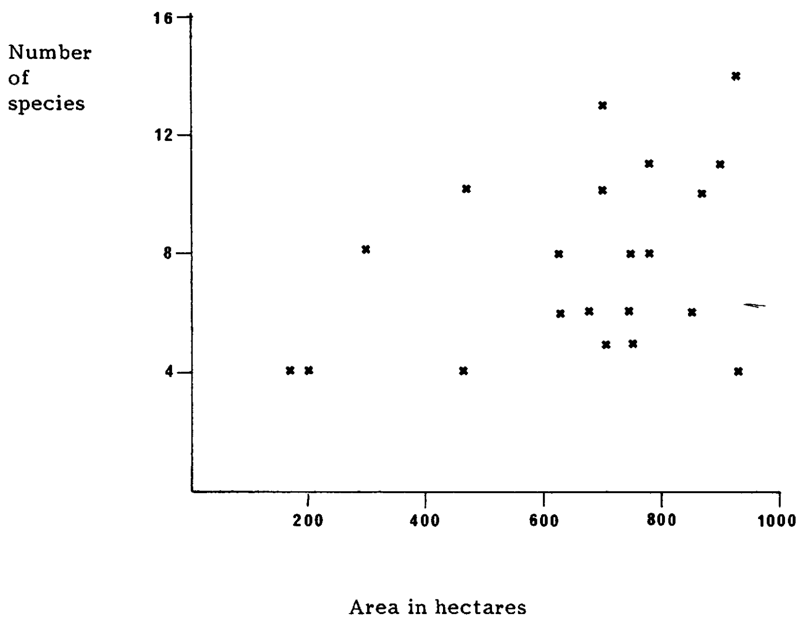

Figure 1. The relationship between the number of breeding non-passerine species and site area in northern Scotland

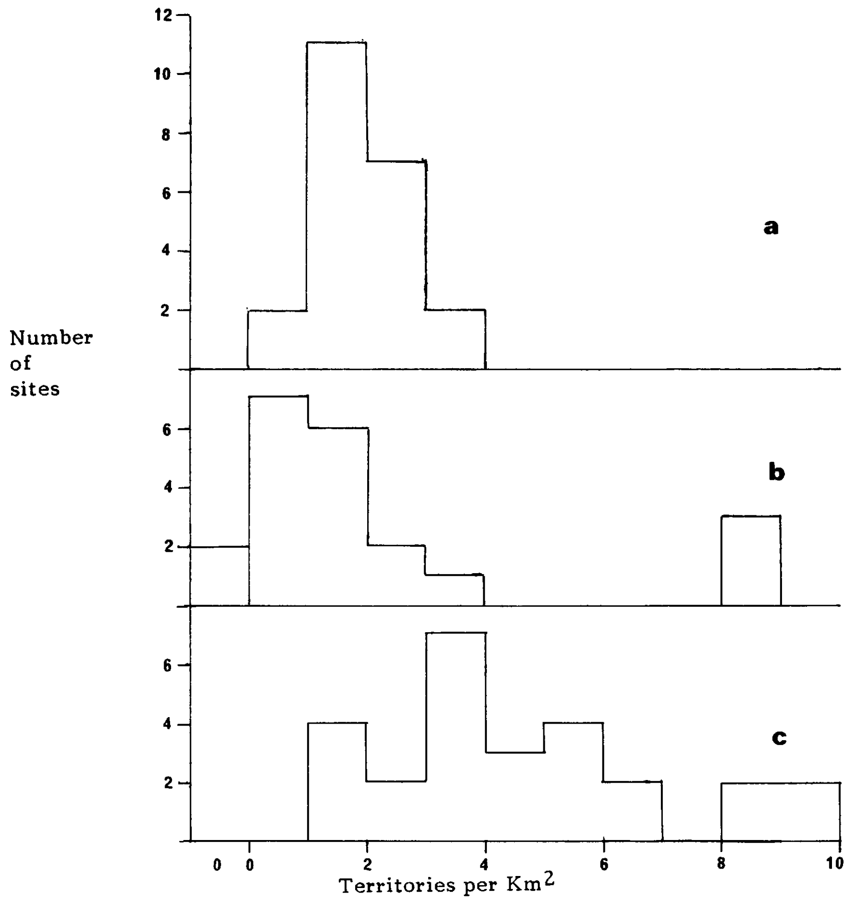

Figure 2. The density of breeding golden plover on upland sites in (a) Caithness (b) Sutherland (c) County Durham

6. CHANGES OF MOORLAND BIRD POPULATIONS FOLLOWING AFFORESTATION

There are few quantitative studies of these changes although evidence for the disappearance of species from certain areas and a decline in range is more abundant. The most detailed record of decline following afforestation is for the raven in Galloway; Marquiss and colleagues (10) reported a 55% decline in the population between 1960 and 1975. Pairs disappeared from areas where tree planting was most widespread and the date of disappearance coincided with the removal of sheep and the planting of the open moorland. The population of a nearby area in northern England where there was virtually no new afforestation remained unchanged during this period. A marked decline in the golden eagle in Galloway has also been coincident with the huge increase of afforestation (Marquiss and Ratcliffe, unpublished). Both nest sites and hunting ranges of merlins have been lost in Northumberland in the past twenty years (11) and thus the area supports markedly fewer birds than formerly.

In Northumberland and Galloway, large areas of moorland suitable for golden plover and other waders has been afforested. Many moorland areas within Caithness and Sutherland which formerly supported greenshank, dunlin and golden plover have also been afforested.

Whilst afforestation has had a completely negative effect on all wading birds, this is not so for all species. The lush vegetation of young plantations is favoured as a nest site by hen harriers although they remain dependent on unplanted ground for hunting. Short-eared owls both nest and hunt within young plantations but they are excluded once the trees reach about 5 metres in height.

7. THE IMPACT OF AFFORESTATION ON ADJACENT OPEN MOORLAND

Amongst wading birds in Britain, only the woodcock Scolopax rusticola nests within woodland. Except for snipe, the other species of wading birds which breed in Britain rarely associate with trees. Hence one might expect an edge effect of a plantation on the wading bird community. This avoidance of trees may have an evolutionary basis with factors such as territorial display, habitat requirements and the detection and avoidance of predators encouraging avoidance. Rankin and Taylor (12) suggested that a minimum moorland area of 270 hectares was required to maintain a representative upland bird community. While area and, especially habitat diversity, influence species richness, Reed and Langslow (unpublished) found no influence of area on the number of species of breeding waders in the peat flows of Caithness and Sutherland. Other factors were much more important.

Preliminary evidence for three sites surveyed in Caithness in 1980 (before planting) and in 1983 (after planting) shows the complete loss of breeding waders for the afforested ground. Planting of sites led to a loss of species richness and abundance in adjacent areas; for example, curlew and golden plover declined at all three sites; (Langslow and Reed, unpublished).

There is a further influence of afforestation outwith the plantation boundary. The management of moorland vegetation by burning at intervals of 8 to 20 years is a common practice. Where planting occurs, burning generally ceases because of the risk of runaway fires; consequent changes in vegetation structure and height can alter the suitability of the area for breeding waders.

8. UNPLANTED GROUND WITHIN NEW PLANTATIONS

Whenever an area is planted with conifers, some parts of the enclosed ground are left unplanted. Usually this is because the ground is unplantable because of exposure to wind, the extent of surface rocks or very low fertility. Foresters have suggested that these unplanted 'islands' within a forest provide a refuge for the moorland bird communities. Of 52 such sites surveyed, 44 had only 2 or fewer breeding species and all supported fewer species than comparable areas of unplanted moorland. The occurrence of birds of prey and waders was especially sporadic (Rankin, Taylor and Lance, unpublished manuscript).

9. CONCLUSIONS

Afforestation of an area completely removes the breeding waders and may also have a deleterious impact on adjacent areas. Hence the long term conservation of most of the existing populations of several species can only be achieved by a conservation strategy which leaves large areas of unplanted ground within the British Uplands. The extremely patchy distribution of many species allows the identification of areas where afforestation does little or no damage to breeding waders; large (more than 1000 hectare) sites where waders breed abundantly must be maintained in the long term. The impact of birds of prey differs in that their nest sites are often unaffected by afforestation but hunting areas containing adequate prey must be maintained.

10. DISCUSSION

Cadbury (UK) enquired whether fragmentation of moorland by improving areas of upland pasture might benefit Curlew and Golden Plover by improving feeding grounds adjacent to the breeding areas. Langslow replied that waders apparently did not feed much on such areas and that, in general, fragments of moorland held lower densities of breeding waders than did extensive areas. Myers (USA) reported that fragmentation of woodlands in America had led to decreases of migrant, but not resident, breeding species. Smart (UK) asked whether Lapwing and Curlew had been forced into upland areas by destruction of lowland wet meadows and so were particularly vulnerable if uplands were to be afforested. Langslow thought that Curlew are poor markers of the affects of afforestation since they occupy a wide range of upland habitats, are fairly tolerant of human activities and will continue to nest in areas for a few years after these have been planted with trees. He suggested that Dunlin, Greenshank and Golden Plover were more sensitive indicator species.

REFERENCES

(1) Sharrock, J.T.R. (Ed) 1976. The Atlas of Breeding Birds in Britain and Ireland. T. & A.D. Poyser, Calton.

(2) Ratcliffe, D.A. 1977. A Nature Conservation Review. 2 vols. Cambridge.

(3) Miles, J. 1977. The influence of trees on soil properties. Annual Report. Institute of Terrestrial Ecology 1977, 7-11.

(4) Harriman, R. and Morrison, B. undated. Ecology of acid streams draining forested and non-forested catchments in Scotland. Report to the Freshwater Fisheries Laboratory, Pitlochry.

(5) Smith, B.D. 1980. The effects of afforestation on the trout of a small stream in southern Scotland. Fish Mgmt., 11, 39-57.

(6) Calder, I.R. and Newson, M.D. 1978. The effects of afforestation on water resources in Scotland. Unpubl. report. Institute of Hydrology, Wallingford.

(7) Harriman, R. 1978. Nutrient leaching from fertilised forest watersheds in Scotland, J. appl. Ecol. 15, 933-942.

(8) Reed, T.M., Langslow, D.R. and Symonds, F.L. 1983. Breeding waders of the Caithness flows. Scottish Birds 12, 180-186.

(9) Langslow, D.R., Barrett, J., Barrett, C. and Reed, T.M. 1983. Breeding waders in Sutherland. Submitted for publication.

(10) Marquiss, M., Newton, I. and Ratcliffe, D.A. 1978. The decline of the Raven Corvus corax, in relation to afforestion in southern Scotland and northern England. J. appl. Ecol., 15, 129-144.

(11) Newton, I., Meek, E.R. and Little, B. 1978. Breeding ecology of the Merlin in Northumberland. Brit. Birds 71, 376-398.

(12) Rankin, G.D. and Taylor, I.R. undated. Changes within afforested but unplanted ground - birds. Unpubl. report to NCC.

WET MEADOWS IN TEMPERATE EUROPE, THREATENED BY AGRICULTURE

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Summary

Wet meadows and pastures harbour a number of breeding shorebird species. Grassland dwelling shorebirds in Europe nowadays depend greatly on agricultural grasslands. The main species concerned are the Oystercatcher Haematopus ostralegus, Lapwing Vanellus vanellus, Black-tailed Godwit Limosa limosa, Redshank Tringa totanus, Ruff Philomachus pugnax, Snipe Gallinago gallinago, and, to a lesser extend, the Curlew Numenius arquata. Initially, the intensification of agricultural practise in grasslands has favoured the shorebirds. This is espec ially true in the Netherlands, where these species collectively are commonly known as 'meadow birds'. An extraordinary example is the Black-tailed Godwit: c. 80% of the total population in Western and Central Europe is concentrated in the lower parts of the Netherlands. Intensifying of dairy farming potentially enables the densities of meadow birds to increase, as a result of increased soil productivity. At the same time, the probability to reproduce successfully will decrease. At present, the process of intensification of farming practise has gone so far, that a number of species can no longer produce enough offspring to maintain their populations. As a result, populations are declining, and the prognosis is, that the more vulnerable species will disappear from agricultural grasslands in the near future, unless special measures are taken. A crucial factor is the maintainance of high water tables.

1. INTRODUCTION

Over the past decades, shorebirds have been receiving an increasing amount of attention. Much of this attention has been devoted to shorebirds migrating through temperate estuarine areas. From a nature conservation point of view this is understandable, because temperate estuarine habitats face great environmental problems, notably pollution, reclamation, and industrial development. Much less attention has been given, so far, to shorebirds breeding in temperate inland regions, especially those breeding in grasslands. Fortunately, this attention is on the increase now, but in many cases it has become very late. Breeding areas of shorebirds in natural grasslands have certainly been threatened a long time already, without much concern from ornithologists. Developments in the North American prairies, for instance, have led to a dramatic decrease in such species as the Upland Sandpiper Bartramia longicauda, and the Marbled Godwit Limosa fedoa. In Europe and nearby Asia, we can only guess what has happened in the past with shorebird populations in natural steppes.

Grassland dwelling shorebirds in temperate Europe are nowadays increasingly depending on seminatural or agricultural grasslands, often secondarily created by man in other habitats. Shorebird communities in secondary grasslands have developed particularly well in The Netherlands, where such inhabitants of meadows and grazed pastures became commonly known as 'meadow birds'. The six major species are the Oystercatcher Haematopus ostralegus, the Lapwing Vanellus vanellus , the Black-tailed

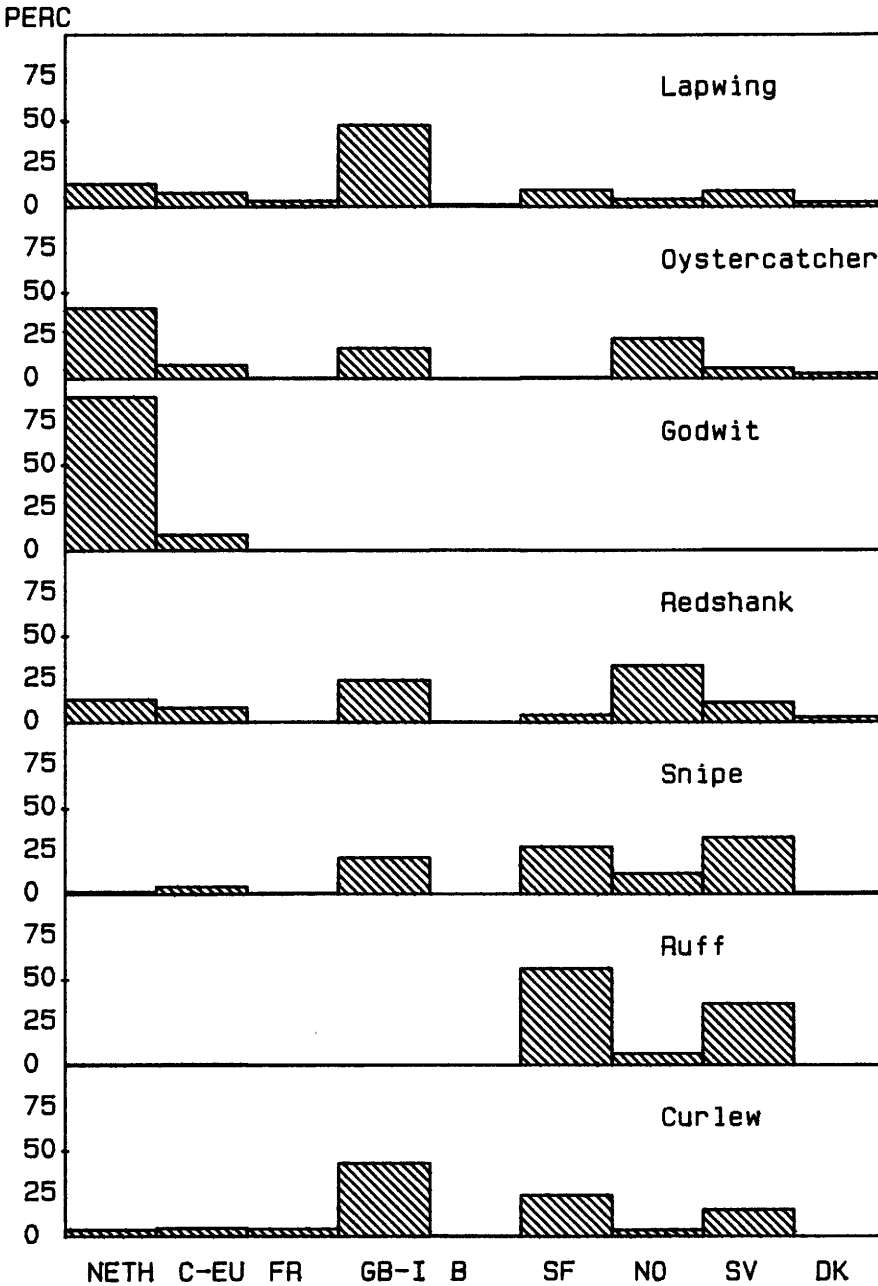

Fig. 1. Relative distribution of numbers of pairs of shorebirds, expressed as percentages of the total populations in a large area of Central and Western Europe (c-EU = Germany, Poland, Switzerland, Chechoslovakia, Austria, Hungary; GB-I = Britain and Ireland).

Godwit Limosa limosa, the Redshank Tringa totanus, The Ruff Philomachus pugnax, and the Common Snipe Gallinago gallinago. The degree to which the birds have developed into meadow birds differs between the species, but also differs geographically. For a number of species, this has been illustrated in fig. 1., which gives the relative distribution of numbers in a large part of Western and Central Europe. It can be seen that within Europe, the Dutch grasslands are totally unimportant for the Ruff, a species which is considered to be one of the most characteristic meadow birds in the Netherlands. The vast majority of the species breeds in northern, natural habitats. The same is true for the Snipe. But for the other species it can be seen that the Netherlands, despite its relatively small surface, holds a significant part of the population. On distribution maps showing densities this is even more obvious. Apparently, these denizens of open, natural habitats, found a nice alternative in our cultivated grasslands. Due to the increased level of soil productivity, they can thrive in much higher densities than in their natural habitats. For example, one square kilometer of good meadow-bird habitat may hold one hundred nests each of the Oystercatcher, Lapwing, and Black-tailed Godwit, as well as twenty nests each of the Redshank, Ruff, and Snipe.

A meadow-bird community can only develop on this scale within narrow margins formed by a rare combination of climate, soil, hydrological conditions, and management practises. The probability that this combination will occur spontaneously seems small, and at present the phenomenon is restricted mainly to the Netherlands, and, within that country, to the lowest lying regions. Thus, the Dutch meadow-bird populations are of great international importance, a fact now recognised by private and governmental nature conservation agencies. This situation is exemplified by the Black-tailed Godwit: the roughly 100,000 pairs in the Netherlands represent some 80% of the total population of Western and Central Europe.

Excellent meadow-bird land can develop on lowland peat, or on silty alluvial plains, and even bett^r, on a combination of these two. Many of the richest places are found on old lowland peat, covered with clay deposits during more recent transgression periods. In the past, due to drainage problems, dairy farming was the only economically feasible kind of agriculture in such areas. The typical flat Dutch polderland is drained by a dense network of ditches and canals. The water table lies very close to the surface, and in the winter parts may even be flooded. In this habitat, the birds find good nesting cover and sufficient food for egg production early in the season. Wet conditions mean postponement of agricultural activities in the fields for many weeks, which makes safe hatching possible, and the moisture also guarantees abundant insect food for the growing chicks later in the season.

Intensification of dairy farming begins with lowering the water table to allow earlier access to the fields for heavy machinery or cattle, as well as to permit the soil to warm up faster to promote vegetation growth in the spring. Accelleration of growth is firther enhanced by the application of fertilizers. Generally, the result is that all processes in the grassland tend to occur earlier in the season. Although the birds respond to this advancement with an earlier start of the breeding season, they are nevertheless exposed to heavy management practices such as mowing or intensive grazing much sooner in their cycle, because of the faster growth of the vegetation. In addition, higher production levels are reflected by higher cattle densities, which means higher nest losses due to trampling. Thus, the delicate balance between birds and management has been disturbed. The meadow birds no longer produce enough offspring, and their populations are steadily declining.

Maintainance of the meadow-bird phenomenon depends very much on the level of intensification of dairy farming. We therefore will further investigate the effects of this intensification on the population dynamics of the birds. I did mention some bad effects already, but there are good effects as well: the meadow-bird phenomenon would never have developed without farming practice in the first place. Still, it is the bad influence we all know the best, because that is what concerns us most since populations started to decline. Therefore, I will start with an analysis of the negative influences, and come to the positive side later.

2. THE BAD EFFECTS

The general idea of the bad effects has already been outlined above. In more detail, we can distinguish three categories:

1. Effects in the nesting stage.
2. Effects in the chick stage.
3. Effects on the adults.

So far, only the effects in the nesting stage have been thoroughly investigated. In a simulation model I have shown that in modern farming reduction of hatching success alone is already sufficient to explain the present decline, irrespective of the question whether chicks can grow up or not. Reduction of nesting success results from trampling by cattle, and early mowing. If nesting success alone is already low enough to prevent sufficient recruitment, variations in chick survival will only modify the extinction speed. The model takes nest predation into account, based on nest survival rates, measured in the field. It has been found that predation rates are strongly related to the amount of nesting cover. Thus, open nests of Oystercatcher and Lapwing suffer more losses due to predation than the well hidden ones of Snipe and Ruff. Nest survival rates are modified by agricultural management. Survival during mowing is simply assumed to be zero, in the case of grazing the situation is more complex. In field experiments we assessed a basic 'trampling value', which is the probability that a nest will survive one day grazing with one animal on one hectare of pastureland. Surprisingly enough this value appears to be the same, when calculated from situations with different cattle densities. This suggests that trampling is a totally random process, although we know that grazing patterns and behaviour of cattle are far from random. Still, this finding is very convenient, as it enables us to use the same trampling value for survival estimates under all sorts of grazing schemes. Basic trampling values differ strongly between different kinds of cattle, young cattle being the worst. Also, values differ slightly between bird species. Large, noisy species, like Oystercatcher and Lapwing, are able to actively prevent trampling, albeit to a very limited scale. Smaller, less impressive species, like Redshank and Ruff, always fail to do so. Finally, and this is one of the most influential elements in the simulation model, renesting is taken into account. The Lapwing in particular is renowned for its relaying capacity. Lapwings have been known to renest op to eight times in succession, within the same breeding season. Renesting greatly increases the probability of achieving hatching success in the end.

If we use the model to estimate the probability that birds will nest successfully under different management schemes, we find that the species are increasingly vulnerable in the order: Oystercatcher, Lapwing, Black-tailed Godwit, Redshank, Ruff (the Snipe is omitted in this case, because we do not have sufficient data on this species). This implies, that in the same order the maximum level of management intensity which can still be tolerated, will decrease. In other words: when this intensity level is steadily increasing, the Ruff will be the first species that will no longer be able to produce enough offspring to maintain its population.

This is exactly what has been happening in the Netherlands. The Ruff has been known to be decreasing already for many decades. Decrease in the Redshank became especially evident in the fifties, the Black-tailed Godwit followed in the seventies. Lapwings are still holding their own, and Oystercatchers are even increasing. This change in the species composition within the meadow-bird community is reflected in the relative numbers of chicks caught annually by bird ringers. Fig. 2 shows the number of chicks of Redshank and Ruff ringed annually, expressed as percentage of the total annual catch of meadow-bird chicks. The contribution of the Ruff to this grand total has already come down to almost zero, and we expect that, with the exception of some reserves, it will totally disappear from our pastures and meadows in the near future.

So far, we only considered the problems in the nesting stage, and it seems evident that these problems are severe enough. Bad effects in the chick stage are as yet not quantitatively known, but one can speculate that early mowing will take its toll, especially among chicks that tend to hide in tall grass, as is the case in the Black-tailed Godwit. Also, one can speculate on effects of drainage and the application of fertilizers on the availability of suitable insect food for the growing chicks, but sound data are not yet available.

The effects on the adults have not yet been investigated properly either. However, we do have some indications that dry conditions in the second half of the breeding season, resulting from improved drainage, have an adverse effect on the availability of soil fauna, the main food for the adults of most species. We have reasons to postulate that under these conditions, the probability of renesting in the case of nest loss, is greatly reduced, maybe simply because the female cannot obtain enough extra food in a short enough time to produce a clutch. This would, in an indirect way, increase the impact of agricultural pressure.

3. THE GOOD EFFECTS

The fact that the meadow-bird phenomenon would never have developed without an increase of the intensity of agricultural use of grasslands, implies that at least some degree of management intensity is required. The factor which is most likely to control bird densities, is food availability. It is well known that manuring leads to a tremendous increase in the density of lumbricids near the surface, and it is especially this kind of fauna which constitutes the main ingredient for the production of eggs in the female.

Again, we can try to arrange our species in an orde according to 'vulnerability', but this time with respect to giving a positive response. More precisely, we can try to arrange the species according to postulated threshold values of management intensity, above which the meadow-bird phenomenom can develop and flourish (the process of 'meadowbirdification'). If it is true that egg production in the female is the bottleneck, this treshold order would simply be according to body weight. The smaller species would then be our oldest meadow birds, the heavier ones more recent acquisitions. There is some evidence to support this idea. The Black-tailed Godwit has been increasing in the Netherlands as recently as the late fourties and early fifties, when the Ruff was already decreasing. Still more recently, the heavy Oystercatcher started to increase as an inland breeding meadow bird. And, finally, I have the pleasure to introduce to you our latest addition to the meadow-bird community: the Curlew Numenius arquata. Of course, Curlews have been known to nest in grasslands already a long time, but in most cases these were relics from nearby destroyed natural habitats. However, less than ten years ago Curlews started to nest in modern, intensily farmed grasslands, which had already lost their significance for other meadow-bird species a long time ago, and which never had breeding Curlews before, as far as memories go. Some of these new populations have since doubled or tripled, and apparently they are doing quite well. Indeed if we look at its properties in the renesting model, it appears that the Curlew can be ranked above the Oystercatcher, and can be considered as one of the least vulnerable meadow-bird species. Therefore, it can be predicted that Curlew populations in the Netherlands will increase in the years to follow, but this may be only temporarily, as it seems to be in the other species.

4. THE BALANCE BETWEEN GOOD AND BAD

Meadow-bird development is thus restricted to certain levels of agricultural management intensities. There is a lower limit of minimal intensity required, and an upper limit of maximal intensity tolerated. Intensification has two main effects, which are counteracting each other. On the one hand, intensification leads to an increase of the potential bird densities. On the other hand, the probability of rearing enough offspring will be reduced. The highest densities of breeding meadow birds will therefore be found in places where the management intensity is just below the upper limit, above which recruitment will be insufficient. As soon as this limit is surpassed, the system will collapse and extinction will follow. It is clear that lower and upper limit are very different for the different bird species, which leads to dynamic changes in the species composition of our meadow-bird community, as a result from the ever increasing level of agricultural intensity.

Although I might have given some optimistic views of increasing Oystercatchers and Curlews, the prognosis for the near future is really bad. Intensification is far from finished yet. Huge reallotment schemes turn large parts of the Netherlands totally upside down, changing entire landscapes, and very severely affecting the living flora and fauna. Similar developments can be seen in Northwestern Germany, and the lower parts of the United Kingdom. Governmental agricultural agencies have strong ideas about optimal farming intensities, and if I test hypothetical, proposed management schemes (considered ideal for future farming) in the renesting model, recruitments are close to zero for all species. Therefore, there is little reason to be optimistic about the future of shorebird populations in meadows and pastures, unless special measures are taken. Of course, there are reserves, and special management areas, but they can only harbour relatively small proportions of the present populations. Also, our government has developed large scale plans to pay farmers in special areas for not doing things, but at present the money needed for that is simply not there. At the same time, the same government stimulates overproduction, in order to obtain EC funds.

5. KEEP OUR MEADOWS WET

As I have stated already in the introduction, the water level is one of the main secrets in shorebird management in grasslands. The problem is how to increase the level of soil productivity without inevitably increasing the management intensity level beyond the limit. Maintaining a high water table is a means to achieve this, because it leads to a retardation in the development of the sward, and who cares about cattle densities after all the birds have safely fledged. Deterioration of shorebird habitats in agricaultural grasslands invariably starts with improved drainage. All the other adverse effects of intensification will then follow automatically. From a shorebirds' point of view, I therefore wish to conclude with a strong plea: keep our meadows wet!

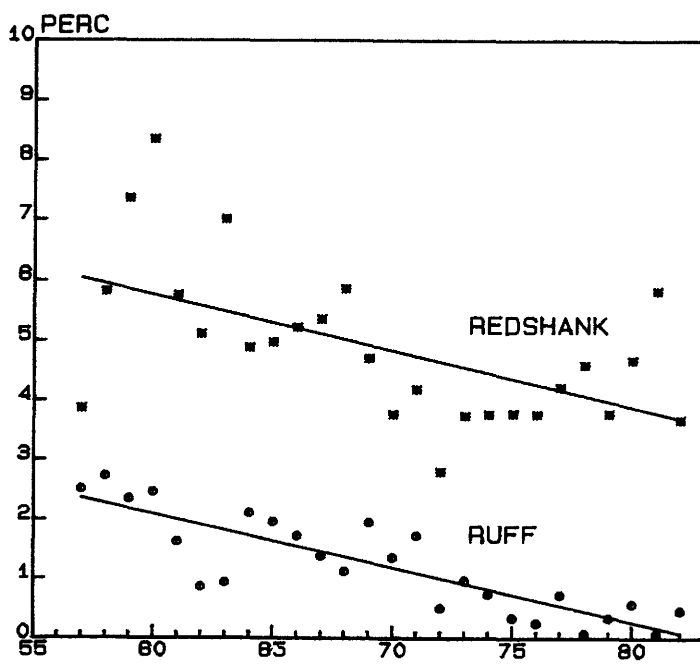

Fig. 2. Relative contribution of numbers of chicks of Redshank and Ruff, ringed annually in the Netherlands, to the total number of meadow-bird chicks ringed annually (expressed as percentage), for the period 1957 - 1982.

Discussion

Oelke (FRG) remarked that most meadowlands are artificial habitats, with a vegetation structure similar to tundra. Beintema agreed, but emphasized that there is very little 'natural' habitat in western Europe (especially Britain) and that artificiality is not a reason for not protecting such habitats. Oelke observed that in Germany most lowland pastures had been converted to grain production and wondered whether breeding birds had been displaced, into the few coastal refuges that remained, and into the Netherlands. Beintema pointed out that this was not true of the Oystercatcher, which was spreading inland as a breeding bird. Cadbury (UK) described attempts made by the RSPB to reverse the dessication of lowland grasslands and mentioned that Redshank densities had been increased in several sites. He was concerned that producing high densities might lead to increased predation and so decrease chick production. Beintema thought this would not be a problem except if linear breeding habitats were created, e.g. the edge of a lake. With a 2-D habitat, predation should not be as important as other sources of nest loss. Smart (U.K.) asked whether there were other important breeding areas for Black-tailed Godwits in Europe, besides that in the Netherlands, since large numbers of godwits were present on wintering areas in west Africa. Beintema replied that he had been told of a concentration of breeding godwits south of Moscow, but could obtain no estimates of numbers. He mentioned that in Latvia & Estonia, meadow bird colonization was apparently at a stage similar to that in the Netherlands 50 years ago, with increasing numbers of Ruff.

THE BREEDING WADER POPULATIONS OF THE WESTERN ISLES OF SCOTLAND AND THE INTEGRATED DEVELOPMENT PROGRAMME

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During the last decade it has become apparent that considerable numbers of waders - Oystercatchers, Ringed Plover, Lapwing, Dunlin, Snipe and Redshank - breed on the western sandy seaboard (machair) of the Western Isles. In 1982 agricultural and fisheries developments in the Western Isles became eligible for grant aid from an Integrated Development Programme, partly funded by the EEC. A proportion of the funds was available for land improvements and the Nature Conservancy Council became responsible for assessing their likely environmental impact. In order to assess the implications of any projects for wildlife, a detailed knowledge of the numbers and distribution of wading birds was required.

A joint survey in 1983 by the Nature Conservancy Council and Wader Study Group showed there to be some 12,200 pairs of waders breeding on the machair of the southern Isles (Table 1). The majority of these (48%) were concentrated into South Uist but Benbecula, North Uist and certain Sound of Harris Islands were also important. A comparison with the estimate for the large islands of Lewis and Harris shows that these have relatively few coastal waders.

The distribution data are not yet fully analysed but certain gross trends are suggested. Lapwings are virtually ubiquitous, breeding in both wet and dry areas, whilst Dunlin, Redshank and Snipe are restricted to the former. Hence it is these species which are most at risk from drainage. Oystercatchers and Ringed Plover are largely birds of the drier and often cultivated areas.

Of the IDP land improvement projects submitted during the first year for grant aid (4040), approximately 10% were for drainage, 10% for reseeding and 50% for fencing. Reseeding has generally involved the regeneration of previously sown areas. Also, whilst new fencing (especially of formerly common land) normally means a change in the grazing regime and hence vegetation structure, the proposals to date have related largely to replacement fencing. For such wetland systems within the machair, and in common with much of NW Europe, it is drainage that poses one of the greatest threats to wildlife. In Lewis and Harris, drainage has been on "blackland" closely adjacent to crofts, with little damaging effect on the natural environment. In the southern Isles too the blackland and machair drainage have both concerned the clearance of old drains. NCC's primary aim has been to minimise the effects by advising against increasing the depth or length of drainage systems. Consequently, to date, IDP related drainage has had little direct effect upon wildlife - drains should still undergo the cyclic process of siltation and clearance. The worrying aspect is that modern clearance is so effective, easy and rapid that it is possible that never before will such a proportion of the total drainage system have been clear at any one time.

Thus to date the IDP has apparently had little direct effect upon the wader populations. However the Programme still has several years to run and the emphasis of projects may, and almost certainly will, change. Even so the conservation case is in a far stronger position, since the true international importance of the breeding wader populations are now known and their distribution mapped. This gives a sound basis to assess both the impact of projects and natural population trends of the birds. What is now required, especially from the conservation management aspect, is an understanding of the processes which underly the very complex local distributions and the true importance of the traditional land use practices.

Table 1. The Coastal Breeding Waders of the Southern Group of the Western Isles in 1983.

	Sound of Harris Islands	North Uist	Benbecula	South Uist	Barra Islands	Total
Oystercatcher	230	928	216	692	5	2071
Ringed Plover	280	583	135	1117	1	2116
Lapwing	347	1210	322	1570	2	3451
Dunlin	344	412	158	1124	0	2038
Snipe	26	104	56	320	5	511
Redshank	162	506	221	1076	18	1983
Total (pairs)	1389	3743	1108	5899	31	12170

Note: Estimates of numbers breeding on Lewis and Harris are as follows: Oystercatcher 300+ pairs, Ringed Plover 100, Lapwing 200, Dunlin 50, Redshank 50+, Snipe ? (adapted from Fuller *et al.* and personal observations).

Reference: R.J. Fuller, J.R. Wilson & P. Coxon, 1979. Birds of the Outer Hebrides: the waders. *Proceedings of the Royal Society of Edinburgh* 77B: 419-430.

DISCUSSION

Smart (UK) enquired what proportion of machair is within nature reserves. Buxton emphasized the lack of an agreed definition of machair, but supposed that about one-quarter lay within Sites of Special Scientific Interest. In reply to an enquiry by Perrins (UK), Buxton confirmed that the breeding wader censuses had been checked and calibrated against nest-finding in three sites, and that the surveys had never underestimated actual numbers by more than about 10% for any species.

THE IMPACT OF TOURISM ON COASTAL BREEDING SHOREBIRDS IN WESTERN AND SOUTHERN EUROPE: AN INTRODUCTION TO GENERAL DISCUSSION

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Summary

This introduction was intended to stimulate discussion (i) to draw together some of the scattered work already done, or in progress, on the impact of tourism on coastal breeding shorebirds; and (ii) to consider what further work is needed. Several aspects of the subject are reviewed briefly to provide a framework for the general discussion.

1. INTRODUCTION

Most conservation problems discussed so far in this Workshop concern shorebirds simply because they happen to use areas whose habitat may be changed by man. The present topic differs slightly in that tourists are attracted to many areas because of their natural features, of which shore-birds may form a major part. Any problem may be concerned less with changes in land-use than with too many people wishing to visit the areas as they are, and thereby changing them.

Although there has been some work in this field, much does not appear to be generally available. Therefore, the main aim of this discussion might be (i) to draw together what is already known and (ii) discuss what further work is needed. Accordingly, this introduction consists basically of sets of headings which may serve to focus attention on these two general points.

2. SOME SUGGESTED EFFECTS OF HUMAN PRESENCE

Increased leisure-time, wealth, private transport and off-road vehicles have tended to increase the number and frequency of tourist visits to many coastal areas in Europe. Three main related effects on shorebirds have been suggested.

a) Reduction in breeding range, e.g. of Ringed Plover *Charadrius hiaticula* (1) and Kentish Plover *C. alexandrinus* (2). As noted in this Workshop by Dr Hildén, proof of such man-induced wide-scale changes is almost impossible to obtain, although the correlational evidence may be very strong.

b) Reduction of breeding density. A recent review of earlier work, together with new observational and experimental studies (3) demonstrated a depression, by the presence of tourists, in nesting densities of Oystercatcher *Haematopus ostralegus*, Kentish Plover, Curlew *Numenius arquata* and Redshank *Tringa totanus* in northern areas of the Netherlands, especially Vlieland.

c) Reduction of breeding productivity. Evidence on this is more difficult to obtain but there is some relevant material. For example, the only simple correlates of nesting success by Ringed Plovers at Lindisfarne National Nature Reserve, NE England, were distance from public access and frequency of visits by tourists (4).

3. SOME FORMS OF POTENTIAL IMPACT

The presence of tourists can act through various routes, as exemplified below.

a) Habitat change. eg erosion of dune, beach and salt-marsh by people, and

especially vehicles.
b) Disturbance: at feeding sites used by adults during laying or incubation; of incubation; or when with young. Unintentional disturbance of incubation of beach-nesting birds is common (e.g. 4) and may also occur in other habitats. For example, Shelducks *Tadorna tadorna* nesting in rabbit-burrows in dunes may not return to their nests if people are present in the general area. Males of the same species defend feeding territories on nearby inter-tidal areas to allow rapid, uninterrupted feeding by the female, which performs all the incubation. Human presence on these areas may totally prevent feeding as other territorial birds prevent feeding in other areas (5).
c) Egg collecting. This still occurs, despite being illegal in most countries, except under special licence.
d) Trampling of eggs or young. As most shorebirds rely on the camouflage of their eggs and young as a major element of defence against predators, and as young tend to crouch still to avoid detection, accidental trampling is a common feature where there are many human visitors to a nesting area.
e) Introduction of dogs increases many of the effects of human presence. Dogs may use scent-trails to find nests, as well as chasing young.
f) Attraction of potential predators into the general area. This may occur as a result of increased easily accessible food, such as picnic waste, or even deliberate feeding of e.g. gulls.
g) Unwitting aid to predators. The presence of humans can cause increased movements by the incubating birds to and from the nest, and there are some indications that avian predaotrs may take advantage of these increased movements to locate nests (e.g. 4). (Many shorebirds remain on the nest when avian predators are the sole immediate threat, as their body camouflage can be effective in concealing the nest.) There is also some evidence that presence of humans in the rearing areas of young Shelducks may indirectly lead to increased predation of ducklings (5).

The persons having these effects can be general holiday-makers at the shore or bird-watchers or -photographers. The effects may differ somewhat according to the behaviour of the humans but frequency of visits and durations of stay appear to be two important elements.

4. HABITAT TYPES

The extent of likely problems as well as suitable protection measures may differ considerably in the various coastal habitats.
a) Tidal flats. These perhaps present fewer problems than some of the other habitats as nests do not occur here and this habitat is not greatly used by the public, especially in the muddier areas. However, some public usage does occur, particularly on small coastal areas and sandy ones. Here, there is potential for disturbance of feeding adults or young, as noted above (see sections 3b, e, g).
b) Salt- and brackish marshes, and c) salt-pans. Similarly, these areas are not greatly used by the public in many places but they may attract large numbers of bird-watchers and -photographers. All these habitats, even the higher and infrequently inundated tidal marshes, may be important for breeding birds.
d) Beaches. This is the habitat perhaps under greatest pressure because of traditional holiday activities.
e) Dunes and links. These may suffer similar high attractiveness to tourists as do beaches. These areas are additionally very liable to erosion.

5. SOME POSSIBLE PROTECTION MEASURES

a) Enforcement of legal measures and public education. The former is mainly of importance in connection with egg-collecting. In most areas, however, this may already be a minor problem. Public education may be of benefit in this area and also, to a wider public, in drawing attention to the fact that birds do nest in the areas which they use for recreation.

b) Exclusion of vehicles, dogs, etc. These may be useful steps without impinging too greatly on public access; in some areas it may be possible to arrange limited vehicle access for handicapped persons only. Similarly, special arrangements may be possible in the case of guide-dogs for the blind.

c) Public exclusion from small areas of colonial breeding;

d) Public exclusion from larger areas of dispersed breeding;

e) Redirection of public access.

This group of possibilities is considered together, because exclusion of the public (when necessary) often works better and is more positive if those interested can view the birds concerned and see the reasons for the exclusion. Thus, use of nature trails directing members of the public to only part of a sensitive area have proved useful in many situations.

Protection of colonially breeding species is obviously somewhat easier here. The measures undertaken by the Station Biologique de la Tour du Valat in Camargue, France, in respect of Herons and Egrets (Ardeidae) (see Hafner, this Workshop) and Flamingoes *Phoernicopterus ruber* provide good examples here.

Many shorebirds present rather different, and often larger, problems as their breeding densities are low, requiring protection of large areas. One interesting idea in this respect occurs along parts of the coasts of Germany and the Netherlands, where a strip of marshland occurs betwwen a pair of dykes forming the sea-defence. In many places this marsh is designated a nature reserve and good views may be available from a road along one of the dykes. Birds appear to become accustomed rapidly to close proximity of humans on the road.

Beach (and to some extent, dune) areas are perhaps the most difficult coastal habitats for effective protection of large areas for dispersed breeding birds, because of the demands of the general public as well as those particularly interested in natural history.

f) Compensatory exclusion or destruction of predators;

g) Habitat manipulation.

The destruction of nest-predators (e.g. Crows *Corvus corone*) has sometimes been justified on the grounds that their populations may have been increased by human activities. This appears to be the case in a recent attempt to improve breeding performance of Oystercatchers in Greece (6). Often, destruction of predators is undesirable for obvious reasons. As eggs of shorebirds are often only a minor part of the diet of such animals (4), protection of the nest may be an appropriate measure. In the case of birds nesting on a peninsula, electric fencing has proved an effective technique preventing access by ground predators (7).

Habitat manipulation presents another possibility in this regard. Recent natural habitat changes at Lindisfarne National Nature Reserve, NE England have tended to support earlier suggestions that nesting density of Ringed Plovers is determined largely by the ease with which predators can find nests (4, 8). Thus, Ringed Plovers nest far more densely where much shingle (which is matched closely by egg camouflage) is present than where the ground is predominantly sand. As the number of nesting Ringed Plovers has decreased in recent years as the covering of sand has increased, the potential may exist for reversing this trend by addition of gravel.

6. SOME ASPECTS WHERE FURTHER STUDY IS NEEDED

a) Experimental work on, e.g., exclusion of various agents. This need arises because of the great number of aspects which have been identified as possible factors affecting breeding success in many species (e.g., 4). If management techniques are to be attempted, a good understanding of the various interacting "natural" and human-induced processes is desirable to avoid wasted effort.

b) Experimental work on possible management techniques. This can develop from (a) to assess the methods most economically effective and causing minimum restrictions on the public.

c) Identification of changes due to "natural" factors. This is necessary to avoid attributing effects to man and trying to overcome them in relation to this, when other factors are responsible. Several particular problems can be identified.

(i) Many coastal habitats are subject to fairly rapid natural change (1,9).

(ii) In Europe, many shorebird species are on the edges of their ranges. This implies that they may rely naturally on immigration from the more central parts of the ranges. Therefore, changes observed are not necessarily the result of local processes.

(iii) Many of the birds concerned are migrants, so that processes acting elsewhere, outside the breeding season, may be affecting their populations.

d) Identification of sets of habitats required by particular species for breeding. As indicated above, combinations of habitats in close association may be needed for successful breeding. These may include different habitats for adult feeding, nest-sites, and rearing of young. Local study is necessary to identify the sets of sites which must be considered as single units. Similarly, the areas which harbour the greatest concentrations of birds may not be the most productive. For example a study of Shelducks (5) found that the densest breeding areas appeared to be the least favoured and that these were the least productive; dispersed breeders produced more young, some of which recruited to the dense populations which were probably not self-supporting. However, conservation activity was concentrated at the densest sites partly because the above situation had not been known, but possibly also because concentrations of birds made a more interesting spectacle for members of conservation organisations.

e) Gathering of existing information. One further problem is that some of these studies which have already been undertaken (or are in progress) have been funded locally on a very small scale and not subsequently published. Perhaps this Workshop can help make any such information more widely available, both for application to management and to help identify which areas do indeed need further study.

REFERENCES

1. Parslow, J.L.F. 1967. Changes in status among breeding birds in Britain and Ireland. Br. Birds 60:97-123.
2. Dybbro, T. 1970. The Kentish Plover (Charadrius alexandrinus) as a breeding bird in Denmark. Dansk orn. Foren. Tidsskr. 64:205-222. (In Danish with English summary).
3. De Roos, G.T. 1981. The impact of tourism upon some breeding wader species on the Isle of Vlieland in the Netherlands' Wadden Sea. Ph.D. thesis. Medelelingen Landbouwhogeschool Wageningen 81-14.
4. Pienkowski, M.W. 1983. Breeding biology and population dynamics of Ringed Plovers Charadrius hiaticula in Britain and Greenland:

nest-predation as a possible factor limiting distribution and timing of breeding. J. Zool., Lond. 202: in press.
5. Pienkowski, M.W. & Evans, P.R. 1982. Breeding behaviour, productivity and survival of colonial and non-colonial Shelducks Tadorna tadorna. Ornis Scand. 13:101-116.
6. Goutner, V. 1983. Oystercatchers breeding in Greece. Paper presented to the 6th International Workshop on the Ecology of Shorebirds, Cardiff, September 1983.
7. Forster, J.A. 1975. Electric fence to protect Sandwich terns against foxes. Biol. Conserv. 7:85.
8. Pienkowski, M.W. 1983. Habitat specialization in breeding shorebirds: a defence strategy against egg-predation? Paper presented to the 6th International Workshop on the Ecology of Shorebirds, Cardiff, September 1983. (Abstract in Wader Study Group Bull. 39 (in press).)
9. Evans, P.R. & Pienkowski, M.W. in press. Population dynamics of shorebirds. In: Burger, J. & Olla, B.L. (eds) Shorebirds. Behaviour of marine animals, Vol. 5 Plenum Press, New York.

DISCUSSION

Programmes of research on effects of disturbance on coastal waders and wildfowl had been started in all three countries bordering the Wadden Sea. In the Netherlands, Smit (NL) reported a study on the effects on time-budgets and feeding ecology of Oystercatcher, Curlew, Bar-tailed Godwit and Grey Plover, chiefly outside the breeding season. Oelke (FRG) reported that a programme to study effects of tourist disturbance on breeding birds on the Wattenmeer coast was in progress; and Laursen (DK) that studies had been made on effects of recreational activities on the distribution of waders and wildfowl during the migration seasons in the Danish Vadelhavet.

Myers (USA) contributed information on studies in California on Kentish Plovers, and the eastern states on Piping Plovers. Production of chicks was inversely related to beach use. However the wintering population of Kentish Plovers on the California coast had not decreased, since most young were fledged inland. Cadbury (UK) referred to the annual survey of terns (Sterna spp) in Britain and commented that most (except Arctic) now bred in nature reserves. Densities of Little Terns had become unusually high in some sites, and heavy predation had followed. Myers agreed that this was true also in the U.S.A., where fencing against ground predators had been successful.

Oelke (FRG) raised the problem of disturbance from military activities, particularly helicopter flights, which had been shown to have disrupted breeding attempts by terns on the German north coast. Smit (NL) referred to a study of the effects of flights on breeding birds in the Netherlands. Outside the breeding season, the degree of disturbance to waders by helicopters depended on the regularity of flights. Birds habituated to such disturbance. Kushlan (USA) confirmed that this was true also for breeding colonial waterbirds which were now regularly censussed from the air in the U.S.A. Disturbance from people is more serious and most colonies have access restricted.

FINAL DISCUSSION

Priorities for Research in the Breeding Season

Evans (UK) summarized the first session and identified four areas: (1) Habitat selection: what are the correlates of high densities of breeding waders, and are these causal factors. In particular, how important are the food resources? Myers (USA) added that the reasons for the clumped distributions of breeding waders within their preferred habitats need to be identified. Is this subtle microhabitat selection, or simply surplus habitat? (2) If habitats can be managed to increase densities of breeding waders, what effect does this have on breeding output? (Marquiss (UK) pointed out that we should be seeking to measure recruitment rather than merely production of young). Conversely, if habitat quality decreases through agricultural practices, does this lead to a general decrease in density, or the concentration of a species into a few refuges, i.e. how important are social effects? (Cadbury (UK) added that information was needed in countries other than the Netherlands on the affects of delays in the breeding season on breeding success). (3) How important are predators in affecting reproductive output, particularly in arctic regions, where man's presence may enhance over-winter survival of e.g. arctic foxes? (4) What is the effect of habitat restriction: does it lead to a reduction in total numbers breeding? or to higher densities? or to a redistribution of birds to other areas (close by? or far away?) and if so to the same or different habitats? and if to the latter, are these sub-optimal habitats?

In relation to the fourth point, Zink (FRG) said that although White Storks were known to be decreasing in western Europe but increasing in eastern Europe, there was no evidence of movement of birds from west to East, either of "displaced" adults or of juveniles. Myers (USA) pointed out that this was not necessary to allow the increase in eastern areas, provided that regulation of numbers took place in the winter quarters. If fewer young were produced in the western breeding areas, then competition on the wintering areas would be less severe and eastern birds would survive better, leading to population increase. Meltofte (DK) and Beintima (NL) both supported the idea of no displacement from areas which were becoming less favourable. Meltofte suggested the converse - that when populations are allowed to increase, they overflow into suboptimal habitats e.g. Shelduck and Oystercatcher in Denmark, following bans on shooting in spring. Hilden (Finland) pointed out that this may not be true for all species, e.g. Little Tern, which has increased in Finland, without any visible improvement in habitat quality there, at the same time that it has decreased in the rest of western Europe. Some species e.g. Little Stint *Calidris minuta*, may overfly large areas each year to search for suitable nesting habitat. Certain arctic wader species do appear opportunistic in where they settle to breed, and are not site-faithful.

Several speakers stressed the need to discover, for each species, whether populations are regulated in the breeding areas, on the wintering grounds, or neither.

SESSION 2

SHOREBIRDS MOULTING, REFUELLING AND NON-BREEDING AERAS: HABITAT REQUIREMENTS AND CONSERVATION PROBLEMS

IDENTIFICATION OF IMPORTANT SITES FOR WADERS BY COORDINATED COUNTS

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Summary

In recent years counts of waders outside the breeding area have been used to determine population sizes and to demonstrate the importance of sites. Theoretical analysis and a comparison of results of counts from the whole Dutch Wadden Sea, obtained through different approaches, make clear that counts yield a fairly reliable picture of actual numbers present, at least for abundant species. Simultaneous wader counts in Europe appear to be suitable to determine numbers and distribution. With the aid of such counts during midwinter it has been possible to estimate the size of the wintering wader population along European coasts as 3 - 3.5 million birds. The population wintering along the W. African coast (Morocco-Guinea Bissau) is of about the same size. Using IWRB criteria it is possible to distinguish between sites of major and minor importance. Whether it is justified to calculate indices of changes in abundance from year to year is still subject to analysis.

Counts alone can only partly show the significance of a certain site for birds. There may be a rapid turn-over of birds, the number actually using an area being much higher than maximum numbers counted. Only a combination of activities (counting, catching, ecological studies) can show the way birds use an area and its importance.

1. INTRODUCTION

Waders are highly migratory birds, often breeding in poorly accessible habitats in the Arctic. Outside the breeding season however, many species concentrate in flocks in intertidal areas along coasts in temperate, subtropical and even tropical regions. Counts in coastal habitats, outside the breeding season, therefore offer the only opportunities to determine the size of the populations of these birds. An increase or decrease in the size of wader populations may be attributed to changes in the breeding areas but also to changes in stop-over areas in autumn or spring or in the wintering areas. Because several intertidal areas are under threat due to land reclamations, pollution, disturbance, construction of barrages reducing the tidal range, counts of waders may be of great value for conservationists. These counts may be used as a tool to demonstrate the significance of a certain area for waders or to show the negative impact of human activities. This is the main reason that in the past 30 years counts have been organized to determine wader numbers in coastal habitats. This paper intends to give brief information on the feasible applications and limitations of counts for these purposes by

putting forward the following questions:
- do counts give a more or less reliable picture of numbers present?
- can counts be used to develop a picture of the distribution of waders outside the breeding season; can they be used to determine the most important sites?
- can counts be used to determine population sizes and trends in population fluctuations?

2. ACCURACY OF COUNTS

During censuses of birds in estuaries usually several observers are involved and many flocks of birds will have to be counted. From field experiments Rappoldt (5) and Rappoldt et al. (6) have calculated the size of the overall stochastic error of many observers counting many different flocks of birds. The size of this error, expressed as a percentage of the average, the Relative Standard Deviation (RSD), amounts to 37%. This high value is due to the variety of conditions birds have to be counted in, to which among others, bird behaviour, vegetation, weather and light conditions contribute. This RSD value does not depend on the size of the flock and no significant differences between species have been detected.

In the counting results for a whole area, the errors made in single group counts will be present next to additional sources of stochastic error: individual birds or small flocks are easily missed or counted twice. Birds occurring in small numbers therefore may have RSD values of 50% or more. However, for abundant species, missing a flock or double counting is more unlikely, as was confirmed by experimental counts in the Dutch Wadden Sea.

By adding up the results of single groups of birds the stochastic error for common species, distributed in many groups of more or less equal size, drops to considerably less than 37%. For Oystercatchers in the Dutch Wadden Sea for example, the total RSD amounts to about 5% (5,6). The same applies for other numerous species. Abundant species however, roosting in a few large flocks and several small ones, show somewhat larger RSD values. These errors demonstrate that large scale counts of abundant species, to which results of many observers and many flocks contribute, yield figures which have a relatively low stochastic error.

Apart from the stochastic error a systematic error is present in the results, being the difference between the actual number of birds present and the number counted. The systematic error is much more difficult to quantify. In the Wadden Sea it generally ranges between 0 and 20% and is almost always an underestimation. No large differences between species or between seasons occur, therefore it is justified to compare the results of large scale counts for abundant species between areas and between years. This does not apply to relatively rare species.

Another indication that simultaneous large scale counts yield reproducible data is given by a comparison of two different approaches to determine total numbers for all wader species for the whole Dutch Wadden Sea. Simultaneous counts have been carried out frequently from 1972 onwards. For the comparison given here the results from 1972 - 1981 were used. Second type of counts are local shorebird counts which have been carried out in the Dutch Wadden Sea from the early fifties on. For the

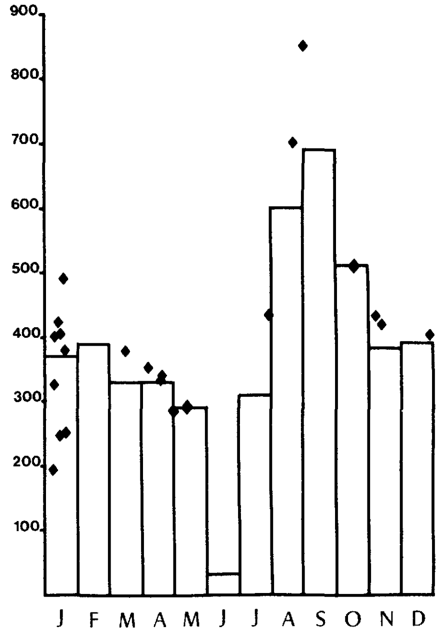

Fig. 1. Average number of waders (in thousands) per month in the Dutch part of the Wadden Sea (diagram), based on a summation of monthly averages of all occurring species in 15 subareas. Results are based on counts from 1953 - 1976 (data: (8)). Results from simultaneous wader counts from 1972 - 1981 are shown by diamonds (data: Zegers, in litt.). Two simultaneous counts under bad weather conditions have been omitted.

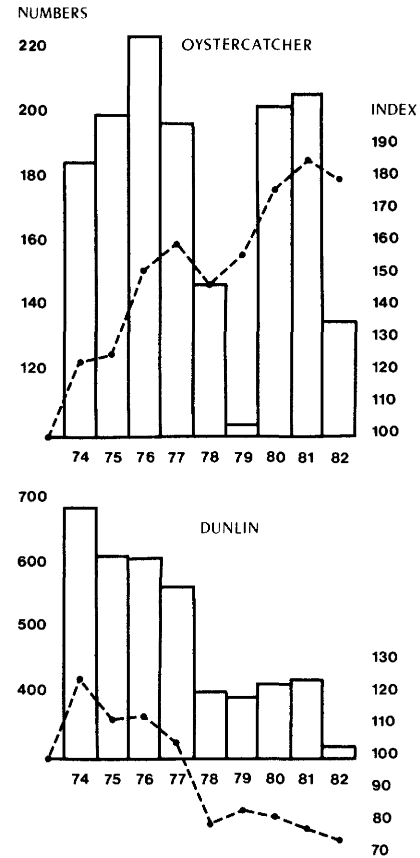

Fig. 3. Results of January counts for Oystercathcher and Dunlin (in thousands) from Britain and Ireland (uncorrected results of counts from the Birds of Estuaries Enquiry) and the indexes (broken lines) for both species (data: (3)).

comparison given here the data until 1976 have been used. During local counts in the Dutch part of the Wadden Sea, the area has been divided into 15 subareas, almost all of these having nutural boundaries as a result of which the local organizers of these counts have always considered them as separate areas. From all subareas monthly averages were computed for all species which, by adding up the results of all areas, were used to calculate monthly averages for the whole area. Though part of the results of simultaneous counts and local counts are identical, the two approaches may be considered as different because the number of local counts is much larger and they have been going on for a much longer period. Results of the calculations are given in the diagram in fig. 1. Results of the simultaneous counts are shown by diamonds. Comparison of the two approaches shows a remarkable coincidence in numbers. January numbers very considerably as a result of cold spells during this month which may cause the departure of a considerable part of the wintering wader population. The average result of simultaneous counts for this month, (349,000) however coincides well with the average result from the local counts.

From these figures, and the analysis of the accuracy of counts, it may be concluded that counts are a usable tool to determine bird numbers, at least for abundant species.

3. RESULTS OF COUNTS

Now we know that counts yield fairly reliable results it is justified to discuss the feasible application of counts. Three important applications can be distinguished: counts may yield 1) patterns of distribution of waders and 2) figures on population sizes and 3) on population trends. The possibilities of the use of counts for these purposes will be discussed below.

3.1 Distribution and population size

Simultaneous midwinter wader counts in Europe appear to be a suitable technique to determine numbers of waders wintering in W. Europe (table I). The total wintering wader population along European coasts amounts to 3 - 3.5 million birds. The most important areas in Europe are shown in fig. 2. In addition about 2¼ million waders are wintering on the Banc d'Arguin in Mauritania (1) and approximately one million in the Archipelago de Bijagos in Guinea Bissau (Zwarts, pers.comm.). Figures on the distribution in mid-winter are generally obtained through simultaneous counts in January. In general fewer counts are available for other months. Simultaneous counts during these months only exist for the international Wadden Sea, the Dutch Delta area, the British Isles and the Atlantic coast of France, though there are some additional incidental counts covering smaller areas. By using the results of these counts and IWRB criteria (7) it is possible to distinguish between important and less important sites. These data and criteria may give conservationists a tool in their attempts to safeguard the most important sites for waders. However, it should be taken into account that information on many Mediterranean sites and wetlands south of Mauritania is still far from complete. This applies to the midwinter situation and even more for autumn and spring.

	Denmark (excl. Wadden Sea)	Wadden Sea	Netherlands, beach	Delta	Belgium, coast	U.K.	Ireland	France	Spain	Portugal	Mediter-ranean	Total
H. ostralegus	0.1	450.5	3.1	101.7	0.4	300.0	32.0	46.0	1.5	0.5	0.8	936.6
H. himantopus									1.0	0.1	0.1	1.2
R. avosetta		0.3		0.3		0.1		17.0	3.5	12.6	15.0	48.8
C. hiaticula		0.2	+	0.2	+	12.0	7.5	6.0	2.5	2.1	0.1	30.6
C. alexandrinus								0.5	3.0	1.1	3.0	7.6
P. squatarola		5.1	0.1	4.6		15.0	1.2	19.5	3.0	6.8	3.0	58.3
C. canutus		71.0		13.9		250.0	30.0	19.0	1.2	0.8	0.1	386.0
C. alba	0.1	2.4	4.1	0.5	0.7	10.0	2.0	1.1	0.7	0.2	0.2	22.0
C. minuta								0.9	1.5	0.4		2.8
C. maritima		0.2	0.4		0.3	18.0	?	1.8	+			20.7
C. alpina	3.2	131.6	0.6	75.6	0.7	500.0	115.0	330.0	25.0	48.2	70.0	1299.9
L. limosa						5.0	9.0	13.6	18.0	9.1	10.0	64.7
L. lapponica		28.9	0.2	5.2		50.0	18.0	11.0	0.4	5.1	0.1	118.9
N. arquata	0.1	85.1	+	10.1		100.0	100.0	18.0	1.6	1.8	7.8	324.5
T. erythropus						0.1	+	+	0.1	0.1	0.8	1.1
T. totanus	0.9	12.0	0.1	3.0	+	100.0	14.5	6.0	2.0	4.7	9.0	152.2
T. nebularia						0.3	0.4	+	0.1	0.1	0.2	1.1
A. interpres		3.3	2.0	1.8	0.7	25.0	5.0	2.5	0.5	0.1	0.3	41.2

Table 1. Estimated total numbers (in thousands) of waders wintering along the Atlantic coasts of Europe and in the Mediterranean basin. Source: (9).

Fig. 2. Sites of major importance for wintering waders in Europe and North Africa (data: IWRB files).

3.2 Trends in population sizes

Results of the Birds of Estuaries Enquiry, organized by the British Trust for Ornithology, have been used to determine trends in population sizes of waders wintering along the British Isles (3).
This was done using the formula

$$\text{index year}_2 = \frac{\text{number year}_2}{\text{number year}_1} \times \text{index year}_1$$

Trends were computed by using data only from areas where counts of two consecutive years were available. This method is also used for the calculation of year to year indexes in the Common Bird Census, a breeding bird census carried out on the British Isles since 1962, which has been the subject of several statistical considerations (i.e. ref. 4). Possibilities for its use for wader counts will depend on the number of sites included in the counts, the availability of sites being surveyed during several consecutive years and some aspects of bird behaviour (no rapid exchange between sites, changes in populations in different estuaries should be more or less proportional). Whether the method can be applied to waders is subject of analysis at the moment (Moser, pers. comm.), but for the British Isles the prospects look much better as compared to most other countries involved. In the extensive Wadden Sea, for example, the choise of the areas where birds roost during high tide depends partly on water levels and disturbance. As a result of these factors, impressive movements of birds to infrequently used roosts may occur, which, dependant on weather conditions, can not always be visited by observers. Therefore in the Wadden Sea at the most a more general calculation of the number of birds missed can be given. Exact calculations of a year index for the whole area will be impossible to make. The same may apply for several large areas elsewhere in Europe, as a result of which calculation of an index on a European scale is difficult for the moment. This is a great pity because indexes may give a much better insight of population changes than the results of the counts alone. The reason is that generally the results of the counts give insufficient information on the number of birds missed, for example because no counts of certain areas were available. This phenomenon is demonstrated in fig. 3, in which the totals for Britain and Ireland of two species are compared with the index for both species. Being part of the technique of the index calculation, it has been taken into account that a varying number of sites has been included in the results, while in the total numbers this correction has not been made. It appears that for Dunlin trends in numbers and indexes more or less coincide. For Oystercatcher however the total results of the counts give a misleading picture of the total numbers wintering in the country, due to not or partly counting of some sites. Total results of counts generally give no information on how complete the coverage of a certain area has been.
Summarizing : the method for calculating trends in population changes may be applicable under certain conditions, i.e. for calculating an index for the British Isles, though some assumptions as well as it accuracy still have to be tested. For the moment its use on a European scale seems to be restricted. If, however, the compiler of the data is informed on both the numbers in each country and the numbers which might have been present in areas not included in the counts, possibilities for the calcula-

tion of absolute numbers and an index calculation on a European scale may exist. This suggestion needs to be tested.

4. POSSIBILITIES VS LIMITATIONS

From the above can be deduced that counts can be considered a reliable tool to establish wader numbers in a certain area. They yield a picture of the distribution of species. In general the sum of numbers during midwinter is used to estimate the size of the total population, from which 1% levels (7) are calculated which are used to distinguish sites of major and minor importance. However figures of total population sizes may be inaccurate due to reasons not yet mentioned: firstly because some wintering areas have not been visited at all or only to an insufficient extent . Future expeditions to those areas are urgently needed! Secondly there are indications that birds wintering in W Africa migrate through E Europe and the eastern part of the Mediterranean and therefore may not be classified as belonging to the East-Atlantic flyway population, i.e. the population passing through NW Europe. Therefore estimates of population sizes of certain species for this flyway may be either under- or overestimates.

As mentioned before, counts also offer, to a certain extent, possibilities of calculations on population trends and to distinguish between important and less important sites. However this latter function can be used only to determine the function as a wintering area in which numbers remain fairly constant for some months. During autumn and spring the number of birds using a certain area may be much higher as compared to the number counted at a certain moment, and the significance in IWRB 1% terms therefore an underestimate. For instance, two recent expeditions in spring to a coastal wetland in Morocco learned that the total number of birds using the study area equalled 4 - 5 times the number counted (2). This may apply for many more wetlands in autumn and spring but turn-over rates of waders in a certain site have rarely been studied before. It is therefore very fortunate that this aspect is part of a Wader Study Group / BTO Birds of Estuaries Enquiry programme in 1984 and 1985, in which both counting and catching activities will be combined. Once again it should be emphasized that breeding areas, moulting areas, wintering areas and areas used for fattening up just before migration (Davidson, this conference) towards the breeding areas and all sites used as stepping stones in between, are links in a chain connecting breeding and wintering areas and are all indispensable. In this chain small stepping stones may play a very important role since areas harbouring very large numbers of waders may be thousands of kilometers apart. Besides wetlands in W Ireland and N Norway, used by large numbers of waders in late spring for only a very short time, may be of vital significance for good breeding success of populations using them. Their significance may be much greater than is apparent from counts alone. The WSG / EEC project on movements of waders between sites (Pienkowski, this conference) may provide us with information on this problem. These activities, together with catching of waders to measure turn-over-rates, studies of use of areas as a moulting place and studies on food intake and fat accumulation before the winter period or prior to spring migration, should be part of study programmes just like counting birds. Only a combination of such activities can show the way birds use a certain area and its importance.

ACKNOWLEDGEMENTS

Thanks are due to Bruno Ens, Marcel Kersten, Kees Rappoldt and Wim Wolff for helpful comments on the manuscript.

5. REFERENCES

1. Altenburg, W., M. Engelmoer, R. Mes & T. Piersma, 1982. Wintering waders on the Banc d'Arguin, Mauritania. Stichting Veth tot Steun aan Waddenonderzoek, Leiden; 283 pp.

2. Kersten, M. & C. Smit, in press. Numbers of waders wintering and migrating along the Atlantic Coast of Morroco. In: Hale, Evans & Goss-Custard (eds.); Proceedings IWRB/WSG Symposium on feeding ecology, Texel, 1981. Cambridge University Press, Cambridge.

3. Marchant, J.H., 1982. In: D.G. Salmon (ed.), Wildfowl and wader counts 1981 - 1982. Wildfowl Trust, Slimbridge: 52 pp.

4. Mountford, M.D., 1982. Estimation of population fluctuations with application to the Common Bird Census. Appl. Statist. 31: 135 - 143.

5. Rappoldt, K. , 1983. Field experiments and calculations on the accuracy of shorebird counts. Wader Study Group Bull. 37: 12.

6. Rappoldt, K., M. Kersten & C. Smit, in press. Errors in large scale shorebird counts. Ardea.

7. Scott, D.A., 1980. A preleminary inventory of wetlands of international importance for waterfowl in West Europe and Northwest Africa. IWRB Special Publ. 2, Slimbridge: 127 pp.

8. Smit, C.J., 1981. The importance of the Wadden Sea for estuarine birds. In: C.J. Smit & W.J. Wolff (eds.), Birds of the Wadden Sea. Balkema, Rotterdam, p. 280-289.

9. Smit, C.J., in press. The importance of Iberian wetlands for waders. In: J. Castroviejo (ed.), Proceedings IWRB Symposium, Sta. Maria de la Rabida (Spain), 1983.

DISCUSSION

In reply to questions, Smit confirmed that the accuracy of counts had been studied only in the Netherlands. The method was to have several persons making independent counts of medium or large flocks of birds at roosts or in meadows, and then to count these birds as they flew in small flocks from the roost to their feeding areas. Buxton (UK) enquired whether accuracy of counting differed between species, but Smit replied that this was not so for waders or ducks. Tamisier (F) emphasized that aerial counts gave different levels of accuracy for diving ducks, surface-feeding duck and Coots *Fulica atra* respectively. Myers (USA) remarked, and Smit agreed, that each individual ornithologist's bias in counting did not diminish with experience. Woldhek (NL) asked why 10 years of counts in the Waddensea were insufficient to produce population trends for each species, as had been calculated in Britain. Smit explained that, although they could estimate the numbers of birds missed during counts, this figure was a total for all species combined, and not separable.

IDENTIFICATION OF RELATIVE IMPORTANCE OF SITES BY STUDIES OF MOVEMENT AND POPULATION TURN-OVER

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Summary

During the long non-breeding season, many shorebirds from breeding areas stretching from arctic Canada to northern Siberia are concentrated in coastal areas of western Europe. Individual birds move between various sites during the non-breeding season and the present study aims to describe the networks of sites used by various species, to provide information required for their conservation. The methods used, involving conventional ringing and use of marks visible in the field, are outlined. Some of the results for an example species, Dunlin *Calidris alpina*, are summarized and a first synthesis of the pattern of movements for this species given. Finally, some of the environmental factors underlying the observed movement patterns are considered briefly.

1. INTRODUCTION

During the long non-breeding season, many shorebirds from wide breeding areas in arctic and cool temperate zones from northern Canada to northern Siberia are concentrated in coastal areas of western Europe. Others pass through these areas in autumn and spring to or from Africa. The coastal habitats which these birds use are subject to a large number of proposals for land-use change, generally involving the loss of their tidal nature and consequent loss of shorebird habitat. Because of the concentration of these shorebirds in intertidal habitats, the area of which is relatively small, such developments may have large effects on the bird populations. The European Community Council Directive on the conservation of wild birds (79/409/EEC) states (Article 4, paragraph 2) "Member States shall take ... measures for regularly occurring migratory species ..., bearing in mind their need for protection in the geographical sea and land area where this Directive applies, as regards their breeding, moulting and wintering areas and staging posts along their migration routes. To this end, Member States shall pay particular attention to the protection of wetlands and particularly to wetlands of international importance."

The coordinated counts described elsewhere in this Workshop provide the first essential step in identifying areas of importance for the birds. However, both counts and preliminary marking studies have indicated that individual shorebirds of many species do not remain for the whole of the non-breeding season in a single area but move between sites separated by hundreds of kilometres. The study outlined below, and commissioned by the European Community Environmental Research Programmes and the Nature Conservancy Council of Great Britain, aims to identify the networks of sites used by these populations of shorebirds in the non-breeding season.

Several component aspects of this aim may be identified. These include:

(i) identification of different sites used by individual shorebirds of the various species;

(ii) determination of whether different sites used are alternatives used in, for example, different years, or part of a sequence of sites visited in each year, or some combination of these;

(iii) quantification, as far as is practicable, of the observed patterns of movements between sites or areas;
(iv) identification of the biological factors underlying these movement patterns, to aid prediction of the effects of any proposed loss of sites.

This paper first outlines the methods used, second summarizes some of the results for an example species, and finally considers briefly some of the possible factors underlying the movement patterns observed.

2. SOURCES OF INFORMATION

This study involves the integration of intensive studies, especially those conducted by Durham University at Teesmouth and Lindisfarne (and particularly relevant to item (iv) above), with several existing extensive surveys and some new ones coordinated by the project team (see references 6, 10, 18). The existing extensive surveys include (a) the national counts coordinated internationally by the International Waterfowl Research Bureau (see C. Smit, in this Workshop); and (b) the recoveries of national bird-ringing schemes, gathered centrally by Euring (the European Committee for Bird Ringing). The transfer of these data to the Euring computerized data-bank has also been aided by a contract from the EEC Environment Programme. For some national schemes, all ringing recoveries will be available for the analysis but, unfortunately, for some countries incomplete computerization has made only a proportion (usually unknown) available.

Details of catch totals, of measurements of birds caught and of recaptures near the ringing site (which are not gathered centrally by most national ringing schemes) are essential to an assessment of the extent to which networks of sites are used by individual birds. Therefore, extensive survey (c) involves the collection of original ringing (and recapture data) from numerous individual ringers and groups in several western European countries, and transfer of this to computer files.

Despite the large numbers of shorebirds ringed, mainly by amateur workers, in western Europe, the chance of a particular ringed bird being reported again within a few months of marking is low. Consequently, information on aim (ii) is hard to obtain from this source for most species. Extensive survey (d) provides information on this aspect, using marks visible in the field. Marking with plumage dyes and coloured temporary leg-flags at selected sites in W. Europe is coordinated by the project team and carried out with the help of amateur bird-ringers and professional ornithologists in several countries. To make most use of the marked birds, a network of about 400 voluntary observers has been organised, to make frequent checks at sites throughout western Europe. As these observers report the numbers of birds examined for marks whether or not marked birds are seen, definite negative information is available as well as positive sightings. Amongst other benefits, this provides data on the seasonal timings of the movements of the birds. Observations from other bird-watchers is also collected, but its usefulness is, of course, more limited.

Surveys (c) and (d) are coordinated by the project team at Durham, and use also the resources of the Wader Study Group (WSG).

3. AN OUTLINE OF RESULTS FOR AN EXAMPLE SPECIES: DUNLIN (CALIDRIS ALPINA)

To illustrate the type of material which can be obtained by these methods, some of the results for Dunlin are presented below. As counts are the subject of another paper at this Workshop, these are not presented here. Data from survey (c) are being collated at present, so that quantification of movement patterns is not considered in detail here and, in any event, lack of space would prevent this. Dunlin is, however, one of the few species for which appreciable numbers of within-year ringing recoveries are available, allowing the use of these, together with those of the visible marking programme, to describe the pattern of site-use by individual birds within one breeding season. Although recoveries of Dunlins ringed in Britain and Ireland (and supplied directly from the British Trust for Ornithology) are included in this provisional analysis, the data from other countries was received from Euring only one week before this paper was prepared. Thus, for these regions, information is based mainly on the visible marking programme.

3.1 Results from ringing recoveries

This analysis of the recently completed data-set of recoveries of British- and Irish-ringed waders was restricted to birds which were ringed and recovered in the same non-breeding season (July to June). This restriction makes the data as comparable as possible with the results of the dye-marking programme. It should be borne in mind that ringing recoveries are subject to considerable biases, due for example to differences in ringing effort in different places, years and seasons, similar differences in chance of recovery, and consequent interactions between these factors. Additionally, it should be remembered that only some of the recaptures near the marking area will have been reported. (This last problem should be largely solved when the data collection directly from ringers is completed.)

A total of 3578 recoveries of Dunlin had resulted by the end of 1981 from ringing in Britain and Ireland. Of these, 561 concerned recoveries in the same non-breeding season as that of ringing. This latter group is considered further below.

For the initial analysis, the non-breeding season was divided into 4 periods: July-August (approximating to early autumn migration), September-October (later migration and/or during moult), November-February (winter), and March to June (spring migration). Recoveries were examined from ringing in several areas of Britain: The Wash, SE England (Thames estuary and Essex & N Kent estuaries); S coast of England; Severn estuary and Bristol Channel; E Irish Sea; Moray Firth, Firth of Forth and Tay; and NE England.

Recoveries were sorted according to ringing area and pairs of time periods between period of ringing and period of recovery, eg both ringed and recovered within July-August; ringed in July-August but recovered in September-October; etc. Of course, not all of these area and time divisions provided sufficiently large samples for further analysis.

a) Within July-August. At several major estuaries, there seemed to be little onward movement within this period. This was true of The Wash (Fig. 1a) where, apart from one movement to northern France, all recoveries were local; SE England (Fig. 1b) from which only one Dunlin moved away - to The Wash - and the rest were local; and the E Irish Sea estuaries (Fig. 1c), from which there was one short movement to the Isle of Man but others were local. This situation was not unexpected for adults, as those from north European breeding grounds should have been starting their annual complete moults. However, the lack of movement of juveniles, despite several recoveries of young birds ringed at The Wash and in SE England is more surprising as these birds do not undergo a complete moult. Perhaps the moulting areas of the adults are used by the young to continue growth of various body components or acquire feeding experience in coastal habitats, which are very different from many breeding areas, or to deposit reserves for onward migration - see below. The coast of NE England appears to fulfil a different function, that of a migration staging post for Dunlin. Several juveniles and adults ringed here were recovered within the same two-month period, some at the ringing site, some further south in Britain, and others in France and Portugal (Fig. 1d). Possibly there is some segregation in areas used by different Dunlin

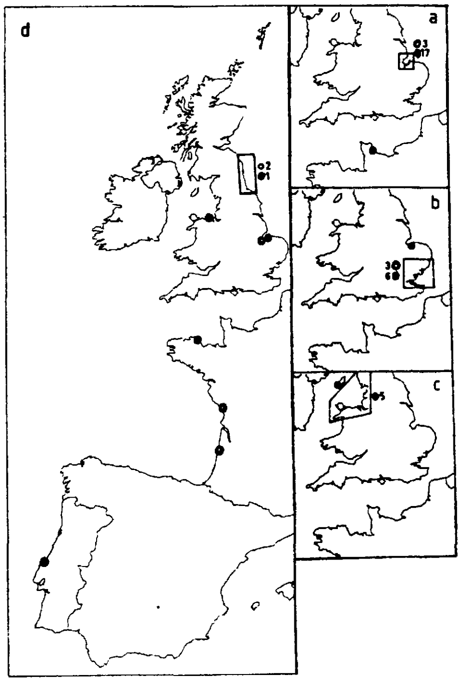


Figure 1. Reported recoveries in the same July-August period of Dunlins ringed in July-August at a) The Wash, b) SE England, c) E Irish Sea, and d) NE England. These marking areas are indicated by boxes, and the numbers of reported local recoveries noted alongside these. (Note that many local retraps made by the ringer may not have been reported.) Open symbols indicate birds identified as being in their first year of life; solid symbols indicate all other birds.

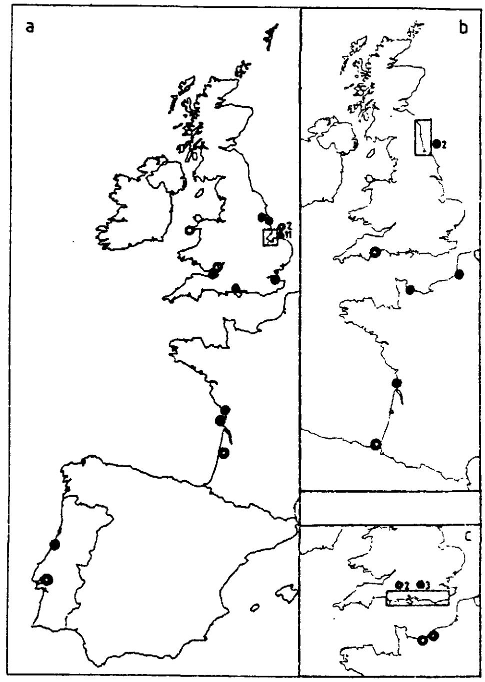


Figure 2. Reported recoveries in the following September-October of Dunlins ringed in July-August at a) The Wash, b) NE England, and c) S coast of England. Other details as for Fig. 1. Two birds in their first year and two adults recovered in Morocco and 1 first-year bird in Mauritania, all from The Wash, are not shown.

populations. Evans (4) has suggested that the Dunlins using the Northumbrian coast at this time are mainly from Icelandic breeding areas (and therefore probably winter in NW Africa - 16). Nothing is known of the movements of the large numbers of Dunlins using the Lindisfarne area of Northumberland as none have been caught there.

b) Ringed in July-August and recovered in September-October. Some birds from both The Wash and NE England were recovered close to the ringing area, others elsewhere in Britain and several in France, Iberia and NW Africa (Fig. 2a,b). There was no obvious difference in distribution between recoveries of juveniles and adults. These data probably refer to birds of two groups: (i) those which come from the breeding populations of the temperate latitudes of Europe (and also Iceland) and which were probably caught whilst refuelling in Britain; and (ii) those of the N Eurasian-breeding population *C. a. alpina* which forms the W European-wintering population. Some of the latter may have undertaken relatively short post-moulting movements in October.

Birds ringed on the south coast of England have shown less extensive movements at this time of year (Fig. 2c), staying within the English Channel region. Possibly this part of England is less used by passage birds. It is notable that the influx of Dunlins from several sources to the French coast coincides with the start of the autumn-winter increase in numbers of Dunlins recorded at several French sites by regular counting (R. Mahéo, *in litt*.).

c) Ringed and recovered within September-October. Even though local recaptures are under-recorded, most recoveries of adult birds ringed at The

Wash or in SE England at this period (of annual moult) were close to the ringing area (Figs 3a,b). Some dispersal of the juveniles is, however, indicated, as well as the migration of three adults, to France and Portugal.

<u>d) Ringed in September-October and recovered November-February.</u> A wide dispersal from several areas used in autumn to sites used in mid-winter is revealed (eg Figs 4a,b,d). This is in broad agreement with the dye-marking results (see below). The essential differences between the results of the dye-marking programme and those of ringing are that the former has provided larger samples but for fewer areas of marking, and has provided more precise information on timings of movements; ringing results refer, of course, to individual birds but take much longer to accumulate.

The recoveries of Dunlins ringed at The Wash (Fig. 4a) appear to show an age difference, with a few adults moving north and west whilst many juveniles moved south and west. This

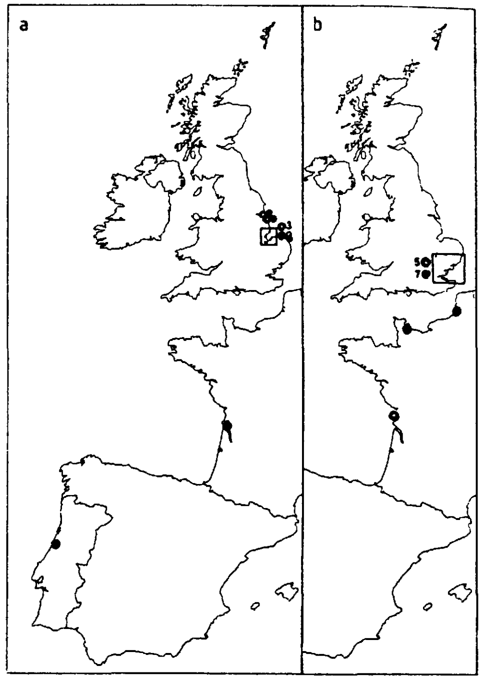


Figure 3. Reported recoveries in the same September-October period of Dunlins ringed in September-October at a) The Wash, and b) SE England. Other details as for Fig. 1.

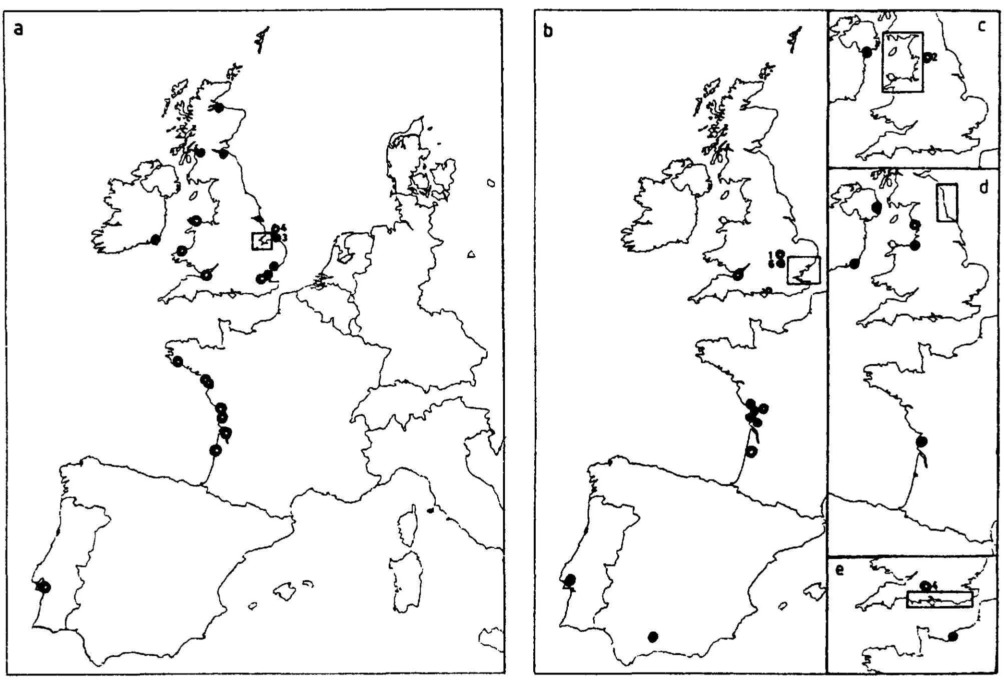


Figure 4. Reported recoveries in the following November-February of Dunlins ringed in September-October at a) The Wash, b) SE England, c) E Irish Sea, d) NE England, and e) S coast of England. Other details as for Fig. 1. Not shown is one bird in its first-year which moved from the S coast of England to Morocco, one bird which moved from SE England to Morocco and one post-juvenile which moved from NE England to Western Sahara.

may, however, be an artifact, as results of dye-marking indicate a wide arc of movement from The Wash by both age categories. Further, the considerable movement from The Wash to south and south-west England, detected by dye-marking and detailed in previous reports on the project, is not apparent in the ringing results. This is presumably because of the low chance of recovery in winter in these areas, since relatively few attempts are made to catch birds then, and most recoveries of ringed birds in Britain have come from recaptures by ringers.

In contrast to the extensive movements from three areas on the E. coast of England (Figs 4a,b,d), less onward movement is evident (Fig. 4c) from birds ringed on the E. Irish Sea coast (although the chance of recovery in Ireland is probably fairly low) or those ringed on the S coast of England (Fig. 4e).

e) Ringed in July-August and recovered in November-February. As might be expected, the recoveries in this category of birds ringed at The Wash (Fig. 5) tend to overlap with those reported in sections (b) and (d) above, except that there are no NW African recoveries. This may be because, by mid-winter, most of the NW African wintering birds have moved on from moulting and staging areas in Morocco, where the chance of reporting of ringed birds is reasonable, to the main mid-winter concentrations on the sparsely-inhabited Banc d'Arguin of Mauritania (16).

It is not known if the relatively high number of recoveries in Iberia reflects a tendency for those birds staging earlier (July-August) at The Wash to winter here, whereas those staging later (September-October, Fig. 2a) winter further north in W. Europe. Alternatively, it could be an artifact of seasonal variations in hunting pressure.

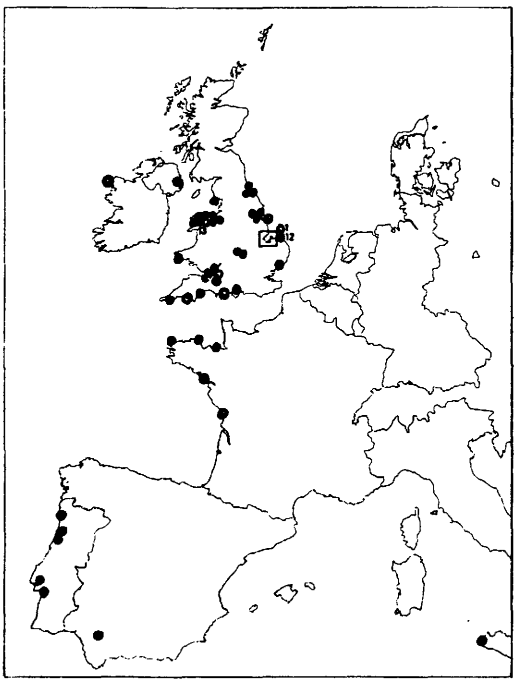


Figure 5. Reported recoveries in the following November-February of Dunlins ringed in July-August at The Wash. Other details as for Fig. 1.

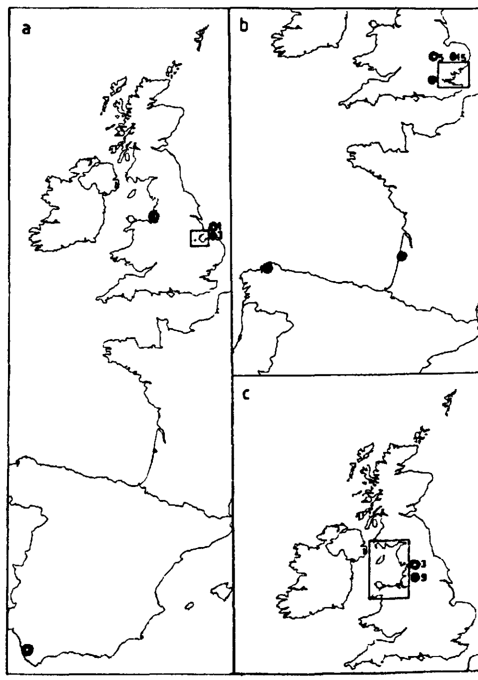


Figure 6. Reported recoveries in the same November-February period of Dunlins ringed in November-February at a) The Wash, b) SE England, and c) E Irish Sea. Other details as for Fig. 1.

f) Ringed and recovered within November-February. This appears to be a fairly static period of the year for Dunlins. Apart from juveniles moving to S Spain and NW England, recoveries of Wash-ringed birds were local (Fig. 6a). Similarly, recoveries of Dunlins ringed in SE England were all local except for one in SW France and one in NW Spain (Fig. 6b). (Unfortunately, ages at ringing of neither bird were established.) All recoveries from the E. Irish Sea estuaries were within the general ringing area (Fig. 6c).

g) Ringed in November-February and recovered in March-June. Spring recoveries are few (Fig. 7), probably because catching activities are fewer or less successful in that season and because the shooting season has finished by then in several of the countries in which this species is hunted. Of Dunlins ringed at The Wash, all recoveries were local, as were recoveries of Dunlins ringed in SE England (Fig. 7a) and the Severn (Fig. 7b), except for one and two birds, respectively, recovered in the German Wattenmeer. Most Irish-Sea-ringed Dunlins were recovered locally with one recovery in each of The Wash and the Danish Vadehavet (Fig. 7c). These recoveries parallel the rather more numerous results from dye-marking, summarized by Pienkowski & Evans (17) and reproduced as Fig. 11.

h) Ringed in autumn and recovered in March-June. Maps of recoveries of birds ringed at The Wash in September-October or July-August and recovered in the following March-June are given in Figs 8a,b. These are slightly more difficult to interpret as they may include both birds still on their wintering grounds and those that had moved to sites used in spring. Therefore, both maps in part reflect the winter distribution of birds ringed at The Wash in

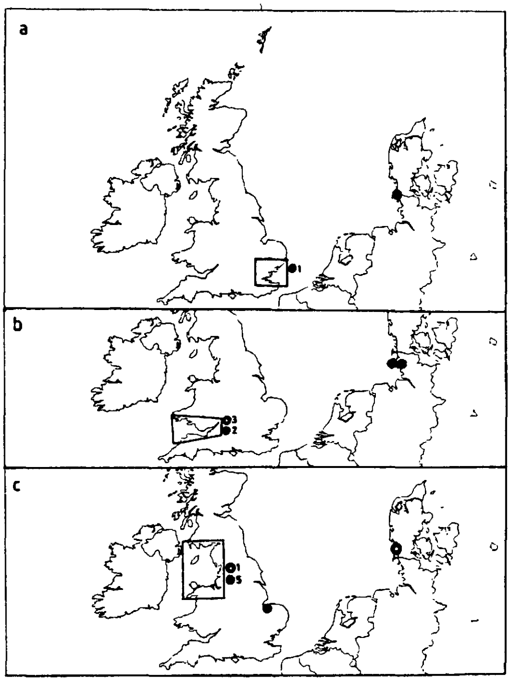


Figure 7. Reported recoveries in the following March-June of Dunlins ringed in November-February at a) SE England, b) the Severn Estuary and Bristol Channel, and c) E Irish Sea. Other details as for Fig. 1. Not shown are recoveries in Finland of one bird each (both in their first year of life) from SE England and E Irish Sea, and one bird from SE England in the Soviet Union.

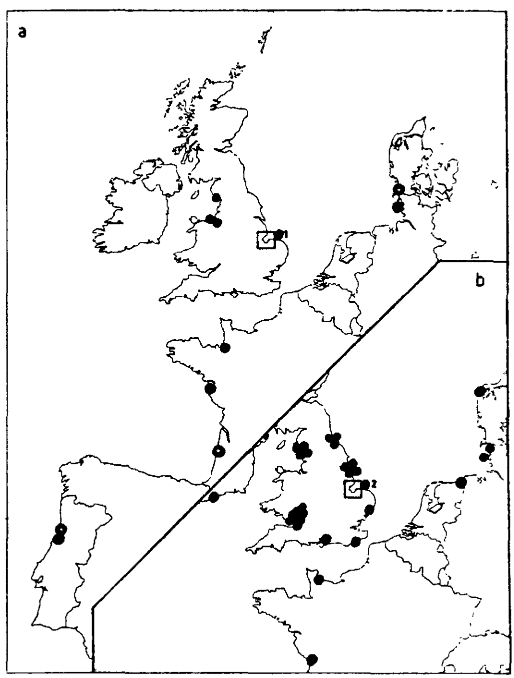


Figure 8. Reported recoveries in the following March-June of Dunlins ringed at The Wash in a) September-October, and b) July-August. Other details as for Fig. 1. Not shown in b) are two birds in the Soviet Union and one in Morocco (all post-juveniles).

autumn (Figs 4a,5). However, considerable usage of the German and Danish coasts in spring by the autumn-ringed birds (Figs 8a,b) contrasts with the lack of evidence of such usage by winter-ringed birds at The Wash (for which all spring recoveries were local). This may indicate that those Dunlins which winter at The Wash tend to remain there through much of the early spring, whilst those leaving to winter further south or west are more likely to use the Wadden Sea in the spring. The fact that some birds which were at The Wash as early as July or August used the Wadden Sea in spring may suggest that these individuals use different sites for their autumn and spring staging areas.

3.2 Results from visible marking

Some of the results of the visible marking have previously appeared in progress reports on the project to EEC, at previous meetings of the Contact Group, and in reports to participants published in Wader Study Group Bulletin. Therefore, to save space, these are presented in less detail than those resulting from ringing.

Figure 9 summarizes some of the sightings in the following winter of Dunlins marked in autumn 1981 or 1982 in the Danish, German or Dutch Wadden Sea, the Zeeland Delta area of the Netherlands and The Wash on the East coast of England. A wide and overlapping dispersal from all these sites is evident. Furthermore, the systematic observations at several sites, notably the Severn (England/Wales) show that the first birds from The Wash, the Waddenzee and the Wattenmeer arrived at about the same time. This was in mid-October, probably shortly after the birds completed their full autumn moult.

Although the movements illustrated in Figure 9 cover an arc from NW to S, a more easterly movement in autumn has been recorded from some other sites.

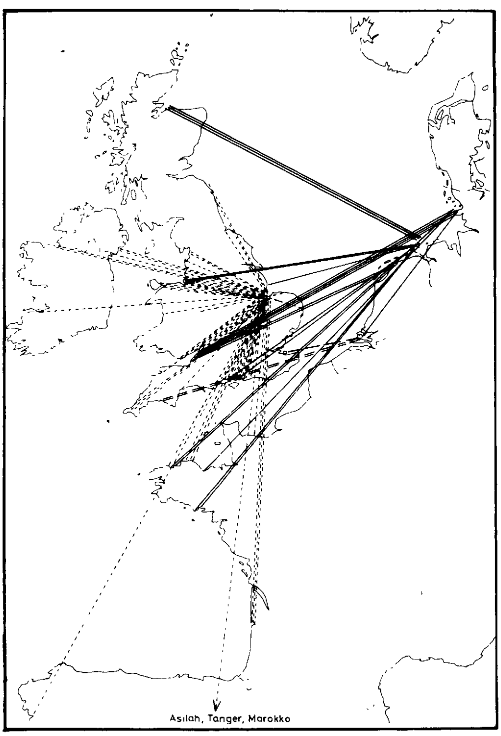


Figure 9. Some of the sightings in winter away from the moulting areas of Dunlins, marked in autumn 1981 or 1982 at the Wattenmeer (———), the Zeeland Delta (— — —), or the Wash (-----). The lines connect sites of marking and sighting of individual dyed birds, but do not necessarily indicate the route followed.

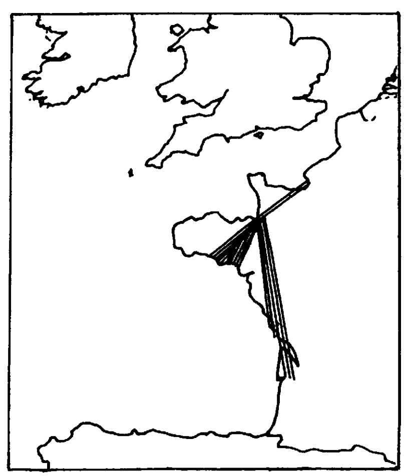


Figure 10. Sightings elsewhere of Dunlins marked at Baie du Mont St Michel, France. Lines join location of marking to that of sighting.

For example, several Dunlins marked in N Wales in August and September 1982 were seen later at several sites on the east coast of England. Movements of Dunlins following marking at Baie du Mont St Michel, France, in November 1982 are shown in Figure 10. Considerable numbers of marked birds remained near the marking area but others dispersed widely along the French coast.

Visible marking has provided rather more information than has ringing on movements from sites used in late winter to those used in spring (Fig. 11).

4. A FIRST SYNTHESIS OF THE MOVEMENTS NETWORK OF DUNLINS

4.1 Introduction

Using the information on within-year recoveries and sightings of dye-marked birds summarized above, a first attempt is made here to identify the networks of sites used by individual Dunlins within the non-breeding season in western Europe. Additional information on the longer-distance movements to and from the breeding grounds of the various populations is taken from earlier publications (eg 9, 14, 16 and previous sources to which reference is made in these papers).

For this synthesis, the various estuaries and other coasts of western Europe are grouped into regions. Where possible, these regions are natural groupings suggested by the results (eg E Irish Sea; S coast of England and part of the N coast of France). However, in other cases, the grouping is more arbitrary and forced by the limited quantity of data presently available (eg Ireland, W France). In some cases, finer resolution may be possible when the ringing recoveries just received from Euring are analysed; this may help subdivision of, eg, the large Wadden Sea areas. At present, only British (and the few Irish) ringing recoveries are included in the compilation.

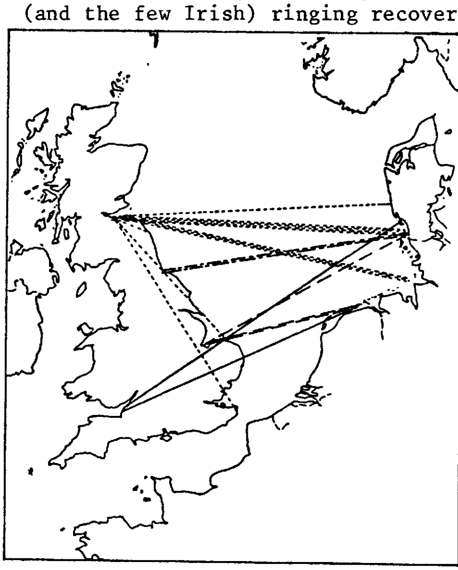


Figure 11. Some of the sightings away from the marking area in the following March and early April of Dunlins marked in winter (1978/9 to 1981/2) at the Severn Estuary (———), The Wash (— —), the Tees Estuary (—·—·), or the Firth of Forth (-----). Lines join the location of each sighting to the marking area and do not necessarily indicate routes taken (from Pienkowski & Evans, 17).

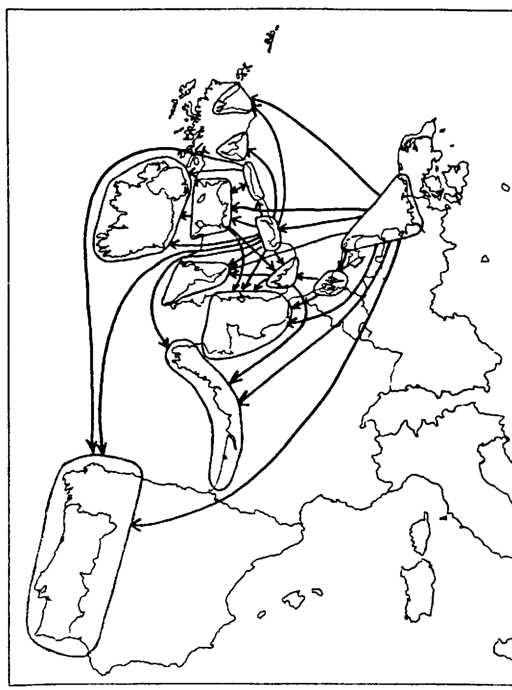


Figure 12. Summary of late autumn (post-moulting) movements of Dunlins, for which there is direct evidence. Lines do not indicate actual routes taken between areas.

4.2 Autumn and spring migration of populations wintering in Africa

Those populations of Dunlins which breed in temperate areas of Europe and in Iceland and Greenland winter mainly in West Africa. Very many coastal areas of western Europe are visited by these birds on their autumn migration (see, eg, 8, 14, 16) and it is not possible at present to establish how many sites an individual uses, nor if particular sites are of especial importance. In spring, there is information that migration of the most numerous component of these populations, that from Iceland, is concentrated on the western seaboard: probably Iberia, W France, W Britain, possibly Ireland, and E Britain from the Humber northwards.

4.3 Movements of C. a. alpina

The remainder of this analysis concerns the more numerous subspecies of Dunlin, which breeds in N. Eurasia and winters in W Europe.

a) Movements from sites used in autumn to sites used in winter

Large numbers of Dunlins move between sites in western Europe, chiefly in October-November; this coincides with the end of moult of the adult birds. Movements for which there is clear evidence are indicated in Figure 12. Additionally, many birds remain at their autumn (moulting) sites: later analyses will try to quantify the relative proportions that stay and that move from certain sites.

Despite the complexity of Figure 12, some distinct patterns are shown. Some areas have a net loss of Dunlins at this time; numbers of birds leaving exceeding numbers of birds arriving. The Wadden Sea is the prime example, particularly the more north-easterly parts of that area. Dunlins from the Wadden Sea move as far west as the Irish Sea, as far north as the Moray Firth, and as far south as Iberia. There is also some movement to The Wash, but this appears to be relatively small. The Wash is also clearly a major "exporter" of Dunlins at this time. Counts support this, showing that peak numbers occur on the Wash in September (21).

Other sites appear to be both major suppliers and recipients of Dunlins: Netherlands Delta, SE England, E Irish Sea and, to some extent, NE England. Finally, several sites on the western seaboard of Europe and in northern Scotland seem to be mainly recipients of Dunlins at this time, although they may hold small moulting flocks of Dunlins earlier in the autumn.

b) The mid-winter period

The period from November to February appears to be the most static period as regards interestuarine movements of Dunlins (Fig. 13). Some movements do occur, for example from The Wash to the Irish Sea and Iberia, and from SE England to France and Iberia. Counts also suggest some continued movement at this period: peak numbers occur at several western and southern sites in January or February (21). Marking at Baie du Mont St Michel in France in November showed numerous mid-winter movements in both directions along much of the W coast of France. Generally, however, the numbers of Dunlins moving is far less than immediately after the moult. A marking study in the Firth of Forth in the winter of 1978-79 showed no appreciable influx into that area over the late winter period (15, 24).

c) Movements from sites used in mid-winter to those used in early spring

In the period from mid-February onwards, more movements occur than in the mid-winter period. Birds move to certain areas for the moult into breeding plumage and deposition of fat to fuel their return to the breeding

Figure 13. Summary of movements of Dunlins, within the period November to February, for which there is direct evidence.

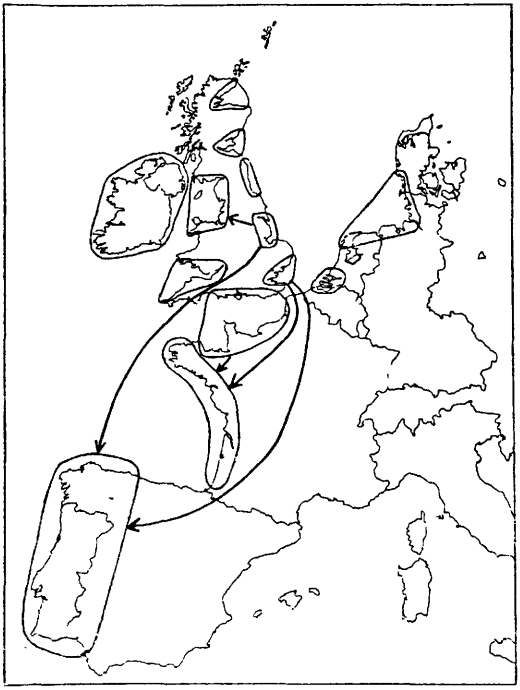
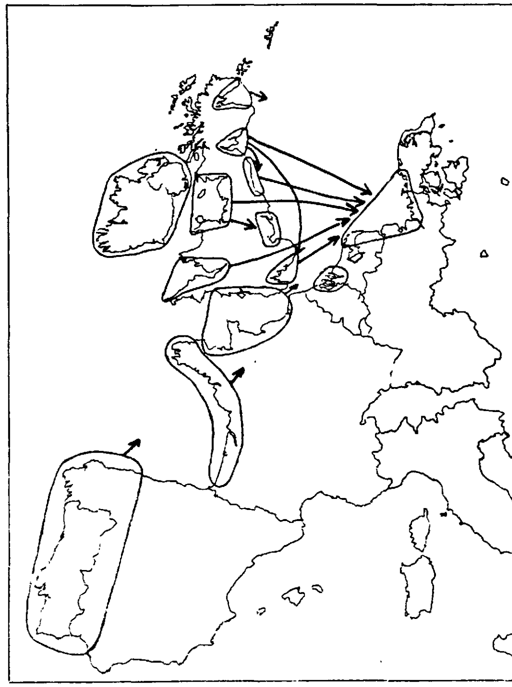


Figure 14. Summary of movements of Dunlins, in the late winter-early spring period, for which there is direct evidence.



areas. Figure 14 summarizes those movements for which there is direct evidence although, as noted earlier, spring information is rather limited. Movements from several areas of Britain to both the Wadden Sea and The Wash are well established. Count information reveals similarly timed departures from many other areas, but direct evidence of the destinations of these birds is lacking.

4.4 Further work

Further studies will refine the outline of movement patterns proposed here and quantify them (in so far as this is practicable). Contrasts between movements of adults and juveniles will be explored further. Use will also be made of recoveries in years other than that of ringing. The approach is also, of course, being applied to other species.

5. WHY DO THE BIRDS MOVE DURING THE NON-BREEDING SEASON?

The environmental factors which underlie the pattern of movement discussed above for Dunlin, and those of other shorebird species, have been discussed by Evans (5, 6), Pienkowski (11), Pienkowski & Prokosch (19) and Pienkowski & Evans (17). These discussions are based on the results of the present study and those of related detailed studies (such as that at Teesmouth) on the effects of environmental factors on the behavioural ecology of the species concerned. Some of these factors and processes are summarized briefly below.

Waders meet their daily food requirements by catching, at a sufficiently fast rate, the worms, molluscs and crustaceans that live in the sand and mud. (Although they can deposit fat and protein reserves to help them over

Figure 15. Mean surface air temperatures (°C) in a) January and b) May, 1931-60 (from Meteorological Office, after 3).

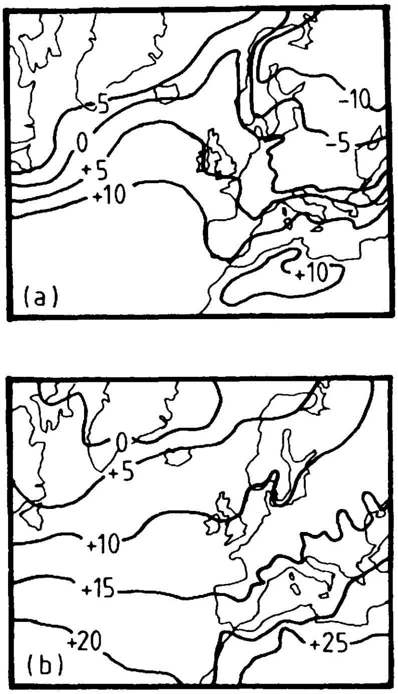
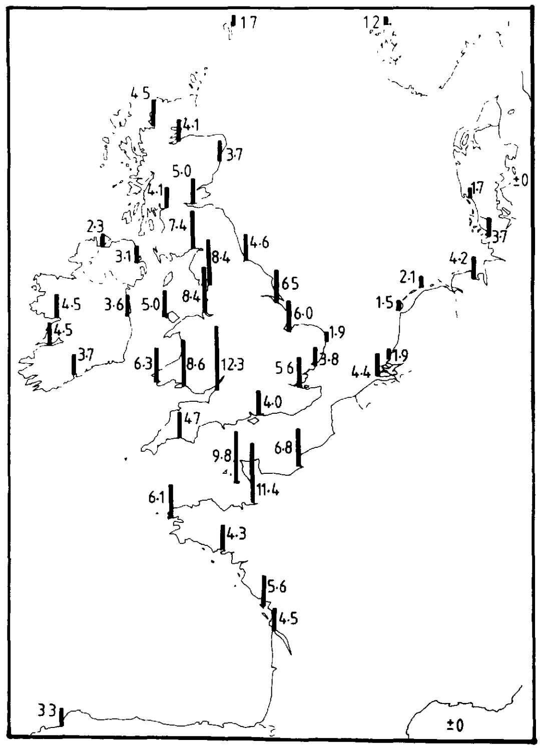


Figure 16. Mean range of spring tides (m) at various sites in Western Europe.



difficult times, these can last only a few days – 20). Generally, the prey can be caught only when they are near the surface and, in some cases, when they are actually active at the surface (11). Generally, prey activity decreases with decreasing temperature (12), and, additionally, in winter some prey animals bury deeper (5, 22). As winter sets in, therefore, feeding rates of waders become reduced and some may have difficulty in obtaining enough food each day (eg 2, 13, 20).

In the warmer weather of early autumn, there are fewer problems for birds to obtain food in western Europe, and at this time most birds perform their annual complete moult of body and flight feathers. At this time reliable sources of food and reasonable safety from predators (while the waders' flight may be impaired) is of obvious importance. The large tidal areas such as the Wadden Sea (Denmark, Germany & the Netherlands) and The Wash on the east coast of England are important moulting grounds. However, by the time moult is ending (generally late October), weather conditions are rapidly worsening. This is more marked further away from (ie to the east of) the Atlantic Ocean, so that by winter the isotherms run north-south, with an average temperature difference of 5 °C between W Ireland and the Wadden Sea (Fig 15). Because of the reduced activity of prey at colder temperatures, as well as the risk of the mud and sand surface freezing (and making prey totally unavailable), there may well be advantages for birds to move west by then.

Another reason for the tendency to westward movement may possibly be important. At the same time that cold temperatures and long nights increase the energy requirements of birds and make the catching of prey more difficult, the incidence of gales, particularly of westerly gales, increases. These may markedly raise the water level in the Wattenmeer areas, so preventing exposure of the birds' feeding areas for long periods. Gales are, of course, at least as common around the British Isles and in W France, but in these countries the tidal range is much greater (Fig 16). Thus, although water levels in these areas are also affected by gales and atmospheric pressure, the effect is much smaller in proportion to the tidal range, and so the exposure times of feeding areas change much less.

By spring, gales have subsided and the continental coasts tend to warm faster than the more oceanic coasts (Fig. 15; reference 3). Many birds return to the Wattenmeer areas (eg Fig. 11; reference 23) for spring moult of their body feathers and fattening for migration before returning to the arctic breeding areas (1).

REFERENCES

1. Boere, G.C. 1976. The significance of the Dutch Waddenzee in the annual life cycle of arctic, subarctic and boreal waders. Part 1. The function as a moulting area. Ardea 64:210-291.
2. Dugan, P.J. 1981a. The importance of nocturnal foraging in shorebirds: a consequence of increased invertebrate prey activity. pp. 251-260 in Feeding and survival strategies of estuarine organisms (eds N.V. Jones & W.J. Wolff). Marine Science, vol. 15. Plenum Press, New York.
3. Dugan, P.J. 1981b. Seasonal movements of shorebirds in relation to spacing behaviour. Ph.D. thesis, University of Durham.
4. Evans, P.R. 1966. Wader migration in north-east England. Transactions of the Natural History Society of Northumberland, Durham & Newcastle-upon-Tyne 16:126-151.
5. Evans, P.R. 1976. Energy balance and optimal foraging strategies in shorebirds: some implications for their distributions and movements in the non-breeding season. Ardea 64:117-139.
6. Evans, P.R. 1980. Movements of wader populations between estuaries: some questions raised by studies at Teesmouth. Wader Study Group Bull. 29:6.
7. Evans, P.R. 1981. Migration and dispersal of shorebirds as a survival strategy. pp. 275-290 in Feeding and survival strategies of estuarine organisms (eds N.V. Jones & W.J. Wolff). Marine Science, vol. 15. Plenum Press, New York.
8. Green, G.H. 1978. Discussion of wader measurements and migrations. pp. 61-68 in Joint Biological Expedition to North East Greenland 1974. (Eds G.H. Green & J.J.D. Greenwood). Dundee University NE Greenland Expedition, Dundee.
9. Hardy, A.R. & Minton, C.D.T. 1980. Dunlin migration in Britain and Ireland. Bird Study 27:81-92.
10. Pienkowski, M.W. 1980. WSG cooperative project on movements of wader populations in western Europe. Wader Study Group Bull. 29:7.
11. Pienkowski, M.W. 1981a. Differences in habitat requirements and distribution patterns of plovers and sandpipers as investigated by studies of feeding behaviour. Proc. IWRB Feeding Ecology Symp., Gwatt, Switzerland, September 1977. Verhandlungen Ornithologischen Gesellschaft in Bayern 23: 105-124.
12. Pienkowski, M.W. 1981b. How foraging plovers cope with environmental effects on invertebrate behaviour and availability. pp. 179-192 in Feeding and survival strategies of estuarine organisms (eds N.V. Jones & W.J. Wolff). Marine Science, vol. 15. Plenum Press, New York.

13. Pienkowski, M.W. 1982. Diet and energy intake of Grey and Ringed Plovers, Pluvialis squatarola and Charadrius hiaticula, in the non-breeding season. J. Zool., Lond. 197:511-549.
14. Pienkowski, M.W. 1983. Calidris alpina Dunlin - Movements. pp 358-361 in The Birds of the Western Palearctic, Vol. 3 (Eds S. Cramp & K.E.L. Simmons). Oxford University Press, Oxford.
15. Pienkowski, M.W. & Clark, H. 1979. Preliminary results of winter dye-marking in the Firth of Forth, Scotland. Wader Study Group Bull. 27:16-18.
16. Pienkowski, M.W. & Dick, W.J.A. 1975. The migration and wintering of Dunlin Calidris alpina in north-west Africa. Ornis Scandinavica 6:151-167.
17. Pienkowski, M.W. & Evans, P.R. 1983. Migratory Behavior. In Shorebirds (Eds J. Burger & B.L. Olla). Behavior of Marine Animals, Vol. 5. Plenum Press, New York. (in press).
18. Pienkowski, M.W. & Pienkowski, A.E. 1983. WSG project on movements of wader populations in western Europe: eighth progress report. Wader Study Group Bull. 38:
19. Pienkowski, M.W. & Prokosch, P. 1982. Wanderungsmuster von Watvögeln zwischen den Küsten-Ländern West-Europas - Bericht über ein laufendes Project. Seevögel 3:123-128.
20. Pienkowski, M.W., Ferns, P.N., Davidson, N.C. & Worrall, D.H. (in press). Balancing the budget: measuring the energy intake and requirements of shorebirds in the field. In Coastal waders and wildfowl in winter (Eds P.R. Evans, J.D. Goss-Custard & W.G. Hale). Cambridge University Press, Cambridge.
21. Prater, A.J. 1981. Estuary birds of Britain and Ireland. T. & A.D. Poyser, Calton.
22. Reading, C.J. & McGrorty, S. 1978. Seasonal variations in the burying depths of Macoma balthica and its accessibility to wading birds. Estuar. & Coast. Mar. Sci. 6:135-144.
23. Smit, C.J. & Wolff, W.J. 1981. Birds of the Wadden Sea. A.A. Balkema, Rotterdam.
24. Symonds, F.L., Langslow, D.R. & Pienkowski, M.W. 1983. Movements of wintering shorebirds within the Firth of Forth: species differences in usage of an intertidal complex. Biological Conservation (in press).

DISCUSSION

M. Marquis asked why Dunlin had been chosen as the example species for this paper.

Reply: Dunlin is the most abundant coastal wintering wader in NW Europe, and the most caught. Consequently, it is the best species, in terms of quantity of data available, for a comparison between the results of studies using marks visible in the field and of those using within-year ringing recoveries. This makes for a clearer story for the meeting and also allows some checking of the methods before they are applied to species with fewer data, but for which also information is required by conservation agencies.

H. Oelke welcomed the way the results of the study allowed the importance of the Wattenmeer as a staging area used by birds which moved on to many other winter sites to be established on the basis of sound evidence previously unavailable.

J. P. Myers asked if it was intended that the chances of reporting of marked birds in different areas would be incorporated in future analyses.

Reply: It is certainly the intention, for both material using ringing recoveries and that based on visible sightings, to allow for numbers of birds checked for marks. This is one of the main reasons for gathering directly from bird-ringers details of their catches, as this information is not gathered centrally in an easily accessible form by most national ringing schemes in Europe. We also intend to take account, in assessing chance of sightings, of the numbers of birds present at each site, by making use of the data from counts.

N. E. Buxton asked if the pattern of movements of shorebirds in winter around western Europe could be explained by differences in prey abundance or the seasonal pattern of this in different estuaries; or were such data not available?

Reply: This was investigated by a research student at Durham (Dugan 1981b). The main problem he found was that the different sampling, analysis and reporting procedures used in different studies made comparison difficult. (These differences arose partly because a different sampling procedure is appropriate if one is investigating, for example, the population dynamics of an intertidal worm than if one is making a wide survey of potential prey of a shorebird.) However, despite the compiling of a great deal of material from many estuaries around the coasts of Britain, there were no indications that differences in prey abundance occurred which could explain the bird movements, and considerable evidence that such differences did not occur. However, that investigation and its development in the present study, outlined in the paper, indicate that area differences in the availability of prey and in the food demands, largely related to weather conditions, could account for at least some of the movement patterns. Of course, critical tests of this would be extremely difficult.

M. Smart asked if shorebirds, like geese, learnt from their parents the location of suitable areas to use in the non-breeding season, and if such traditions could cause problems in utilizing new areas, especially if some existing ones are lost through human activities.

Reply: Shorebirds do not migrate in family parties and, indeed, the young of most species usually migrate from the breeding grounds rather later than the adults. There is evidence from both waders and coastal ducks that young of the same brood may winter in widely different areas (eg Pienkowski

1983b, Pienkowski & Evans 1979).

There is increasing evidence that the behaviour of young shorebirds in their first autumn largely determines their migratory patterns and spacing behaviour in subsequent years. This is best exemplified by Townshend's (MS) studies on Grey Plovers Pluvialis squatarola at Teesmouth. Whether a bird stays to winter at Teesmouth and, if so, whether or not it defends a feeding territory appear to be determined in the first year, body size possibly playing an important role. On this basis, one would expect considerable potential for moving to new sites on the part of young birds but rather less on the part of adults. This might lead to problems in that, unlike some songbirds, at any one time a high proportion of individuals in shorebird populations are adults. (This is a consequence of adaptation to very variable conditions in the breeding season, by limiting the risks taken in breeding - and the production - in any one year so that adults live long and have many breeding attempt.) This might be relevant in a consideration of lead-time required in the provision of alternative sites.

A further problem is that we do not know to what extent further sites are available. For example, does the outward movement in winter from moulting centres in the Wadden Sea and The Wash, described above for Dunlin, imply that sites at the limit of this movement are not yet full? Similarly, are some birds at present effectively excluded from some sites by, for example, the intensity of shooting: would the habitats there be suitable if shooting ceased?

Additional references

Pienkowski, M.W. 1983b. Development of feeding and foraging behaviour in young Ringed Plovers Charadrius hiaticula in Greenland and Britain. Dansk orn. Foren. Tidsskr. (in press).

Pienkowski, M.W. & Evans, P.R. 1979. Shelducks of the Firth of Forth. Edinburgh Ringing Group Report 6:10-18.

Townshend, D.J. MS. Decisions for a lifetime: establishment of spatial defence and movement patterns by juvenile shorebirds. Submitted to Ibis.

IDENTIFICATION OF REFUELLING SITES BY STUDIES OF WEIGHT CHANGES AND FAT DEPOSITION

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Summary

Waders migrating long distances between breeding and wintering grounds must refuel at least once on route. Many waders breeding from arctic Canada in the west to northern Siberia in the east refuel at estuaries in western Europe. Refuelling sites are readily identified by rapid gains in total mass and fat (the main fuel) of populations and individuals. Estimates of flight ranges, based on the amount of fat carried, can be used to identify the sequence of estuaries used for refuelling. Problems in validating estimates of flight ranges are discussed. The use of fat reserves in identifying important refuelling sites in Europe is demonstrated. Migration phenology and the importance of refuelling sites should be assessed from an integration of data on fat storage, movements, and population counts.

1. INTRODUCTION

Few waders that breed in arctic or northern temperate regions spend the winter close to their breeding areas. Most move between south and west after breeding, to overwinter chiefly in coastal habitats from the northern temperate region as far south as South Africa, South America and Tasmania. For long-distance migrants, the maximum fat load that can be carried, around 50% of body mass (1), cannot fuel a direct flight between breeding and wintering grounds. These birds must therefore use one or more stopover sites to replenish their fat reserves to complete a migration. Additionally, many waders gather to moult in autumn in a few sites that they do not always use as wintering areas. They may move between several sites during a single winter (2). Thus the coasts and estuaries of north-west Europe are of crucial importance as moulting, wintering and refuelling sites for many species and populations of waders breeding in northern Europe and in the arctic between Siberia to the east and northern Canada and Greenland to the west.

In this paper, I shall indicate how study of fat reserves might be used to identify refuelling sites, and where more information is needed. The approach described applies not only to waders but also to other migratory birds. I describe chiefly results from long-distance non-stop migrants, since these demonstrate the approach most clearly, but the methods are also applicable to birds migrating in shorter steps.

2. SEASONAL VARIATION IN FAT LOAD

Most variations in the total mass of waders are caused by variations in fat load. A refuelling site can thus be identified from the body condition of birds caught there and examined on different dates, either from their total live mass, or from the fat loads of specimens (3). Although methods of estimating the fat loads of live birds are available, laboratory analysis of specimens remains preferable for accurate determin-

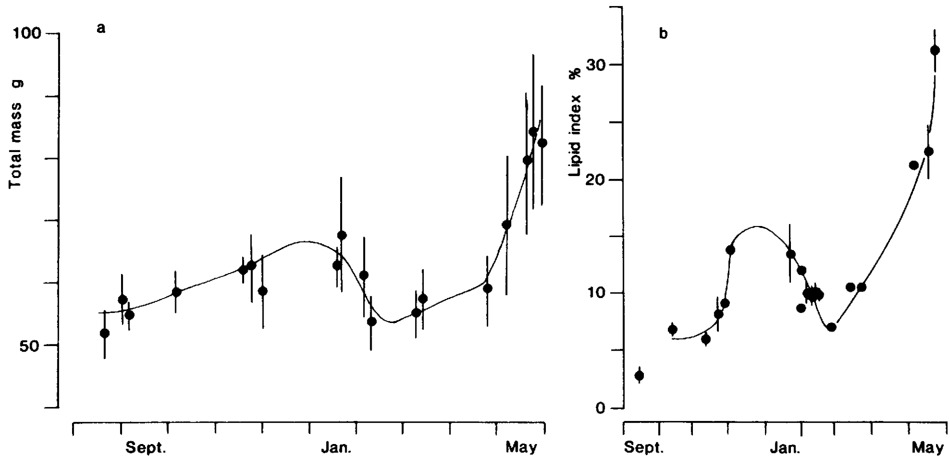

Figure 1 Seasonal cycles of mass and fat in waders at Teesmouth, from (3).
a) Total mass of Sanderlings Calidris alba, means ± s.d.,
b) Lipid index (fat as % total mass) of Dunlins C. alpina, means ± s.e. Note the midwinter peaks and rapid spring increases.

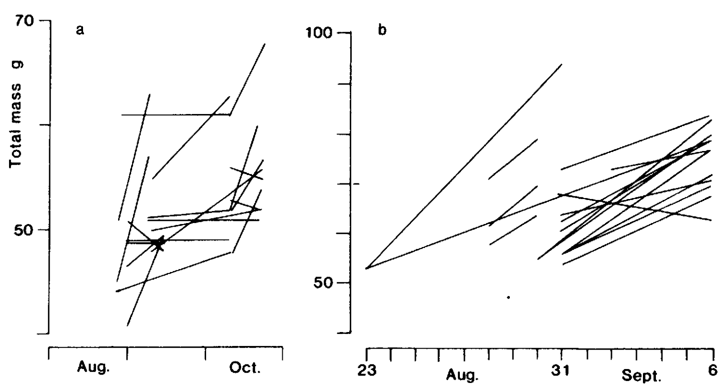

Figure 2 Individual changes in mass during refuelling. Each line joins the mass of one bird weighed twice (or more).
a) Dunlins at Teesmouth, from (3).
b) Curlew Sandpipers Calidris ferruginea in eastern England, from (8).

ation of fat loads (4).

Most waders wintering at a single site in western Europe carry high fat loads in midwinter, but these then decline until March. The functions of this regulated cycle are discussed elsewhere (3,5,6,7). At a refuelling site used during migration, birds increase in total mass or fat load particularly during spring (March to May), as shown in Figure 1. It is important to confirm that the pattern shown by successive samples parallels fat accumulation by individuals refuelling at a site, rather than turnover of individuals with different fat loads. Confirmation comes from increases in the mass of individuals weighed more than once during the same refuelling stop (Figure 2).

3. REFUELLING RATES AND DEPARTURE CONDITION

Rates of accumulation of fat vary widely, but highest rates of gain are 5-7% of lean (fat-free) mass per day. Rates of gain can be calculated from either the average change in mass or fat in successive samples (Figure 1) or from recaptures of individuals (Figure 2). Waders do not always accumulate fat throughout their stay at a stopover site: Figure 2a shows two Dunlins that maintained a steady mass for over one month and then gained mass rapidly during the next 1-2 weeks. These differences in 'migratory readiness' result in great variation in the time after capture at which

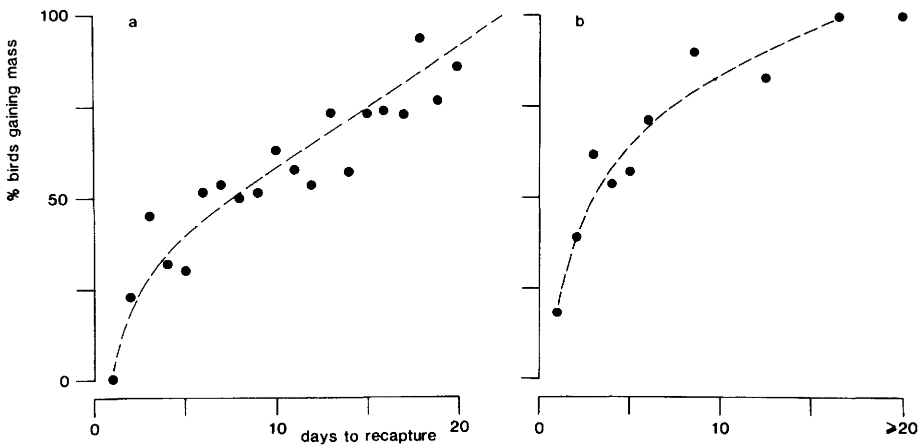

Figure 3 Timing of refuelling in relation to capture varies greatly: some waders gain mass within 1 day of capture, others not for at least 20 days. a) Turnstones *Arenaria interpres*, from (9), (b) Semi-palmated Sandpipers *Calidris pusilla*, from (10).

refuelling begins at one stopover site (Figure 3). Refuelling rates calculated for the whole stopover period will be too low: rates should be derived preferably from individuals during their period of hypertrophy only.

Rates of fat accumulation permit calculation of fat loads of birds weighed at known intervals before departure. The fat loads carried on departure determine the potential flight ranges of migrants. These ranges affect the number of sites used in the migration system. Departure condition is often difficult to assess: even during periods when many birds depart on migration, for example in late May, total masses of individuals

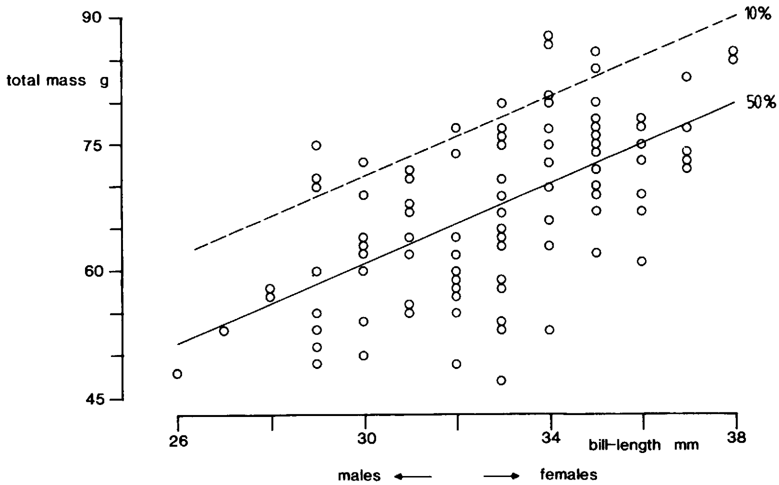

Figure 4 The total mass of Dunlins at the time of spring departures after refuelling at Teesmouth in relation to body size (bill length). Individuals of the same size vary greatly in mass, with the heaviest 10% of the population above the dashed line (---).

vary greatly (Figure 4). The lightest birds are unlikely to be close to their departure dates, whilst the heaviest are probably ready to migrate. When birds with intermediate masses will depart is less clear, since these could be about to fly a shorter distance, or be unready for departure.

Calculations of flight range require knowledge of a lipid index or fat mass at departure. These can be found either by estimating fat load from correlations of body size and lean mass (4,10) or, better, by fat extraction of specimens in the laboratory. The former is sometimes of limited application during migrations, because lean mass changes rapidly. This reduces the accuracy of fat load estimates.

4. FLIGHT RANGE VALIDATION

Several formulae for calculating flight ranges have been published. Those by Greenewalt (11), McNeil & Cadieux (12) and Summers & Waltner (13) are based on estimates of flight speed and metabolism, that by Pennycuick (1) on aerodynamic principles. All give increased range with increased fat load, but give widely differing range estimates (Figure 5), ranges calculated from Summers & Waltner's formulae being up to twice those from Pennycuick's. Obviously these can provide greatly different predictions of the number of fattening sites required during a journey, so the method(s) giving the most reliable estimates for waders must be identified.

Very few shorebirds have been weighed immediately before and after a migratory flight: yet these are the criteria needed to test flight range predictions. However, there are a few known migrations that help to validate the formulae. One Turnstone Arenaria interpres, weighed on the Pribolof Islands, south-west of Alaska, in late August was shot, but not weighed, on its arrival in Hawaii 3.5 days later, after an over-water flight of over 3600 km (9). Since its estimated flight time was 2.5 days,

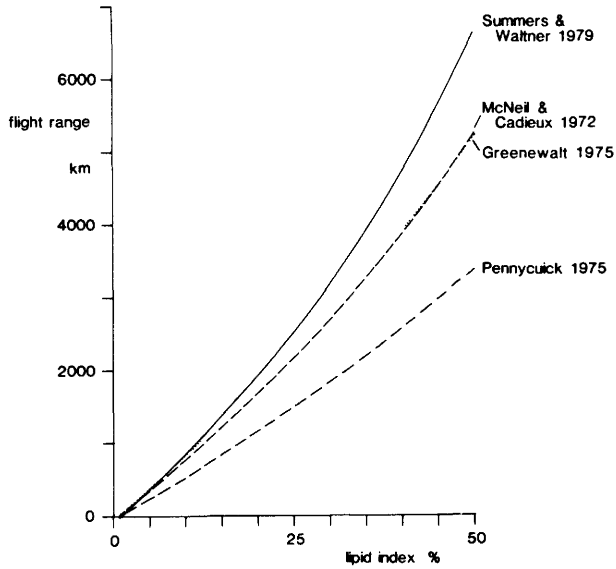

Figure 5 Flight range increases with fat load, but estimates from different formulae vary by up to 80%. Ranges were calculated for a Dunlin with spring average lean mass of 55g.

this bird had little time in which to fatten further before departure. Table 1 shows that even if it had carried 45% fat (nearly the maximum load for shorebirds), it would have failed to reach its destination by over 300 km, and in its probable departure condition by over 700 km, according to Pennycuick's formulae.

Table I Estimated flight ranges of a Turnstone caught on the Pribolof Islands on 27 August and shot on Hawaii (3635 km south) on 31 August. Underlined values indicate predicted successful arrival.

	Flight Range (km)			
	Summers & Waltner (13)	McNeil & Cadieux (12)	Greenewalt (11)	Pennycuick (1)
Depart 27 August (39% fat)	<u>4460</u>	<u>3760</u>	<u>4100</u>	2750
Depart 28 August (41% fat)	<u>4760</u>	<u>3970</u>	<u>4360</u>	2910
Depart 45% fat	<u>5620</u>	<u>4550</u>	<u>5090</u>	3290

Similarly, the flight range of a Bar-tailed Godwit <u>Limosa</u> <u>lapponica</u> weighed at Teesmouth, north-east England, and found 5 days later in Western Sahara (3680 km to the south), indicates a short-fall if Pennycuick's formula is correct, but arrival with varying amounts of fuel remaining from other estimates (Figure 6). Since waders usually start migratory flight with a tailwind (14), this bird had probably departed within 1.5 days of capture. Even with a 50% fat load, Pacific Golden Plovers <u>Pluvialis</u> <u>dominica</u>

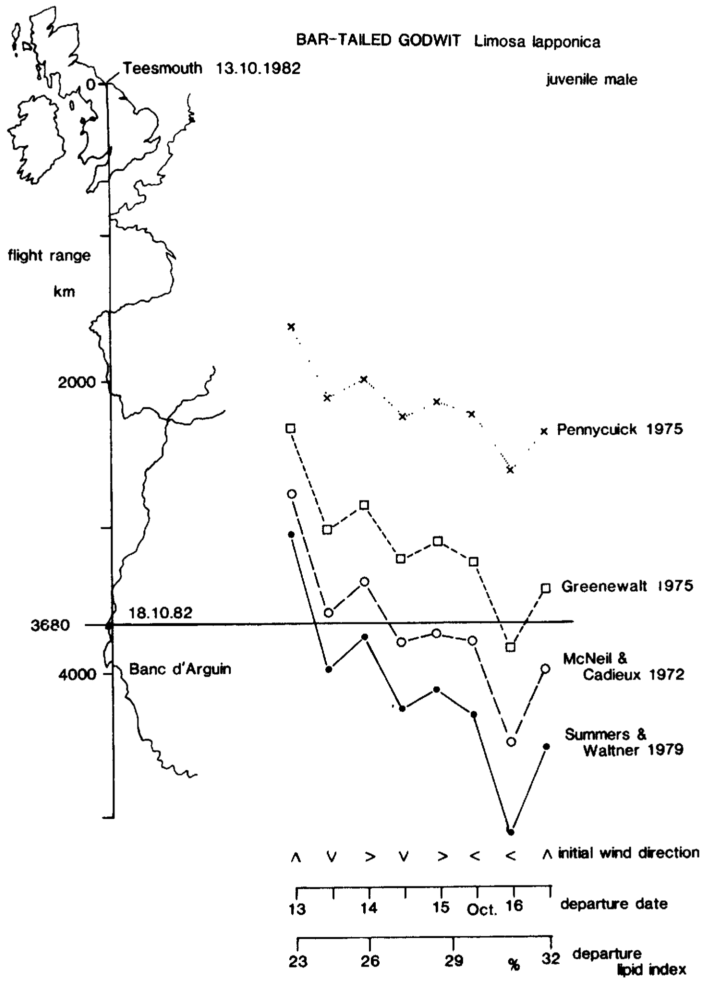

Figure 6 Estimated flight ranges, adjusted for wind speed and direction of a Bar-tailed Godwit Limosa lapponica known to have flown from Teesmouth to Western Sahara in 5 days, suggest that Pennycuick's formulae underestimate flight range.

according to Pennycuick's formula, would fail to complete a known overwater flight from Wake Island in the Pacific Ocean to Alaska, a distance of 3500 km (15).

In all these cases, to achieve known flight ranges if Pennycuick's formula is correct, waders would need a tailwind of at least 10 $m.s^{-1}$ throughout the flight. Pennycuick (pers. obs. in 16) suggests that the streamlining of waders may reduce drag below that used in the derivation of his formula. This would increase flight range. Much more precise information on known migrations is needed if the validity of flight range formulae is to be confirmed. I shall refer later mainly to flight ranges

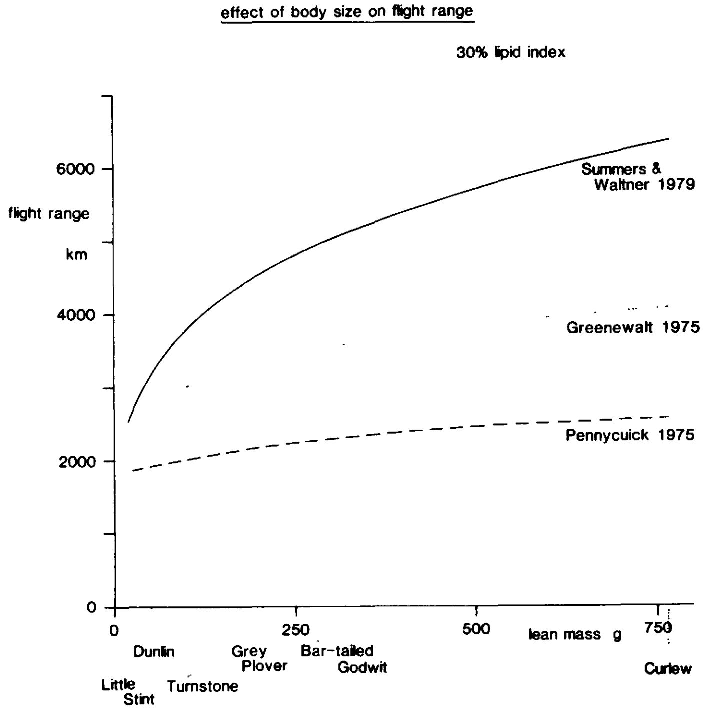

Figure 7 Large waders achieve a longer flight than small waders with the same lipid index.

calculated from Summers & Waltner's formula since these give maximum attainable range.

So far, I have referred mainly to still-air ranges, although some effects of wind speed and direction during flight are shown in Figure 6. These refer to ground-level windspeeds: those at high altitude can be stronger and may offer greater assistance to migrating shorebirds. Many other variables can affect flight range. During migratory flight, altitude should increase, and airspeed and lean mass decrease (17). All three will modify estimated flight ranges. Prior to spring migration, small waders such as Dunlins increase their lean mass. This results in an increased flight range with a given lipid index (Figure 7). The effect of an increase in lean mass on flight range is particularly marked in small waders.

Flight ranges described here are maxima: the estimated ranges achieved when all the fat reserves have been used. Most waders arrive after a migratory flight with some fat reserves remaining. This surplus may be used if adverse weather is met during flight, or for survival after arrival if feeding conditions are poor and food intake cannot satisfy energy demands. Some waders do arrive after migration in an exhausted, emaciated state, notably juvenile Knots Calidris canutus in autumn in Mauritania. Also in autumn, condition of juveniles is often poorer than that of adults (3), and these emaciated juveniles may have started a long flight before storing adequate reserves. Distances between refuelling sites are, then, usually less than the maximum estimated flight range.

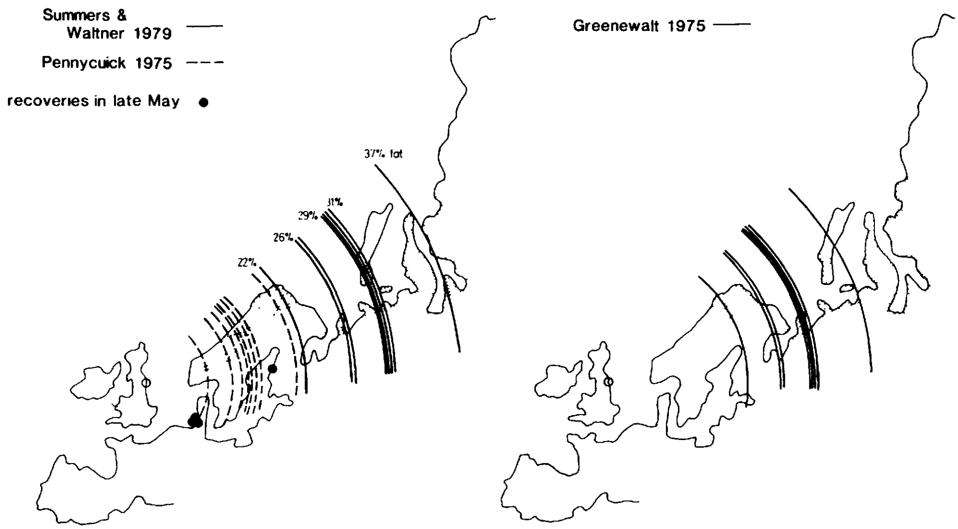

Figure 8 Flight ranges of individual Dunlins refuelling for flight to the breeding grounds (shown stippled) from Teesmouth (O), according to different flight range formulae. Birds ringed at Teesmouth in May, and found at other refuelling sites in late May are shown ●.

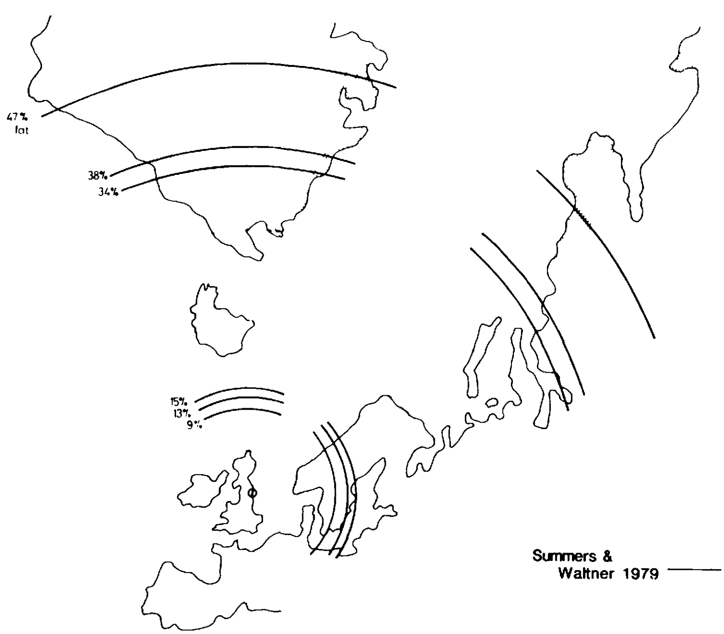

Figure 9 Flight ranges (Summers & Waltner's formula) of individual Sanderlings at Teesmouth in late May. Legend as Figure 8.

5. FAT RESERVES AND MIGRATION PHENOLOGY

Below, I illustrate how fat reserves and calculated flight ranges can be used in studies of the migration phenology of waders to confirm the importance of known refuelling sites, and to identify the presence of previously overlooked sites.

Figure 8 shows the maximum flight ranges of Dunlins in late May, during their period of departure from Teesmouth for breeding grounds. Ranges from Summers and Waltner, and Greenewalt, indicate direct return to breeding grounds in Norway and western Russia, but suggest an intermediate refuelling site if birds were to arrive at breeding grounds further east with some reserve remaining. Further refuelling for some Dunlins after leaving Teesmouth is supported by ringing recoveries: the movement of 3 birds ringed in winter and spring at Teesmouth and recovered in later years between 25-28 May in north-west Germany; and especially one adult ringed at Teesmouth on 18 May 1977 and recovered in south-west Finland 10 days later (Figure 8). (Note that, as described above, ranges calculated according to Pennycuick's formulae are shorter, and would indicate a direct return to only the most westerly breeding grounds, in Norway.)

Sanderlings at Teesmouth in late May (Figure 9) showed greater variation in fat loads than Dunlins. Three birds carried large reserves (34%–47% of total mass as fat), but another three had small reserves (< 15% lipid index) and were evidently unready to leave Teesmouth. Few Sanderlings are recorded in spring at possible refuelling stops further north and west in Europe. The breeding grounds of Sanderlings refuelling at Teesmouth in late May could be Greenland, Siberia, or both. According to maximum flight ranges, these high fat levels would have allowed all 3 birds to make a non-stop flight to Greenland breeding grounds, but only the fattest to Siberian breeding grounds. This indicates an intermediate refuelling site for members of the Siberian population leaving Teesmouth with less than a 45% lipid index. Indeed, if Sanderlings are to arrive on Siberian breeding grounds with some fat reserves remaining (see above), an intermediate stop-over may be necessary for all this population. This site (or sites) has yet to be identified from ringing recoveries or population counts.

There have been rather few attempts to assess the migration phenology and importance of refuelling sites of waders from integration of fat accumulation, population counts and turnover, and ringing recoveries. An initial appraisal can be made of the role of fat reserves in the spring migration through western Europe of Knots breeding in both arctic Canada and Greenland, and Siberia, from the results of several studies (18,19,20). Known and presumed migrations and flight ranges are shown in Figure 10, which also highlights gaps in the knowledge of even this system. Notable gaps are the location and importance of refuelling sites in Africa of the Siberian population (which winters in West and South Africa), and the origins and destinations of members of this population refuelling in Finmark. Figure 10 also illustrates clearly the major importance of refuelling sites in western Europe for Knots, as for many other species of waders. Knots could not store sufficient fat to reach their breeding grounds without refuelling sites such as the Vendee (France), the Wattenmeer (FDR) and Morecambe Bay (U.K.), and effective conservation of many waders may depend on an understanding of the networks of refuelling sites, both in Europe and elsewhere, used during migration. Evaluation of the role of refuelling sites should be through an integration of studies on movements of wader populations, such as (2,19), and fat storage, using the techniques described in this paper.

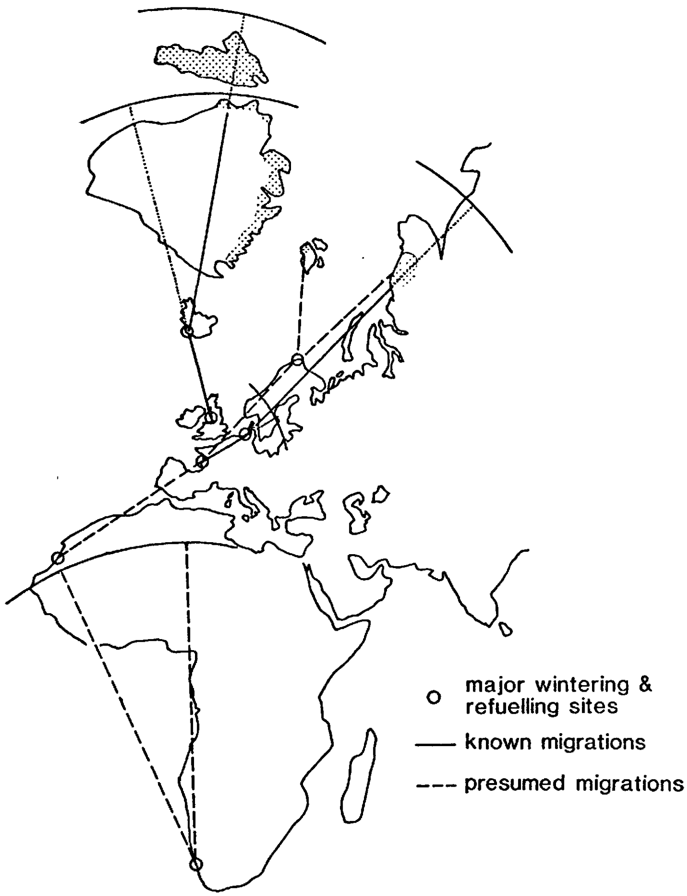

Figure 10 Flight ranges (Summers & Waltner's formula) of Knots on spring migration. Breeding areas are shown stippled, and ···· shows the difference between the maximum estimated flight range and known flights between refuelling sites, and to breeding grounds.

6. REFERENCES

(1) Pennycuick, C.J. 1975. Mechanics of flight. pp 1-75 in Avian Biology 5, eds. D.S. Farner & J.R. King. Academic Press, New York and London.

(2) Pienkowski, M.W. 1983. Identification of relative importance of sites by studies of movement and population turnover. These proceedings.

(3) Davidson, N.C. 1981. Seasonal changes in nutritional condition of shorebirds during the non-breeding seasons. Ph.D. Thesis, University of Durham.

(4) Davidson, N.C. 1983. Formulae for estimating the lean weight and fat reserves of live shorebirds. Ringing & Migration 4: 159-166.

(5) Davidson, N.C. 1982. Changes in the body condition of Redshanks during mild winters: an inability to regulate reserves? Ringing & Migration 4: 51-63.

(6) Dugan, P.J., P.R. Evans, L.R. Goodyer & N.C. Davidson 1981. Winter fat reserves in shorebirds: disturbance of regulated levels by severe weather conditions. Ibis 123: 359-363.
(7) Evans, P.R. & P.C. Smith 1975. Studies of shorebirds at Lindisfarne, Northumberland. 2. Fat and pectoral muscles as indicators of body composition in the Bar-tailed Godwit. Wildfowl 26: 37-46.
(8) Stanley, P.I. & C.D.T. Minton 1972. The unprecedented westward migration of Curlew Sandpipers in autumn 1969. British Birds 65: 365-380.
(9) Thompson, M.C. 1974. Migratory patterns of Ruddy Turnstones in the central Pacific region. Living Bird 12: 5-23.
(10) Page, G. & A.L.A. Middleton 1972. Fat deposition during autumn migration in the Semipalmated Sandpiper. Bird-Banding 43: 85-96
(11) Greenewalt, C.H. The flight of Birds. Trans. Amer. Phil. Soc. 65: 1-67.
(12) McNeil, R. & F. Cadieux 1972. Numerical formulae to estimate flight range of some North American shorebirds from fresh weight and wing length. Bird-Banding 43: 107-113.
(13) Summers, R.W. & M. Waltner. Seasonal variations in the mass of waders in southern Africa, with special reference to migration. Ostrich 50: 21-37.
(14) Richardson, W.J. 1978. Timing and amount of bird migration in relation to weather: a review. Oikos 30: 224-272.
(15) Johnston, D.W. & R.W. McFarlane 1967. Migration and bioenergetics of flight in the Pacific Golden Plover. Condor 69: 156-168.
(16) Johnson, O.W. 1979. Biology of shorebirds summering on Enewatok Atoll. Studies in Avian Biology 2: 193-205.
(17) Pennycuick, C.J. 1978. Fifteen testable predictions about bird flight. Oikos 30: 165-176.
(18) Morrison, R.I.G. & J.R. Wilson 1972. Aspects of spring migration of Knot in Morecambe Bay. Wader Study Group Bulletin 5: 9-11.
(19) Dick, W.J.A. 1979. Results of the WSG project on the spring migration of Siberian Knot Calidris canutus 1979. Wader Study Group Bulletin 27: 8-13.
(20) Haland, A. & J.A. Kalas 1980. Spring migration of the Siberian Knot Calidris canutus: additional information. Wader Study Group Bulletin 28: 22-23.

Discussion

Hilden (Finland) confirmed that several thousand Dunlin occur on the west coast of Finland in May, and that a passage of perhaps 20,000 Knot occurs through the Gulf of Finland on about 10 June, some 2 weeks later than the movement through north Norway. Perrins (UK) asked whether birds might need to carry some fat to the breeding grounds, in order to start breeding as soon as they arrive. Smit (NL) enquired whether the condition of birds in spring might affect subsequent breeding performance and hence the number of juveniles coming to western Europe in autumn. Davidson replied that this was difficult to test because of separation of age-classes into different areas or habitats in autumn, and of bias in catching juveniles.

BARRAGE SCHEMES - PREDICTING THE EFFECTS OF CHANGES IN TIDAL AMPLITUDE ON WADER POPULATIONS.

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Summary

The Oosterschelde is an estuary in the so-called 'Delta area' in the S.W. part of the Netherlands. It is very important for overwintering waders. A storm-surge barrier is under construction in the mouth of the estuary. This will cause reduction in tidal amplitude and subsequently a reduction of both feeding grounds and feeding time for waders. This paper raises several points in an attempt to predict the impact of this environmental changes on wader populations. In the first part we discuss how the site can be divided into several habitats, characterised by both benthos organisms and bird species. Then, factors influencing the occurrence of birds within the habitats are discussed. The overall food intake is considered to provide an important negative feedback affecting bird density. It is likely that the density in preferred feeding areas cannot increase any further. It is believed that the reserve or buffering capacity of the marginal areas will play an increasing role, together with an expected increase in benthos density. If not, total numbers of birds must certainly decline.

1. INTRODUCTION

Estuaries in NW. Europe represent ecosystems with a very high biological productivity. This results in large numbers of birds being present between August and May. For many of them these estuaries are of vital importance for survival in the non-breeding season. The biological productivity also results in their economic importance for shellfish fisheries. On the other hand, estuaries are often suitable areas for industrial development and outdoor recreation. Clearly these functions form conflicting demands. Threats to the natural estuarine habitat, e.g. reclamation, especially from coastal engineering projects, are manyfold (14). Fortunately, in the last ten years, environmental aspects have become a matter of great concern in planning and development (17, 18). However, predicting the effect of barrage building and reclamation schemes on wader populations remains a difficult task. Possible influences are discussed by Goss-Custard (9) and Prater (16). The most detailed information on both prediction and real effects, is available from the research done at the Tees estuary (4,5). This paper outlines the approach followed to predict the influences of a major engineering project: the construction of a storm-surge barrier in the Oosterschelde.

2. THE OOSTERSCHELDE : PRESENT SITUATION AND EXPECTED CHANGES

The Oosterschelde is situated in the so-called 'Delta area' in the SW. parts of the Netherlands. It is a large estuary (overall size 45,100 ha) of outstanding natural beauty. Its high and constant salinity together with clear water cause a very diversified plant and animal life. The importance of the area for waders is described by Saeys and Baptist (18).

After the disastrous storm-surge in 1953, the Dutch government decided to dam up 6 of the 7 estuaries in the 'Delta area'. The Oosterschelde was to be closed last, at latest in 1987. Due to increasing pressure from nature conservation and environmental movements, as well as fisheries, the government decided in 1976 to build up a storm-surge barrier instead of a closed barrage in the mouth of the Oosterschelde. This is supposed to be a compromise between safety, economy and environment.

The storm-surge barrier itself consists of 66 pillars between which caissons are suspended. In this way the estuary remains under the influence of the tides but can be closed if necessary as a protection against a storm-surge. The whole construction causes a considerable reduction in the cross section of the estuary, from 80,000 m^2 to 14,000 m^2. After the barrier is completed, two secondary dams are to be built further inland (fig. 1). Behind these, two lakes (Markiezaatsmeer and Zoommeer) will be formed. All this will thoroughly change the hydrodynamic properties of the estuary (Table 1).

2.1 Changes in the vertical range (tidal amplitude).

The considerable reduction in tidal amplitude from 3.40 m to 2.70 m will cause a reduction of intertidal area of approximately 20% (2110 ha.). Also, the duration of inundation of the mudflats will be strongly affected: below mid-tidal level, tidal flats will be exposed for a shorter time than previously; and above mid-tidal level for longer.

2.2 Changes in horizontal tidal action.

The speed of the current will lessen in the whole area, except in the immediate surroundings of the barrier, on average by one third.

Table I

Some important characteristics of the Oosterschelde (data from RIJKSWATERSTAAT)

	Present	With barrier
Cross section	80,000 m^2	14,000 m^2
Tidal amplitude	3.40 m	2.70 m
Surface intertidal area	16,880 ha	9,400 ha
Speed of current	0.75 m/s	0.5 m/s
Salinity (average)	15.5-16.0 g Cl/l	15.0-16.5 g Cl/l

2.3 Other changes.

The salinity will not be affected significantly. However, the formation of the two lakes (Markiezaatsmeer, Zoommeer) will cause an extra loss of tidal land of 4230 ha.

In comparison with other studies, predicting the influence of tidal reduction is quite complex. When damming up an estuary the problem for birds is mainly one of the effects of increased bird density in the remaining areas. Reclamation may add the problem of reduced feeding time if the upper shore levels disappear. With a reduction of tidal amplitude we have both a loss of feeding area, changing feeding times,but an expected increase in benthic biomass.

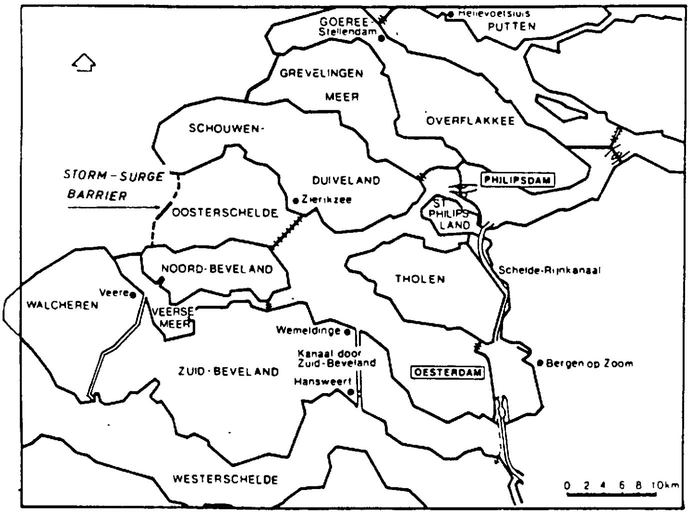

Fig.1 Map of the Oosterschelde with the storm-surge barrier and the secondary dams (Philipsdam,Oesterdam)

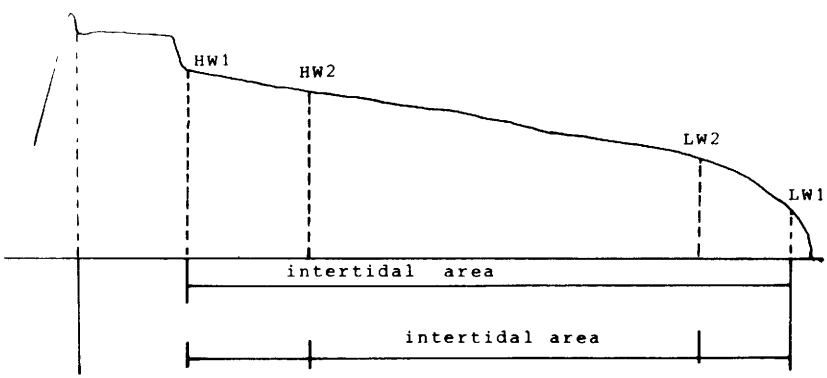

Fig.2 Profile of a mudflat
HW1,LW1 high and low water in the present situation
HW2,LW2 high and low water after the reduction in tidal amplitude

3. AIM OF THE STUDY

In the previous section we pictured the expected changes in the Oosterschelde. The aim of our study is to predict the effects on wader populations. This is not because the results could alter the planning or execution of the barrier (they are building it already) but rather to provide advice concerning the following points:

1) On manipulations of the barrier.
The storm-surge barrier can be used to decrease the tidal amplitude still further for a period of time in order to facilitate engineering projects. It can also be closed for several days at low tide level (e.g. to facilitate harbour works) or at high water level (e.g. to reduce mortality of mussels in severe weather conditions).

2) The date and method of closure of the secondary dams.
It is not decided yet when and how the secondary dams will be closed. The several alternative possibilities differ in duration and amount of extra reduction in tidal amplitude.

From a conservationist point of view, it is important to assess to what extent wader populations, now present in the area, will be affected. Appropriate measures can then be taken for protecting areas of special importance.

4. THE APPROACH

4.1. Bird counts.

Essential to the present purpose is a good knowledge of the number of birds in the area. Since 1976 monthly counts have been carried out by the Delta Department and organized by H. Baptist and P. Meininger. Our research is mainly restricted to the Slikken van Vianen, a smaller mud flat in the Oosterschelde.

4.2. Community approach.

4.2.1. Wader densities.

Waders are not normally spread evenly over the tidal flats of an estuary. Rather some areas are used more than others. Thus the real density of waders can be quite different from the average based upon High-water counts and available surface. The average density of Oystercatchers on our study area is 10 birds/ha. The real densities vary between 0-1/ha and 100/ha. Therefore when waders are confronted with a reduced intertidal area the % changes in their numbers do not equal the % reduction in feeding area (cf. ref. 4).

4.2.2. Benthos communities.

Therefore we tried to recognise different types of feeding habitats. Based upon numerical classification of study plots we were able to distinguish several communities of benthic organisms (15). They coincide with visible zonations on the mudflat. Each community can be characterized by several macrobenthos species. They are considered as a grouping or assemblage of species. The factors which control the distribution of the species are responsible for the assemblages that we observe, rather than some process of biological control. The factors which seem to be most important are soil composition and duration of exposure (15).
Fig. 3A illustrates how our study plots are clustered into several

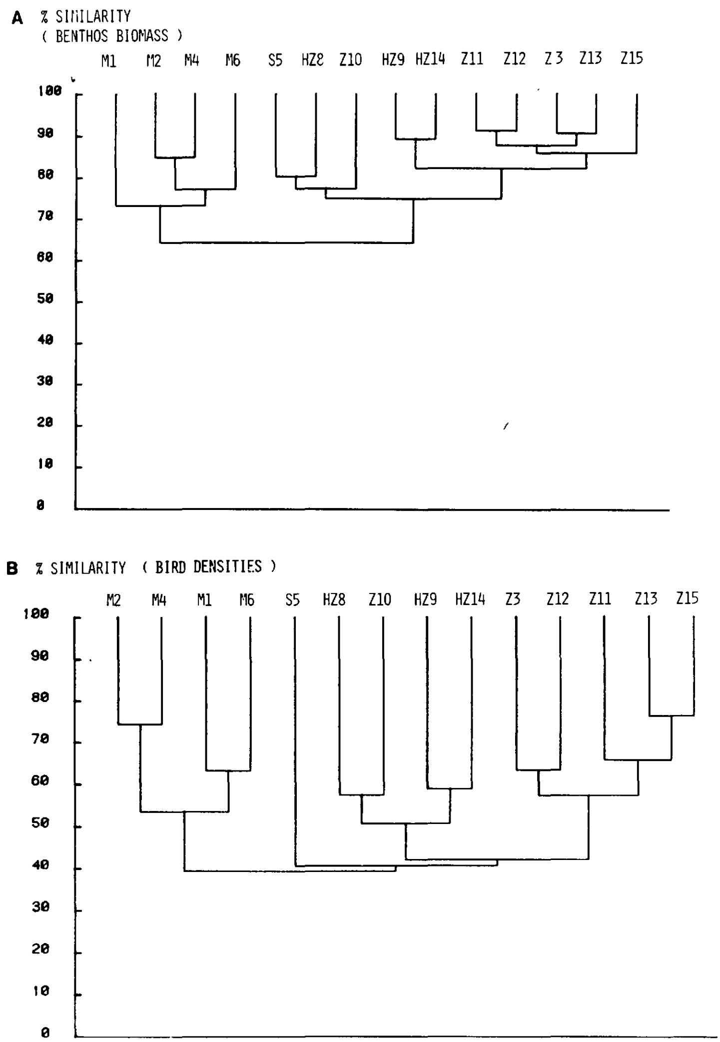

FIG.3 SIMILARITIES BETWEEN THE PLOTS PRESENTED AS DENDROGRAMS

A. BASED UPON BENTHOS BIOMASS

B. BASED UPON WADER DENSITIES

communities.

4.2.3. Relation between benthos and bird communities

When the same plots are clustered on the base of the occurrence of feeding waders we found the same groupings (fig. 3.B). In this way we could associate benthos communities with groupings of waders.(15). This approach enables us to assess the importance of specific benthos communities as food resources for certain bird species. If some areas or zones of mud flats disappear, these results allow us tp predict which wader species are most likely to be affected. Furthermore if we know the surface of each benthos community their importance can be compared for birds. Duration of exposure and soil composition are likely the most important factors determining the community types. They can be predicted quite accurately by hydrodynamic models of the estuary. This will enable us to predict the surface of each community. (This research will be done in cooperation with J. Coosen from the Delta Institute, Yerseke). Based on this we can estimate if the influence of the barrier will be stronger for one group of waders or another.

4.2.4. Interactions between bird species

Obviously, the next step in our approach is an investigation of mutual relations between bird species. Zwarts (23) gives evidence for interspecific competition and Evans (4) found that after reclamation of a major part of Seal Sands (Tees estuary), the numbers of some species were negatively correlated. We believe this is not important in our study area; diet overlap between all birds is very small indeed. Likewise, we could not find so far any negative correlations between bird species within one community. In comparison the studies mentioned before deal with situations where but one or a few prey species are taken by all the birds.

5. A MODEL

After this qualitative approach, we need detailed quantitative information focused on those factors which determine the occurrence of waders within the benthic communities. In our studies at Vianen, only the most abundant waders (Oystercatcher, Curlew, Bartailed godwit, Dunlin and Knot)are taken into account.

5.1. Description

In order to predict quantitative aspects about these populations we are building a model. The simplified preliminary version in fig. 4 especially helps us at this stage to focus our research on certain functions. In a later stage we will run the model to simulate the present situation and to generate predictions.The model is a combination of several factors which already have been discussed in literature. However no attempt is made so far, to combine these to generate predictions or functions of environmental changes. First we discuss the different steps; afterwards the applicability and problems of the model are discussed. In fig. 4 all the functions are shown as boxes and the variable is transferred to the next box (function) by an arrow. The exact formulation of the functions is the subject of our present research. In the discussion we use as units a community (as defined earlier) and one species.

The number of birds in the area (N) is known to be dependent on the size of the estuary (16) and the amount of food present (4, 11,20). Still

other factors e.g. breeding success may be important (all these are not shown in fig. 4). The fraction of birds (N1) which feeds in community 1 is determined by N and by the number feeding in other areas (N2-Nn). The available surface of feeding area in the community will be a function of tidal amplitude and other factors. Together with N1, this determines the bird density D. These birds will feed at a certain intake rate (IR) which is dependent on the available prey density. For several species, feeding on a restricted diet, the relation between prey density and intake rate is known. (6,7). As to bird species with a diverse diet, it is much more difficult to find a simple relation between prey density and intake rate. Based on an optimal diet model we can calculate which prey species are taken and the intake rate. This has been done for Bartailed godwits (Meire and Bogaert in prep.). On the other hand there is increasing evidence that the density of waders itself may reduce the intake rate. It is shown that the intake rate decreases as functions of the bird density for oystercatchers (2,22) and curlew (23). The possible mechanisms of this <u>interference</u> have been reviewed by Goss Custard (10). The overall intake of the animals is then the intake rate times the feeding time. The maximum feeding time is determined by the tidal rhythm and the topography of the area. It can also be dependent on the bird density. Indeed there is increasing evidence that the density of waders has a negative influence on the time they are feeding (15,24). The total amount of food taken in a community will act as a negative feedback on the density. This can work either by dispersal or mortality. It also has an influence on the prey density (depletion).
Depending on the strength of interference the overall intake determines the numerical response. The density however will vary depending on the need of the animals. If the overall intake needs to be higher (e.g. in winter) this is reflected in a lower density. We found indeed a negative correlation ($P < 0.05$) between the Oystercatcher density and the date (July-December), while controlling for the total number present and the prey density. Assuming that intake rate is determined by an optimal diet model, we can also expect the wader density being related with the average profitability of an area, rather than with a measure of prey density. This indeed is found already in Oystercatchers feeding on cockles (21).

The effect of this feedback on the total population size will depend on the availability of other feeding areas and the importance of that specific community in a "tidal cycle" for the waders under study. Indeed although some species mainly feed at higher levels of the shore (1) the communities below mid-tide are the most important food resources (15). Bartailed godwits obtain 80% of their energy budget in winter there (Meire and Bogaert in prep.). Therefore it will be important to link together what happens in each community.

5.2. Use of the model in the future Oosterschelde situation

We have discussed several links in the model. Now we will try to see how the major changes in the Oosterschelde can be fitted in the model and what their effect is likely to be.

5.2.1. Reducing the area of feeding grounds

Due to the reduction in feeding grounds, bird density has to increase if the same population is to remain in the area. How long these densities will be sustained by the system depends on "saturation" of the area. From the previous discussion we know that bird density may reach a ceiling level in preferred areas so that a loss of habitat would cause an increasing number of birds feeding in rather marginal areas. (9). This effect will certainly vary between species. Before we can make any guess on the influence, the available surface of each community has to be measured.

5.2.2. Increase in biomass

An increase in biomass will have a positive influence especially in the less favoured feeding grounds, because,we believe, birds are not yet at their ceiling levels. However, whether an increase in prey density will increase the maximum possible wader density is yet unclear.

5.2.3. Changes in feeding time

A very important factor is the reduction in feeding time in the lower areas, where waders collect most of their energy during the non breeding season. Due to stronger interference, caused by higher densities, birds will feed for a smaller proportion of the available time, which is already decreased. This will result in a lower food intake and lower densities. Therefore it must be found out if birds are able to feed at a higher rate or if they already reach their maximum intake rate. An experimental approach to tackle this problem will be described in detail elsewhere (Kacelnik and Meire in prep.).

Two results originated from this work. First, animals seem to be able to work harder for their food when the feeding time is limited. Field observation on Bartailed godwits already indicate that they can increase their work rate (pecks/min.), but this did not increase their intake rate (12). It is therefore important to study in more detail the foraging behaviour to see if birds would be able to manipulate it (3), in order to increase the intake rate. The second important result concerns the body weight of the animals. Birds are anticipating their bodyweight when confronted with a reduced feeding time (13). The longer the non-feeding time the higher the weight must be at the end of the feeding period. This increase in bodyweight is certainly reflected in the amount of food taken and in this way can influence the feedback. If the intake rate on the feeding grounds above mid-tide is small this point may become important.

6. DISCUSSION

In comparison with estuaries in Britain (16) the density of waders in the Oosterschelde is quite high. There is strong belief that after the closure of the Grevelingen estuary (one of the other estuaries in the Delta area) the total number of birds did not decrease (Lambeck, pers. comm.). On the other hand, wader populations in the Oosterschelde have been increasing steadily over recent years (Baptist, pers. comm.).

The expected changes in the Oosterschelde are important with respect to the wader populations present in the area. Especially, we doubt that a further, forced, increase in density will be possible.

To try to understand and predict what will happen we outlined some factors determining the density of waders within a community. How the total number of birds will be affected is a more complex problem and depends on the relative importance of the several communities. Notwithstanding recent data can fill in many parts of the model, several points remains unanswered. Furthermore the e will always be uncertainty about environmental factors. The applicability is therefore limited as long as these question are not answered. However we believe it will be possible to generate predictions for many combination of factors and to calculate probabilities of an outcome. This can subsequently be used for advice.

All our present research only concerns one study area. A project sponsored by the Ministery of Public Works (Rijkswaterstaat) will start next year.

Within this project the ecology of the waders will be studied in the whole estuary. Counting, ringing, feeding ecology and benthos-studies will be the major topics.

In this way we will collect the required data to make reasonable predictions on the basis of the approach outlined before.

We hope this will keep large numbers of birds in the Oosterschelde after 1987.

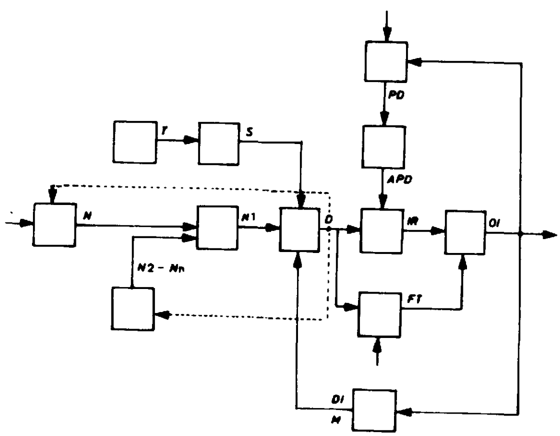

Fig.5 The model (for explanation see text)

N:number of birds;N1:number of birds in community 1
D:density of birds;IR:intake rate;OI:overall intake
T:tidal conditions;S:surface feeding area;PD:prey-density;APD:available preydensity;FT:feeding time
DI:dispersal;M:mortality

REFERENCES

1 BRYANT, D.M. 1979. Effects of prey density and site character on estuary usage by overwintering waders (Charadrii).
Est. and Coast. Mar. Sci. 9 : 369-384.

2 ENS, B. & J.D. GOSS CUSTARD . (in press). Interference among oystercatchers (Haematopus ostralegus L.) feeding on mussels (Mytilus edulis L.) on the Exe estuary.

3 EVANS, P.R. 1976. Energy balance and optimal foraging strategies in shorebirds : some implications for their distributions and movements in the non-breeding season.
Ardea 64 : 117-139.

4 EVANS, P.R. 1979. Reclamation of intertidal land : some effects on shelduck and wader populations in the Tees estuary.
Verh. Orn. Ges. Bayern 23 : 105-124.

5 EVANS, P.R., D.M. HERDSON, P.J. KNIGHTS & M.W. PIENKOWSKI. 1979. Short-term effects of reclamation of part of seal sands, Teesmouth, on wintering waders and shelduck.
Oecologia 4I : 183-206.

6 GOSS-CUSTARD, J.D. 1977. The ecology of the wash.
III : Density- related behaviour and the possible effects of a loss of feeding grounds on wading birds (Charadrii).
J. Appl. Ecol. 14 : 721-739.

7 GOSS-CUSTARD, J.D. 1977. Responses of Redshank, Tringa totanus, to the absolute and relative densities of two prey species.
J. Anim. Ecol. 46 : 867-874.

8 GOSS-CUSTARD, J.D. 1979. Role of winter food supplies in the population ecology of common British wading birds.
Verh. Orn. Ges. Bayern 23 : 125-146.

9 GOSS-CUSTARD, J.D. 1979. Effect of habitat on the numbers of overwintering shorebirds.
Studies in Avian Biology 2 : 167-177.

10 GOSS-CUSTARD, J.D. 1980. Competition for food and interference among waders.
Ardea 68 : 31-52.

11 GOSS-CUSTARD, J.D., D.G. KAY & R.M. BLINDELL 1977. The density of migratory and overwintering Redshank, Tringa totanus (L.) and Curlew, Numenius arquata (L.), in relation to the density of their prey in South-East England.
Est. and Coast. Mar. Sci. 5 : 497-510.

12 GOSS-CUSTARD, J.D., P.R. EVANS, P.J. KNIGHTS & M.W. PIENKOWSKI (in press) Short-term effects of reclamation of part of seal sands, Teesmouth, on wintering waders and shelduck. 2 : Changes in feeding behaviour ecology & foraging.

13 KACELNIK, A. 1979. Studies of foraging behaviour and time budgeting in great tits (Parus major).
Ph.D dissertation Oxford.

14 LANGSLOW, D.R. 1981. The conservation of intertidal areas in Britain.
Wader Study Group Bulletin 31 : 18-22.

15 MEIRE, P.M. & E. KUYKEN. (in press). Relations between the distribution of waders and benthos communities on the Slikken van Vianen (Oosterschelde, the Netherlands). In 'Coastal waders and wildfowl in winter'. P.R. EVANS, J.D. GOSS-CUSTARD & W. HALE (Eds.). Cambridge Univ. Press.

16 PRATER, A.J. 1981. Estuary birds of Britain and Ireland.
T. & A.D. Puyser, Calton.

17 SAEYS, H.L.F. & H.J.M. BAPTIST 1977. Wetland criteria and birds in a changing Delta.
Biol. Cons. 11 : 251-266.

18 SAEYS, H.L.F. & H.J.M. BAPTIST. 1978. Evaluatie van West Europese overwinteringsgebieden van watervogels.
Rijkswaterstaat - Deltadienst, afdeling Milieuonderzoek, Middelburg
Nota 78-10, 66 p.

19 SAEYS, H.L.F. & H.J.M. BAPTIST. 1980. Coastal engineering and European wintering wetland birds.
Biol. Cons. 17 : 63-83.

20 SUTHERLAND, W.J. 1981. Food supply and dispersal in the determination of wintering population levels of Oystercatchers, Haematopus ostralegus.
Est. Coast. Shelf. sci. 16 : 223-229.

21 SUTHERLAND, W.J. 1982. Spatial varation in the predation of cockles by Oystercatchers at Treat Melynog, Anglesey.
II The pattern of mortality.
J. Anim. Ecol. 51 : 491-500.

22 SUTHERLAND, W.J. & P. KOENE. 1982. Field estimates of the strength of interference between Oystercatchers, Haematopus ostralegus.
Oecologia 55 : 108-109.

23 ZWARTS, L. 1978. Intra- en interspecific competition for space in estuarine bird species in a one-prey situation.
Proceedings : Int. Orn. Congress, Berlin : 145-150.

24 ZWARTS, L. & R.H. DRENT. 1981. Prey depletion and the regulation of predator density : Oystercatchers (Haematopus ostralegus) feeding on mussels (Mytilus edulis).
in ; Feeding and survival strategies of estuarine organisms.
Eds. JONES, N.V. & W.J. WOLFF. Plenum Press, London.

THE EFFECTS OF PREDATORS UPON SHOREBIRD POPULATIONS IN THE NON-BREEDING SEASON

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Summary

Present knowledge of the effects of both avian and mammalian predators on shorebirds is minimal. One intensive study revealed very high rates of predation by raptors in California. The situation in European estuaries is considered. Calculations show that even single raptors could have a significant effect upon shorebird populations. Data from the Tees estuary show that mammals may be important predators of some species. Predators may also affect shorebird behaviour.

The possibility of control of at least mammalian predators in order to safeguard diminishing shorebird populations is discussed.

1. INTRODUCTION

This paper examines the sparse information available on the effects of predators on shorebirds, and how these might be quantified further. Predation on adult shorebirds is known to occur during both the breeding and non-breeding seasons, but little is known of its magnitude.

Anecdotal records of both avian and mammalian predators killing shorebirds are scattered through the scientific literature. From such records lists can be compiled of the taxonomic range of predators on shorebirds, and of the shorebird species taken by each of these predators. The lists vary both seasonally, with different predators on the breeding and wintering grounds, and geographically, e.g. between different breeding areas. However, from these spot observations alone it is not possible to quantify the rates of predation upon shorebird populations. Intensive studies of the prey taken by predators in one site are required. Only one thorough study has been made, by Page and Whitacre (1). They measured predation by raptors.

2. RAPTOR PREDATION

Page and Whitacre quantified the daily rates of predation by raptors (Falconiformes and Strigiformes) upon the shorebird populations of a small estuary in California, and extrapolated from these to estimate the number of shorebirds of each species killed by each predator species during a winter. Because of the abundance of raptors hunting over the estuary, and the specialization on shorebirds by a single Merlin *Falco columbarius*, raptor predation was a significant cause of mortality of shorebirds there (Table I). It is probable that raptors take much smaller proportions of shorebird populations on European than on Californian estuaries because there are fewer raptors wintering on European coasts, at least in recent years (Table II). However, calculations presented below using the rates of predation measured by other workers show that even single raptors could have a considerable effect upon the shorebird populations of an estuary.

At Teesmouth, N.E. England, a single female Merlin is present through

Table I RAPTOR* PREDATION ON WINTERING SHOREBIRDS IN CALIFORNIA

% of total wintering populations taken by raptors

	1 MERLIN *Falco columbarius*	1-4 SHORT-EARED OWLS *Asio flammeus*	1 LONG-EARED OWL *Asio otus*	ALL RAPTORS
DUNLIN (N = 1900) *Calidris alpina*	5.6%	11.7%	3.0%	20.7%
LEAST SANDPIPER (1600) *Calidris minutilla*	7.1%	2.3%	1.5%	11.9%
WESTERN SANDPIPER (350) *Calidris mauri*	7.5%			7.5%
SANDERLING (130) *Calidris alba*	13.5%			13.5%
DOWITCHERS (100) *Limnodromus* spp.				15.5%

(Data from Page and Whitacre (1))
*Falconiformes and Strigiformes

Table II RAPTORS* HUNTING SHOREBIRDS OVER TWO ESTUARIES IN WINTER

	BOLINAS LAGOON, CALIFORNIA	TEESMOUTH, N.E. ENGLAND
Regular	1 Merlin *Falco columbarius* 3 American Kestrels *F. sparverius* 1-4 Short-eared Owls *Asio flammeus* 1 Long-eared Owl *A. otus*	1 Merlin *F. columbarius*
Occasional	1-2 Great Horned Owls *Bubo virginianus* 1 Hen Harrier *Circus cyaneus* 1 Cooper's Hawk *Accipiter cooperii* 1 Sharp-shinned Hawk *A. striatus*	1-3 Short-eared Owls *Asio flammeus* 1-2 Kestrels *Falco tinnunculus*
Rare	1 Red-tailed Hawk *Buteo jamaicensis*	1 Peregrine *Falco peregrinus* 1 Sparrowhawk *Accipiter nisus*

*Falconiformes and Strigiformes

each winter, and has been seen capturing Dunlin *Calidris alpina* but no other species of shorebird. Over a winter this predator could kill between 10% and 23% of the Dunlin population (Table III) if it took only this prey. This value is suspiciously high for a species with an overall annual mortality rate of 25-30%, of which over a quarter is known to occur during

Table III POSSIBLE IMPACT OF ONE MERLIN UPON TEESMOUTH DUNLIN POPULATION

Teesmouth population of Merlins *Falco columbarius*	1 female
Present on estuary	August to mid-April ≡ ∿260 days
Prey taken on mudflats	Dunlin *Calidris alpina*
Estimate of no. of Dunlin-sized birds killed per day:	
1) Brown (2)	1 or 2 birds/day
2) Page & Whitacre (1)	2.2 birds/day
If Dunlin are only prey*	
No. taken per winter:	
@ 1 bird/day	260
@ 2.2 birds/day	570
Tees mid-winter population of Dunlin	2500
% of Dunlin population taken by Merlin	
@ 1 Dunlin/day	10%
@ 2.2 Dunlin/day	23%

* Passerines probably constitute a part of this Merlin's diet.

the four weeks of incubation in the breeding season (3). The calculation, therefore, has very limited value as it stands, but it does serve to emphasise the necessity of considerable additional information on the foraging behaviour and prey selection of the predator(s) before realistic and reliable estimates of predation rates can be produced.

3. MAMMALIAN PREDATION

Page and Whitacre's excellent work did not consider predation by mammals. Thus the total predation on shorebirds during a winter at their site was not known; nor are any other estimates available of the proportions of total mortality of shorebirds in either the breeding or non-breeding seasons that are due to predation.

At Teesmouth the maximum rate of mammalian predation on shorebirds was estimated by locating all the dead individuals from a cohort of Grey Plovers *Pluvialis squatarola* carrying radio-transmitters. Table IV sets out the results of this study. The overall predation rate was 12% (at maximum); foxes *Vulpes vulpes* ate or cached 6 out of the 7 birds that died. It is not known how many were actually killed by foxes and how many were dead when found and eaten by them, but clearly foxes could be important (nocturnal) predators on shorebirds on some sites.

4. OTHER EFFECTS OF PREDATION

In addition to the direct effects of predation, changes in behaviour of

Table IV MAXIMUM ESTIMATE OF PREDATION RISK FOR RADIO-TAGGED GREY PLOVERS

		ADULT	JUVENILE	TOTAL
No. radio tagged		31	30	61
No. found dead at Teesmouth		8	8	16
Cause of death not predation		2	3	5
Cause of death possible predation		6	5	11
Above as % of no. tagged		19%	17%	18%
Tagged birds found dead in first week		3	1	4
Possible predation after first week		3	4	7
Above as % of no. tagged		11%	14%	12%
Possible predators	a) fox	max. 2	max. 4	6 (11%)
of these 7 birds	b) raptor	1	0	1 (1%)

shorebirds may occur which could indirectly increase mortality.

In autumn all adult shorebirds undergo a complete moult of body and wing feathers so that at this time their flight capabilities are impaired. Their distribution in Western Europe is much more restricted during the moult period than it is during the rest of the non-breeding season. They use the largest estuaries, with wide expanses of inaccessible mudflats, e.g. The Wash and the Wadden Sea, probably to decrease risks from predators, particularly mammalian. Once moult has been completed, many shorebirds migrate from the moulting areas to a wide range of often smaller estuaries.

The risk of predation may be a factor promoting flock feeding in many non-breeding shorebirds (4). Watching for predators will reduce the time available for feeding. During cold weather this may lead to deaths of individuals either by starvation, because they have insufficient time in which to meet their food requirements, or, if vigilance is reduced in order to increase feeding time, by predation. It is extremely difficult to quantify this effect.

On many estuaries shorebirds are known to change roost site between diurnal and nocturnal high tides. At night they prefer to roost standing in water or on offshore islands and other inaccessible sites, probably to reduce the risk of predation by nocturnal ground predators. Changes in nocturnal roost site after the arrival in an area of a night-hunting owl have also been reported. It is thus important to consider the availability of safe roosting sites, in addition to adequate feeding areas, when assessing how to manage estuaries for shorebirds.

5. THE IMPORTANCE OF DATA ON PREDATORS FOR THE CONSERVATION OF SHOREBIRDS

A small increase in winter mortality in shorebirds can significantly decrease population size (5). In European estuaries an increase in raptor density, following the bans on certain pesticides, could result in an increase in shorebird winter mortality, possibly up to the levels observed in California. Thus information on predation rates is essential in interpreting observed changes in the sizes of winter populations of shorebirds.

Quantitative information is needed on (i) prey selection by each potential shorebird predator, (ii) the rates of predation by each predator upon each species of shorebird, and, ultimately, (iii) the total extent of predation on shorebirds at a site, by both avian and mammalian predators.

The methods of Page and Whitacre (1) should be adopted. In addition, radio-tagging could provide information on predation. Firstly, the use of space by foraging predators, particularly nocturnal mammals and owls, could be investigated. Secondly, by extending the technique described earlier, the attachment of miniature radio transmitters to a sample of several shorebird species at intervals throughout the non-breeding season would enable corpses to be found and causes of mortality to be assessed. Experimentation in techniques for exclusion or control of predators might be important at a later stage.

6. VARIABLES AFFECTING PREDATION RATES

(a) Geographical location - The types and abundance of predators hunting shorebirds over estuaries during the non-breeding season vary geographically. This may result in differential predation risks for large and small shorebirds.

(b) Local habitats - Differences and seasonal changes in the use by different predators of the available habitats within an estuary, such as high and low mudflats and saltmarshes, will result in differences in both the species of shorebird and the individuals within a species that are most at risk. Furthermore, the vegetation surrounding an estuary, especially a small one, can influence the predators hunting over the mudflats and saltmarshes.

Human habitation can also influence predation risk, e.g. in Greenland predators concentrated around a research station to scavenge from rubbish tips and thereby put nearby breeding shorebirds at greater risk.

(c) Accessibility of intertidal feeding sites - Although mammalian predators have been seen on mudflats 4 kilometres from the shore, the risk of predation is probably much less for shorebirds feeding on softer substrates, and on more distant and lower tidal level sites. Shorebirds such as Grey Plovers which tend not to use such feeding sites are at greater risk to mammalian predation than for example Knot *Calidris canutus*.

Many raptors rely on surprise when hunting. If local topography permits an undetected approach to certain intertidal flats or marshes, shorebirds are likely to be at greater risk.

(d) Shorebird behaviour - Within a single site at any one time the risk of predation may vary between individuals. At Teesmouth some Grey Plovers and Curlews *Numenius arquata* exclude conspecifics from their feeding sites. These solitary individuals are believed to be at greater risk of predation by foxes *Vulpes vulpes* at night than are other individuals that feed in flocks on less accessible mudflats. Indeed, in California Sanderlings *Calidris alba* abandon territorial defence when an avian predator is present (6).

Assessment of the effects of shorebird predators will be complicated by seasonal variation in the composition of the flocks of each shorebird species on a site. It is known from ringing recoveries and sightings of marked birds that individuals of many shorebird species visit several sites during the non-breeding season. Also geographical races of a species may visit the same sites but at different times, as is found in the Dunlin in N.W. Europe.

(e) Weather and season - Page and Whitacre (1) observed a dramatic increase in the number of raptors hunting shorebirds during cold weather.

7. THE POSSIBILITY OF PREDATOR CONTROL

In estuaries where a large proportion of the population of a rare shorebird species spends some or all of the non-breeding season, control of predators of shorebirds might be considered as a possible management technique. A necessary prerequisite is adequate information on foraging of the predators, as outlined earlier.

To be legitimate, predator control must result in an increase in shorebird numbers. At present, it is not certain what proportion of the shorebirds taken by predators represents a "doomed surplus" of individuals that would have died from other causes anyway. For example, at Teesmouth, foxes cached birds of very low weight which (if not already dead) must have been close to starvation. Also, it must be established that higher survival of shorebirds following predator control would not lead to greater competition for food and space and thereby to increased mortality amongst the shorebirds later in the winter.

Predators could be controlled either by killing them or excluding them from the areas used by shorebirds. Killing resident predators can be questioned on several grounds. Replacement individuals might take over the site, as for example with Merlins at Bolinas Lagoon, California, which arrived if the resident bird disappeared (1). As far as raptors are concerned, European populations are low at present and killing them would not be acceptable. However, this argument does not necessarily apply to mammalian predators. Exclusion is obviously practicable only for mammals, and not birds, and only on small sites.

REFERENCES

1. Page, G. & Whitacre, D.F. 1975. Raptor predation on wintering shorebirds. Condor 77: 73-83.
2. Brown, L. 1976. British Birds of Prey. Collins, London.
3. Soikkeli, M. 1967. Breeding cycle and population dynamics in the dunlin (Calidris alpina). Ann. Zool. Fenn. 4: 158-198.
4. Goss-Custard, J.D. 1970. Feeding dispersion in some overwintering wading birds. pp. 3-35 in Crook, J.H. (Ed.). Social Behaviour in Birds and Mammals. Academic Press, London.
5. Goss-Custard, J.D. 1981. Role of winter food supplies in the population ecology of common British wading birds. Verh. orn. Ges. Bayern 23: 125-146.
6. Myers, J.P. 1980. Sanderlings Calidris alba at Bodega Bay: facts, inferences and shameless speculation. Wader Study Group Bull. 30: 26-32.

DISCUSSION

Beintema (NL) argued strongly against advocacy of predator control, emphasizing that they have an important role in ecosystems. Myers (USA) agreed but suggested that birds of prey may now take greater proportions of shorebirds if these are concentrated into fewer areas as a result of destruction of their habitat. Evans (UK) suggested that the economic justification of conservation lay in public attitudes favouring preservation of specific groups of animals (of which birds were probably top of the list) and specific groups of birds, including waders (and birds of prey). Wood (UK) believed that the emphasis should be on conservation of ecosystems. Pienkowski (UK) pointed out that not all predators are birds of prey and that assessing the importance of predation does not require advocacy of its control.

IS POLLUTION A THREAT TO SHOREBIRD POPULATIONS?

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Summary

Apart from one incident involving alkyl lead compounds, there is no evidence of direct kills of shorebirds by pollutants in Europe. Waders may accumulate heavy metals between autumn and spring, particularly before moult into breeding plumage, but they eliminate them during the summer (except for cadmium). There is no evidence that these residues effect longevity of adults and no information on any effects on reproduction.

INTRODUCTION

Chemical pollutants theoretically could threaten the future size of shorebird populations in several ways: (i) in the short-term, by causing large-scale mortality sufficiently often to outweigh any recruitment; (ii) in the longer term, by reducing longevity of adults through cumulative effects of chronic exposure to pollutants; (iii) by reducing reproductive output; or (iv) by a combination of (i) to (iii). Three groups of pollutants could be significant for waders: petroleum hydrocarbons (oil), chlorinated hydrocarbons (e.g. DDT and PCBs), and heavy metals.

Mortality

Large kills of shorebirds in Europe are relatively rare, except in periods of severe winter weather (1,2,3,4,5). Oil pollution of the North Sea is not the hazard to waders that it is to some auks and diving ducks. Although, occasionally, a few waders with oil on their plumage are found dead on the tide-line, it is by no means certain that they have died through ingesting oil; starvation is more probable. Similarly, there is no evidence of kills of waders on a large scale through poisoning, directly or indirectly, with chlorinated hydrocarbon residues. The only well-documented incident involving heavy mortality, of Redshank *Tringa totanus* and Dunlin *Calidris alpina*, occurred on the Mersey estuary, NW England, in autumn 1979, and again on a smaller scale in 1980 and 1981 (6,7). Birds were poisoned by alkyl-lead compounds, resulting from the discharge of industrial effluents from a factory producing organolead compounds as petrol additives. Several thousand waders died, but this has had no noticeable effects on the numbers present in subsequent winters, though early autumn numbers have been lower.

Chronic effects

So little information is available on levels of chlorinated hydrocarbon residues in waders in Europe that no conclusions may be drawn as to possible accumulation of such chemicals in shorebirds. However, because they are fat-soluble chemicals, and shorebirds store (and use) large quantities of fat before (and during) migration, the chlorinated hydrocarbons are potentially important pollutants. Several studies on levels of heavy metals in a variety of species, particularly Dunlin (8), Oystercatcher *Haematopus ostralegus* (9) and Bar-tailed Godwit *Limosa lapponica* (10) indicate that cadmium is the only metal so far examined that increases in concentration in shorebird tissues with age. However, seasonal effects, with concentrations of several metals such as zinc and mercury rising in late winter, are also known to occur (11,12). This may be associated with preparation for moult into breeding plumage. Levels of metals fall again by the following autumn (except for cadmium). There is no indication that longevity has been reduced appreciably by the presence of such heavy metal residues.

Effects on reproduction

No information is available at present.

Research requirements

These have been reviewed elsewhere (12).

REFERENCES

1. Clark, N.A. 1982. The effects of the severe weather in December 1981 and January 1982 on waders in Britain. Wader Study Group Bulletin 34: 5-7.
2. Davidson, N.C. 1982. The effects of severe weather in 1978/79 and 1981/82 on shorebirds at Teesmouth. Wader Study Group Bulletin 34: 8-10.
3. Davidson, N.C. & P.R. Evans 1982. Mortality of Redshanks and Oystercatchers from starvation in severe weather. Bird Study 29: 183-188.
4. Pilcher, R.E.M. 1964. Effects of the cold winter of 1962-63 on birds of the north coast of the Wash. Wildfowl 15: 23-26.
5. Swennen, C. 1983. Characteristics of Oystercatchers killed by cold-stress in the Dutch Wadden Sea area. Ardea 71: 155-159.
6. Head, P.C., B.J. D'Arcy & P.J. Osbaldeston 1980. The Mersey estuary bird mortality, autumn-winter 1979 - Preliminary report. Scientific Report Ref. No. DSS-EST-80-1, North West Water Authority, Great Sankey, Warrington, England.
7. Bull, K.R., W.J. Every, P. Freestone, J.R. Hall, D. Osborn, A.S. Cooke & T. Stowe 1983. Alkyl lead pollution and bird mortalities on the Mersey estuary, UK, 1979-1981. Environmental Pollution (Series A) 31: 239-259.
8. Anderson, J.M. 1982. Some heavy metal studies in an estuarine food chain. Unpublished Ph.D. thesis, University of Cardiff, U.K.
9. Hutton, M. 1981. Accumulation of heavy metals and selenium in 3 seabird species from the U.K. Environmental Pollution (Series A) 26: 129-146.
10. Evans, P.R. & S.J. Moon 1981. Heavy metals in shorebirds and their prey in north-east England. In 'Heavy Metals in Northern England' (Eds. P.J. Say & B.A. Whitton). University of Durham.
11. Parslow, J.F.L. 1973. Mercury in waders from the Wash. Environmental Pollution 5: 295-304.
12. Evans, P.R. in NERC (1983). Contaminants in Marine Top Predators. Publication Series C. No. 23. Pp. 31 Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU, England.

CREATION OF HABITATS AND MANAGEMENT OF SITES FOR SHOREBIRDS

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Many coasts and estuaries throughout Europe are threatened by loss of natural intertidal habitats, particularly through changes such as reclamation for industry and agriculture, and by construction of tidal power barrages and surge barriers. Many areas have already been extensively altered and reduced in size. As the areas of natural habitats become smaller, so pressure for the reclamation of the remaining sites may become greater, whilst the need for their conservation also increases. Most attempts to conserve estuaries have concentrated on maintaining remaining areas in their natural or semi-natural state. An alternative approach (when that above is not possible) is to create new intertidal areas to compensate for the loss of existing ones. This approach has the advantage of reducing the loss in total area of intertidal land on an estuary, thus reducing the impact of reclamation on existing natural populations. This may be especially important when all remaining mudflats on an estuary are to be lost through reclamation. Compensation can be by the creation of new, or the enhancement of existing, areas. The habitats created must closely resemble those lost.

The value of many freshwater and inland wetlands, for example gravel pits, have been successfully enhanced. However, few studies have identified the requirements and methods of establishing new intertidal areas, and very few attempts have been made to create mudflats as a means of conservation of shorebirds. Before attempting to create such sites, the existing use and biological importance of all areas involved must be assessed, to avoid damage to existing important populations of plants and animals. At Teesmouth, in north-east England, we examined the importance of potential compensatory sites and identified the features that a new site must possess to maximise suitable habitat for waders in the non-breeding seasons (1). It is particularly important to establish the lead time needed for site creation. This is the number of years needed for sufficient sedimentation and infaunal development to provide the correct sizes and types of foods to support wader populations. Different waders have different habitat requirements which may vary geographically. These must be identified, and the type of site created should reflect the existing importance and species composition of the area to be reclaimed, so that new sites will continue to support populations of those species that were important before reclamation.

Much further study of the creation and management of intertidal habitats is needed, particularly of methods of creating different habitats (e.g. mudflats, sandflats, saltmarshes), the level of compensation that is biologically acceptable, and the economic feasibility of site creation.

REFERENCE

(1) Davidson, N.C. 1981. Seal Sands Feasibility Study. A report to Cleveland County Council and the Nature Conservancy Council. pp 144.

Discussion

Laursen (DK) gave details of the creation of a salt-water lagoon, which has been built behind a recently-constructed dyke enclosing 1200 ha of saltmarsh on the Danish coast of the Wadden Sea. The lagoon will cost only 5% of the total cost of building the dyke. It will be 250 ha in extent and about 40 cm deep; fluctuations in depth of 5-10 cm are expected through wind action. The value to birds will be monitored over the next 3 years. It is hoped to encourage breeding birds and to provide for some passage migrants.

Woldhek (NL) drew attention to the conference on 'Integration of Ecological Aspects in Coastal Engineering Projects' held at Rotterdam in June 1983. The Proceedings are appearing in the journal 'Water, Science and Technology' and may be purchased at a cost of about £80. Evans (UK) reported that a copy of the preprints of conference papers and of the discussions is held at Durham. Few papers covered attempts to predict how to create suitable habitats; most reported what had been done incidentally. Pienkowski (UK) emphasized that very few engineering projects had been followed up by monitoring the effects on birds.

Smart (UK) informed the meeting of the IWRB handbook 'Managing wetlands and their birds' which is available from IWRB at Slimbridge, Glos. GL2 7BT, U.K. at a price of £6. It deals chiefly with management of inland wetlands but includes both wildfowl and wader habitats. Smart also mentioned the method used to build new saltmarsh in the Wadden Sea areas - fences of stakes and wattles placed at right angles to the shore - as a possible method for creation of mudflats. Smit (NL) referred to plans at Rotterdam for building raised basins just offshore to hold the (polluted) dredgings from Rotterdam harbour. These constructions were expected to create some additional intertidal habitat between the basins and the existing coast.

Myers (USA) spoke of management of coastal wetlands, in the eastern states of the U.S.A., for migratory wildfowl and shorebirds by control of water levels to different depths at different seasons. Cadbury (UK) cautioned about the uncertainty of creating habitats similar to those lost, so that it may not be possible to retain the exact ornithological interest that was originally present.

SUMMARY
OF SHOREBIRD WORKSHOP

Research priorities for studies of birds during the breeding season were summarized in the final discussion after the first session of the workshop. The outcome of the second session was to highlight that additional sites may be identified (in addition to those already notified to DGXI) as important for shorebirds during moult, migration and in the non-breeding season. Such sites can be discovered by studies of population turnover at particular localities and by examining patterns of weight change in migrants that could indicate where refuelling sites must be. It must be recognized that some potentially good sites may not be used extensively at present because of disturbance, e.g. from hunting.

Attempts to predict the effects of change in shorebird habitats, e.g. by reclamation or alteration of tidal regimes, must be intensified and management of habitats given increased attention.

Finally, the need to discover where regulation of numbers occurs - on the breeding grounds, on migration, or in the non-breeding areas - is a most important problem. Separate consideration must be given to each species.

P.R. EVANS

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II. CONSERVATION OF HERONS EGRETS AND OTHER WATERBIRDS

SESSION 1

HABITAT REQUIREMENTS DURING THE BREEDING SEASON

INTRODUCTION

In contrast to most shorebird species for which western Europe is of greatest significance as a wintering site or resting place during the course of migration, most species of herons and pelicans which occur in the region breed there during the summer months in large or internationally significant numbers. However at the end of the breeding season the majority of these large waterbirds move away from the breeding areas and overwinter far to the south. During the course of this annual cycle of breeding and migration three major questions of considerable significance to the conservation of these species can be identified.

(i) In order to achieve successful breeding what types of nesting sites are required ?

(ii) Given that adequate nesting sites are available, what size and area of different types of feeding site are required in order that nesting may be successful ?

(iii) What are the ecological requirements of these birds outside the breeding period, particularly during the course of migration and in winter ?

It is the aim of this volume to provide an overview of current ability to answer these questions and to identify what steps should be taken to improve this understanding.

H. HAFNER

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PURPLE HERON COLONIES IN THE CAMARGUE

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Summary

The results of nest censuses have revealed a recent decline in the number of pairs of Purple herons which breed in the Camargue. The factors which limit the size of colonies and of the Camargue breeding population are examined. Colonies are found only in reedbeds, none of which is currently protected by reserve status. Adverse management of these habitats for duck-hunting has reduced both the number and individual size of colonies of Purple herons that remain. Studies of their foraging ecology during the breeding season have shown that when breeding habitat is superabundant, colony size is limited, through territoriality on the feeding grounds, by the availability of food resources in the surrounding area. Thus, the pairs which have been displaced through habitat loss are unlikely to be able to breed successfully in existing colonies. Effective conservation of this species on its breeding grounds requires the protection of existing breeding sites, the creation of new breeding sites and further research into feeding habitat quality and requirements.

1. INTRODUCTION

Six species of colonial heron (Ardeidae) breed in the Camargue, S. France. Four of these species nest in trees, while the other two nest in reedbeds. Much is already known of the distribution, abundance and ecology of the former group (7, 8), and successful measures have already been taken to protect these species on their breeding areas (9). Far less is known of the ecology of the two reed-nesting species, the Grey heron *Ardea cinerea* L. and the Purple heron *Ardea purpurea* L..

The Grey heron colonised the Camargue only recently (1), but has expanded greatly in numbers since then (14, 12) both in the Camargue and throughout Central Europe. The breeding populations of this species are not therefore in need of special conservation measures. In contrast, breeding populations of the Purple heron have recently declined both in the Camargue and in other Mediterranean wetlands.

The Purple heron is a summer visitor to the Camargue and other wetlands of Central and Southern Europe. Ringing studies have shown that the majority of the birds from these breeding areas winter in the Sahel zone of West Africa (10). The number of pairs returning to breed each year in the colonies of Holland have been shown to be correlated with drought conditions in the wintering areas (4), a finding which is also supported by evidence from ringing recoveries (3). In this paper, I examine the factors which determine the number of pairs of Purple herons which breed each year in the Camargue, and hence recommend guidelines for the protection of the

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breeding populations which remain in this area. Many of the findings will also be appropriate to the conservation of other colonial wetland birds on their breeding grounds. The importance of conserving these species on their wintering areas is discussed elsewhere (5).

2. RESULTS AND DISCUSSION

-Nest censuses

The number of pairs of breeding Purple herons in the Camargue have been counted in most years since 1968 (Table I). All areas of suitable breeding habitat were checked for colonies in every census year. Both ground counts, and in recent years, aerial counts (by photography) were used to census the colonies. The two methods gave comparable results and are described in full elsewhere (12).

The size of individual colonies ranged from 5-381 pairs. During the four years in which counts were made, both in and outside the delta (1979-82), the total breeding population varied between 800-1 300 pairs. A comparison of counts within the delta from 1968-71 and 1979-82 shows a fall in the average number of colonies per year from 7,0 to 4,3, and a fall in the number of pairs from 649 to 328, or 50%. The pattern of colony occupancy shown in Table I is sporadic, with no individual site having held a colony in every census year. This contrasts strongly with the situation reported in Holland (4), where the two largest colonies were both occupied in all 19 consecutive seasons for which counts were made. The reasons for these differences are discussed below.

-Habitat characteristics

Colonies of Purple herons occurred in reedbeds of *Phragmites australis* only. The distribution of colonies was therefore restricted to freshwater areas where dense reedstands occurred. Occupied reedbeds generally had the following characteristics:

- they were composed of extensive, unbroken stands of mature reed.
- they were permanently inundated throughout the breeding season.
- they were free from disturbance.

There was a relationship between the number of pairs in each colony, and the surface area of suitable reeds available for nesting (Figure 1). Thus reedbeds smaller than 20-30 hectares physically limit the size of the colony, whereas colonies in reedbeds larger than this were limited in size by some other factor.

All colonies were located on properties managed for the hunting of duck in winter, and none on reserve areas. Extensive reedbeds were not used by duck, and management procedures on these properties are generally concerned with the removal of extensive stands of reed to leave only fringes as shelter for the duck. Removal of reeds is usually achieved by the temporary drainage of a marsh, followed by the burning, cutting or grazing of the reed. All these processes inhibit the nesting of Purple herons. The recent intensification of such processes in the Camargue has brought about a reduction in both the number of reedbeds available for nesting and in the size of the reedbeds which remain.

-What limits colony size, and hence the number of herons that can breed in an area ?

The results of habitat management for duck-hunting, reported above, have been to reduce both the number of sites in which Purple herons can

TABLE I

Numbers of pairs of Purple Herons at different breeding sites in the Camargue and environs, 1968-1982. Letters refer to locations marked on map in Figure 1.

Colony	1968	1969	1970	1971	1972	1973	1974	1979	1980	1981	1982
A	200	250	140	160	100	0	80	120	149	0	0
B	140	140	130	25	0	100	110	0	0	0	108
C	0	0	0	0	0	0	0	0	0	0	8
D	0	100	50	80	10	0	20	0	0	0	0
E	75	100	X	150	100	70	65	160	144	110	0
F	0	0	50	0	0	16	60	0	0	8	140
G	0	0	0	0	0	0	0	0	0	9	21
H	90	0	0	250	250	40	200	0	82	42	0
I	0	0	0	0	0	150	120	0	0	0	15
J	0	0	0	0	0	0	0	0	0	0	118
K	50	0	0	30	0	0	0	0	0	71	0
L	40	35	80	120	120	70	150	5	0	0	0
M	30	35	26	10	0	10	0	0	0	0	0
N	10	0	0	0	0	0	0	0	0	0	0
O	X	X	X	X	X	X	X	200	300	174	213
P	X	X	X	X	X	X	X	X	X	14	18
Q	X	X	X	X	X	X	X	X	381	182	380
R	X	X	X	X	X	X	X	X	0	280	346

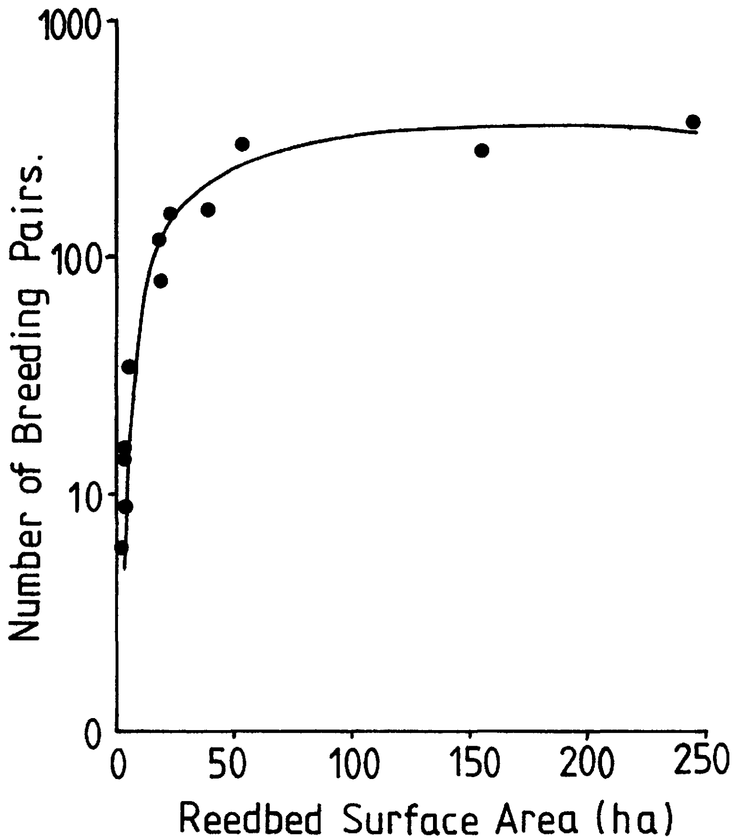

Figure 1 : The relationship between reedbed surface area available for nesting, and maximum colony size of Purple herons in that reedbed.

breed and to reduce the number of pairs that can breed in many of the sites that remain. A vital question for the conservation of both this and similar colonial species, is whether those individuals which have been displaced from a particular breeding site by habitat loss are able to join and breed successfully in other colonies at sites not limited by the availability of breeding habitat. Alternatively we can ask, what limits colony size when space for breeding is superabundant ?

The availability of food has often been shown to limit bird populations (12). There is some circumstantial evidence, for a number of species from several different regions, that the size and distribution of heronries is related to the availability and quality of food resources in the area surrounding the colony (11, 2, 6). However, the mechanism linking these two parameters has not yet been demonstrated for any colonial species.

I carried out a study to examine these effects in the 1981 and 1982 breeding seasons, at the colony of the Etang de Landre ('O' in Table I). This colony was chosen for study because:

- there was a superabundance of reeds available for nesting
- there were no other large colonies nearby
- adults from this colony fed in four discrete areas of marshes which were separated by large areas of habitats not used for feeding. These zones differed in size, and particularly in their distance from the colony (Fig. 2). Each was composed of a variety of different feeding habitat types (freshwater marshes, ditches, canals, etc.). It was assumed that the relative opportunities offered for feeding by each zone did not change during the course of a breeding season.

Observations of the relative use of these four feeding zones by foraging adult Purple herons departing from the colony revealed very similar patterns in the two years. At the start of each season, almost 50% of the departures were to local feeding areas, whereas by the end, this proportion had fallen to about 10-15% (Fig. 3). Examination of the rates of departures showed that the number of departures to the local feeding areas remained constant throughout each season, and that the increases in total departures, as more birds joined the colony, were explained entirely by an increased rate of departures to the more distant feeding areas. Thus, the local feeding areas were filled at the beginning of each season to a level which could not support more birds later in the season, suggesting that these are the preferred areas.

Detailed observations of individual adult herons from marked nests, including some individuals carrying radiotransmitters, showed that each bird was extremely faithful to a particular foraging zone. Of the 37 Purple herons which were observed intensively, only three changed foraging zone during the course of a season and these were all adults which had initially been feeding in an area which was subsequently drained for hunting management. Regular observations of the feeding sites of six individuals which fed near to the colony, from an observation tower, showed that not only were these individuals faithful to this feeding zone, but that they defended exclusive feeding territories on it. There was no relationship between the areas defended by the two members of the pair. Thus, the first birds to arrive at the colony each year occupy territories in the feeding areas nearest to the colony, which they defend exclusively against other individuals which join the colony later in the season.

Further observations of the foraging ecology and time budgets of breeding adult Purple herons help to explain the advantages of foraging in these local zones, rather than at greater distances from the colony. Purple herons do not forage by night, and must therefore meet their own daily energy requirements and those of their brood in the 16 hours of day-

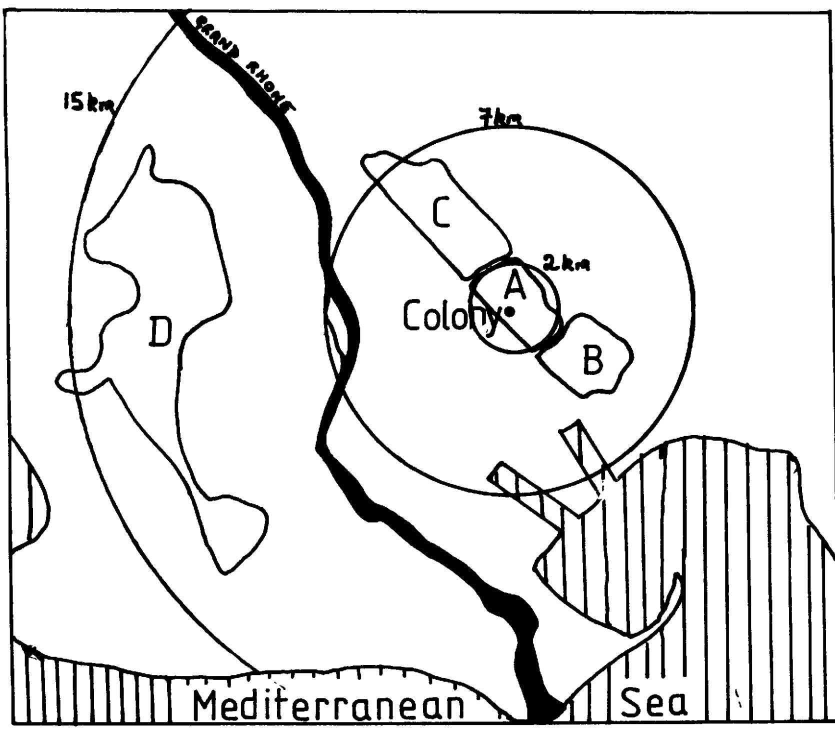

Figure 2 : Sketch map of the study area at the Etang de Landre, showing the location of the colony and the four main feeding zones (A - D).

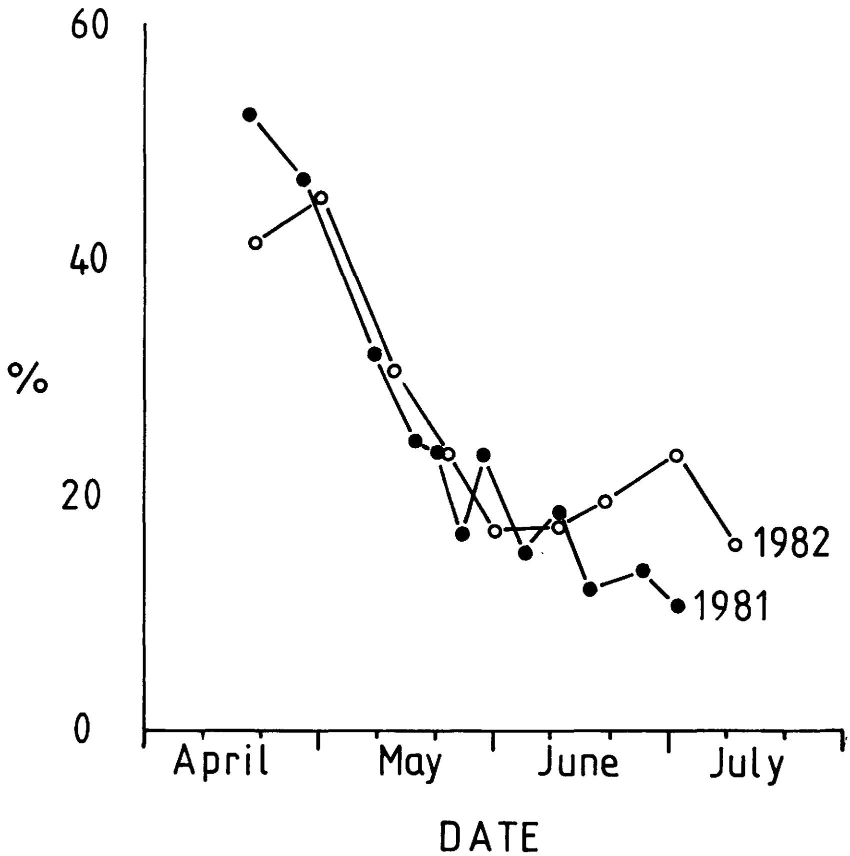

Figure 3 : Seasonal change in the proportion of departures of foraging adult Purple herons from the study colony, to the local feeding areas (A in Fig. 2).

light available at this time of year. The nestlings are continually guarded for their first 20 days of life by one adult, thus effectively halving the food-gathering potential of the pair during this period. The average duration of each foraging trip decreases to a minimum when the chicks are 15-20 days old. At this time the adults forage throughout the daylight hours, suggesting that they are pressured to meet the requirements of their brood.

The average flight speed of Purple herons was measured to be 44 km per hour, under calm conditions. From the time budgets of known adults, and the measured distances to their different feeding zones, it is possible to calculate the amount of time that each adult must spend in flying to its feeding area per day. Thus, an adult feeding in the local marshes at 1 km from the colony would spend 2% of the daylight hours in flight, assuming 6 foraging trips per day, whereas an adult feeding in the most distant marshes 15 km away would spend 26% of the day in flight. This represents a cost of 24% less time available for feeding, plus the extra energetic cost of maintaining flight activity. If the feeding grounds at different distances are of approximately similar quality, then the cost of using them as a feeding ground will increase in proportion to their distance from the colony. The relationship between these costs and breeding success is discussed elsewhere (12).

The costs of feeding at increasing distances from a breeding site, outlined above, offer a mechanism by which colony size will be limited by the amount of food resources in the area around the colony. As the colony grows in size, and the feeding territories nearest to the colony become occupied, it will become less and less advantageous for new pairs to join that colony. Thus, to answer the original question, it seems unlikely that individuals which are displaced from one colony, through habitat loss, would be able to breed successfully at another occupied breeding site unless the numbers present in this new colony were below that level set by the availability of food resources.

3. CONCLUSIONS AND RECOMMENDATIONS

Purple heron colonies in the Camargue occur in reedbeds on private properties, managed for the hunting of duck in winter. Current intensification of such management practices have resulted in a reduction in the number of breeding sites available to herons, and the population has declined in the Camargue as a result of this. The birds which are displaced by these activities are unable to join other colonies in the area, as the number of pairs which can breed in a particular colony is limited by the food resources in the surrounding area. Territoriality on the feeding areas appears to be the mechanism by which colony size and food resources are related. It is recommended that the following steps be taken to conserve the remaining breeding populations of Purple herons in the wetlands of the Mediterranean basin.

- Existing breeding sites should be protected and submitted to management régimes favourable to the nesting of Purple herons.

- Suitable breeding habitat should be created at a number of former breeding sites and other apparently suitable areas. These should be chosen for their distance from other occupied colonies, and their proximity to adequate feeding areas.

- Further research should be initiated to examine in more detail the feeding habitats required by Purple herons during the breeding season, and the optimal management régimes thereof.

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5. REFERENCES

(1) BLONDEL, J. (1965) - Le Héron cendré Ardea cinerea nicheur en Camargue. L'Oiseau et R.F.O. 35: 59-60.

(2) BRAAKSMA, S. & BRUYNS, M.F.M. (1950) - Overzicht van de broed-kolonies van de Blauwe Reiger Ardea cinerea L. in Nederland in 1949. Ardea 38: 135-162.

(3) CAVE, A.J. (1983) - Elsewhere, this volume.

(4) DEN HELD, J.J. (1981) - Population changes in the Purple heron in relation to drought in the wintering area. Ardea 69: 185-191.

(5) DUGAN, P.J. (1983) - Elsewhere, this volume.

(6) FASOLA, M. & BARBIERI, F. (1978) - Factors affecting the distribution of heronries in northern Italy. Ibis 120: 537-540.

(7) HAFNER, H. (1977) - Contribution à l'étude écologique de quatre espèces de hérons (Egretta g. garzetta L., Ardeola r. ralloides Scop., Ardeola i. ibis L., Nycticorax n. nycticorax L.) pendant leur nidification en Camargue. Unpublished thesis, Toulouse.

(8) HAFNER, H., BOY, V., GORY, G. (1982) - Feeding methods, flock size and feeding success in the Little egret Egretta garzetta and the Squacco heron Ardeola ralloides in Camargue, Southern France. Ardea 70: 45-54

(9) HAFNER, H. (1983) - Elsewhere, this volume.

(10) KOOIJ, H. van der (1976) - De trekwegen en overwinteringsgebieden van vogel 400 (Purperreiger). L.H. Wageningen, Vakgroep Natuurbeheer, Rapport nr. 359.

(11) LACK, D. (1954) - The stability of the heron population. British Birds 47: 111-119.

(12) MOSER, M.E. (in prep.) - Resource partitioning in a community of herons and egrets, in the Camargue, southern France. Ph.D. thesis, University of Durham, England.

(13) NEWTON, I. (1980) - The role of food in limiting bird numbers. Ardea 68: 11-30.

(14) WALMSLEY, J.G. (1975) - The development of a breeding population of Grey herons Ardea cinerea in Camargue. Terre & Vie 29: 89-99.

6. DISCUSSION

In contrast to the situation described for Camargue all colonies in the Netherlands are on nature reserves and hence protected (Perdeck; NL). In contrast little is known about the feeding habitat used. However it is generally thought that there is currently no major threat to the Purple heron in the Netherlands (Perdeck). The relationship between drought in the wintering areas and the size of the dutch breeding population indicates that the major threat to this population lies on the wintering grounds. However no such relationship has yet been demonstrated for the population which breeds in the Camargue, probably because the number of pairs breeding there is limited by the lack of suitable breeding habitat (Moser ; UK/F). This is also true of several other areas in the Mediterranean where nesting habitat has been destroyed or where the wetland has been lost completely (Moser).

The relationship described between reedbed area and condition, and the number of birds breeding there may hold true for other species such as the Bittern Botaurus stellaris and this should be investigated (Moser, Langslow; UK).

HERONS AND EGRET COLONIES IN ITALY

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Summary

The highest populations of Night Heron (17,500 nests) and of Little Egret (6,700) of any European country breed on a 150 by 450 km area in Northern Italy, together with small numbers of Squacco, Grey and Purple Herons. Within this area, some characteristics of colony distribution and species composition are related to the availability of different feeding habitats within the foraging ranges of the colonies. The heronries are concentrated in the zone of widespread rice cultivation. From data on feeding ecology of the Night Heron and Little Egret on rice fields, it is estimated that 46% and 39% respectively of their populations in Italy are supported by the fields and the irrigation canals as feeding habitats. Land reclamation has reduced colony site availability to a minimum. Recently, one third of the heronries have been protected by setting up natural reserves.

1. INTRODUCTION

The only complete census of the heronries in Italy was accomplished in 1981 (1) and showed that the breeding populations of some species were well above the previous estimates (2). The partial censuses made in the past (3) (4) (5) do not allow the detection of population trends, except for the Grey Heron *Ardea cinerea* which decreased after the thirties and has increased over the last few years, as in other parts of Europe. Other unpublished censused made from 1972 to 1983 indicate that the 1981 population was not exceptional.

I summarize here the information on herons breeding in Italy. The aims are to define population size in relation to the other European countries; to relate some characteristics of colony distribution and species composition to the availability of feeding habitat; to ascertain the influence of a particular feeding habitat, the rice fields, on population size.

2. POPULATION AND DISTRIBUTION

Night Herons *N. nycticorax* and Little Egrets *Egretta garzetta* are very abundant in Italy and breed in colonies of large average size. Far less numerous are the Squacco Heron *Ardeola ralloides*, the Grey Heron, and the Purple Heron Ardea purpurea (Table I). The total European populations of these species are unknown, because some Southern and Eastern countries have been incompletely censused. However Italy seems to have the largest populations of Night Herons and Little Egret in Europe, as shown by the provisional estimate presented in Tab. II.

TABLE I

Number of colonies, their size, and total breeding population of herons in Italy in 1981.

	no. colonies	no. nests/colony		total no. nests in Italy
		average	range	
Night Heron	49	385	15-1400	17 500
Squacco Heron	17	15	1-80	300
Little Egret	45	160	4-940	6 700
Grey Heron	12	55	5-120	680
Purple Heron	35	20	1-80	650
Ardeinae	73	420	6-1700	23 830

Data from (1), supplemented by information on two small colonies overlooked during the 1981 census. The no. nests/colony is calculated only for the 60 colonies censused by the author.

TABLE II

Estimate of the European populations of Night Heron and Little Egret.

Country	Night Heron	Little Egret	Reference
ITALY	17 500	6 700	(1)
Spain & Portugal	3 500	2 500	(6)(7)
France	1 500-3 500	1 800-2 300	(8)
Hungary	650	150-200	(2)
Romania	2 500	?	(6)
Yugoslavia	10 000	1 000	Dimitrijevic com. pers.
Greece	1 500-1 600	1 500	(2)
USSR	5 000	4 500	Skokova com. pers.
Other countries	500	?	(2)
EUROPE	44 000	19 000	

Over 98% of the Italian breeding herons are concentrated on the plain of the Po river, over an area whose maximum diameters are 150 by 450 km (Fig. 1). Within this area, the distance between colonies varies, as does species composition and colony size. In order to investigate these differences and to explain the overall abundance of the herons, I divided the Italian breeding range into 5 zones (Fig. 1), distinguished on the basis of the dominant feeding habitat in each zone (i.e. rice fields, Po and other large rivers, inland ponds of the Eastern plain, coastal lagoons of the Adriatic sea, small streams of the South-Western plain).

To define the boundaries of each zone, a radius of 10 km (an average feeding range) was added to the outermost colonies; all the circles around them were then connected, including the areas between; the sum of the nests of the heronries in a zone, divided by the area of the zone, is the Density Index (DI), an indicative measure of the abundance of each species. Previously, the densities of Grey Herons had been calculated for the total extent of entire countries (9). Obviously an entire country contains many zones unsuitable for the herons. The calculation of the DI within the presumed foraging range of a group of colonies mitigates somewhat the error of including unsuitable habitats.

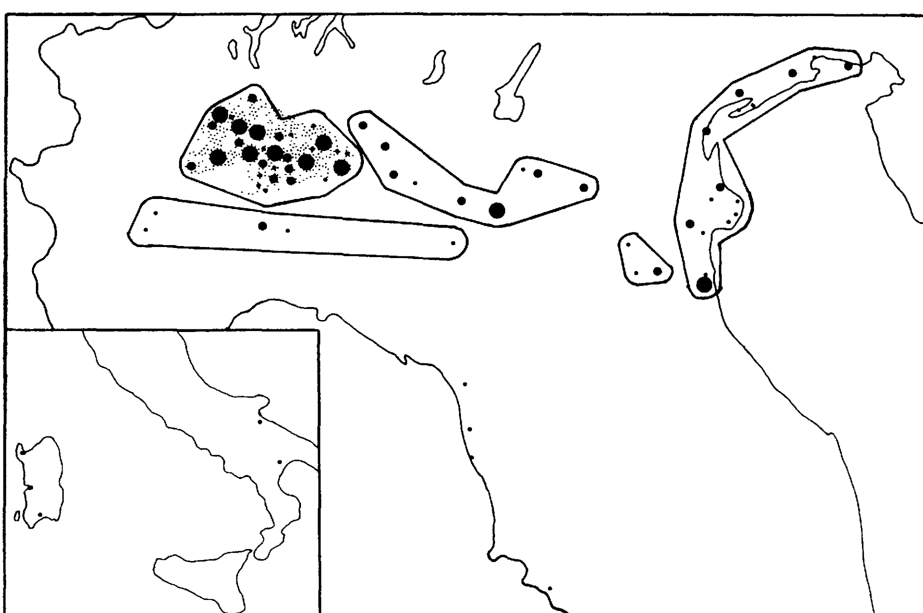

FIGURE 1. Distribution and size of the Italian heronries. Size classes: • < 250 nests, • 250-750, ● >750. (——) boundaries of the 5 zones, see text. Stipples = area with intensive rice cultivation. North and South Italy at different scales.

Some of the inequalities of the DI between the Italian zones (Tab. III) may be explained by the feeding habitat preferences of the species. The highest DI in "coastal lagoons" is that on the Little Egret, the only one of these species feeding currently in brackish waters (2)(10)(pers. obs.). The maximum DI of the Purple Herons is in "inland ponds" because it prefers densely vegetated shallow waters (op. cit.) which are most abundant there. The DIs of Grey and Purple Heron are almost complementary, as the two species are parapatric, the Grey breeding only in the North-West, and the Purple Heron in the North-East, centre and Sardinia. The total DI for the Ardeinae is similar in three of the zones, 10 times lower in "small streams" and about three times higher in "rice fields" zone. Rice covers 20-30% of tis zone, and in some regions reaches 95% i.e. it is the sole crop (Fig. 2). In this zone a quantitative relation between local abundance of rice fields and density of the heronries was found (11).

TABLE III

Density Index (no. nests/10 km^2) of the herons in the five main zones of the Italian breeding range shown in Fig. 1.

	"rice fields"	"rivers"	"coastal lagoons"	"inland ponds"	"small streams"
Night Heron	19.88	8.16	1.95	7.86	0.71
Squacco Heron	0.88	0.01	0.25	0.48	0
Little Egret	4.51	0.78	5.65	1.44	0.06
Grey Heron	1.07	0	0	0	0.05
Purple Heron	0.25	0.08	0.40	0.53	0
Ardeinae	25.80	9.03	8.26	10.12	0.82

FIGURE 2. Aerial view of a zone of intensive rice cultivation.

3. FEEDING ECOLOGY IN RICE FIELDS

The importance of rice fields for breeding herons suggested detailed investigations of their feeding ecology in these fields.

The numerically most abundant prey of the Night Heron in the "rice fields" zone are amphibians, although fish becomes the main prey by weight (12). In order to estimate the proportion of the prey supplied by the rice fields and by the other habitats in the zone (some rivers and small riverine marshes) I compared the diet of the chicks with the prey captured by the adults on the fields (Tab. IV). From the fields, all the worms, crustaceans, tadpoles and a part of the frogs are collected, while the rest of the frogs and all the fish are taken from the vast network of irrigation canals which surround the fields and which are maintained for the cultivation of rice, and from the rivers and marshes. In summary, I estimate that about 60% of the food of the Night Heron during nestling period is contributed by the agricultural wet habitat (rice fields and irrigation canals).

The use of rice fields by Night Heron and Little Egret lasts only during May and June (Fig. 3). However this is the period of chick development and high energy demands, and the peak of prey availability in the fields coincides with the time of fledging, hence increasing the importance of the rice fields, which are used also by minor numbers of Squacco, Grey and Purple Herons. Other studies (14) (15) support the importance of the rice fields for the herons.

TABLE IV

Prey regurgitated by nestling Night Herons, compared with those captured by the adults on rice fields, and abundance of the prey in the fields.

	% no. prey regurgitated by nestlings	% no. prey taken by adults on rice	prey abundance on rice
Anellida	4	42	+++
Crustacea	23	31	+++
Tadpoles	4	23	+++
Frogs	41	4	++
Fish	26	0	-
Others	2	0	+
no. items observed	1064	500	

abundance rank: +++ high, ++ medium, + low, - absent. Data from (12)

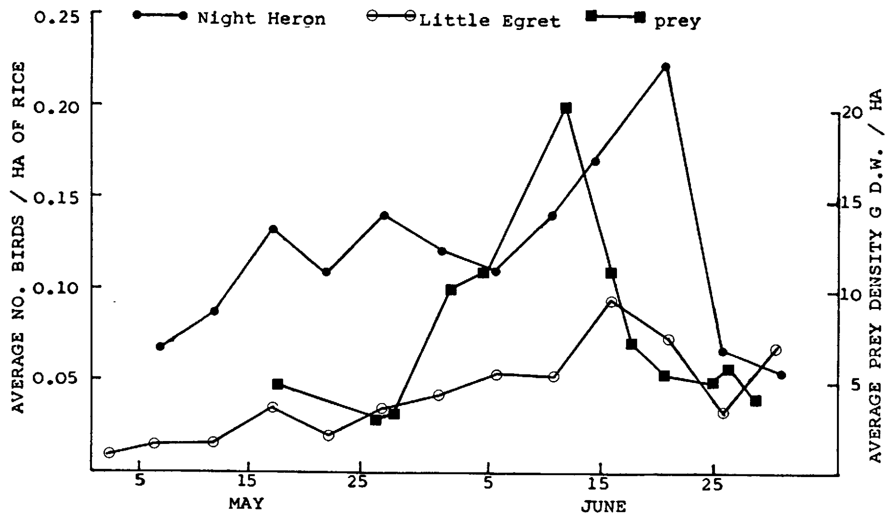

FIGURE 3. Density of herons and of their prey on a sample area of rice fields. Data from (13).

4. INFLUENCE OF THE RICE FIELDS ON THE POPULATION

A total of 11,800 pairs of Night Heron and 2,700 Little Egret breed on the "rice fields" zone. From the information obtained on feeding ecology of these species, the proportion of the population supported directly by the agricultural wet habitat for foraging could be estimated by the three methods below, each based on independent assumptions.

1) The "rice fields" and "river" zones differ mainly for the presence of the fields: so the difference in DI of the two zones, multiplied by the extension of the "rice fields" zone (5,960 km^2) is a first estimate (Tab. V, 1).

2) At the peak of breeding, about 60% of the prey of the Night Heron in the "rice fields" zone are obtained from the agricultural habitat. Hence 60% of the population could be supported by it (Tav. V, 2).

3) The density of feeding Night Herons and Little Egrets on a sample area of rice between two heronries averaged respectively 12.7 and 3.7 adults/km^2 at the peak of breeding. Multiplying these densities by the total area of rice fields in the zone (1,596 km^2, data from Ente Nazionale Risi) an estimate of the population supported by the same fields was obtained (Tab. V, 2).

Averaging these estimates, I conclude that about 8,100 pairs (69%) of Night Heron and 2,600 (96%) of Little Egret in the "rice fields" zone are supported by the fields. These figures correspond to 46% and 39% respectively of the entire Italian population of these species.

TABLE V

Number of nesting pairs in the "rice fields" zone supported by the agricultural wet habitat for feeding.

estimate based on	Night Heron	Little Egret
1) difference in DI bewteen zones	6 960	2 210
2) proportion of food taken from agricultural habitat	7 080	?
3) density of herons feeding in the rice fields	10 130	2 950

5. COLONY SITES AND CONSERVATION

The North Italian breeding range of the herons extends over a densely inhabitated and intensively cultivated landscape. While food is supplied also by agricultural habitat, few safe heronry sites are available. Many colonies, some over 1,000 nests, occupy small woods surrounded by many km^2 of cultivated land lacking other patches of natural vegetation. The increased land reclamation could reduce in the near future the breeding populations of the herons, which seem to be at the low limit of colony sites availability. However during the past 5 years a number of heronries have been protected by setting up local natural reserves on colony sites.

The fate of 64 of the heronries censused in 1981 is known up to the 1983 breeding season. Of these heronries, 3 were destroyed by land reclamation; 15 are in danger as they are settled on small and non protected natural patches; 8 are naturally protected by site inaccessibility or difficulty of draining; 17 are temporarily protected by land owners, e.g. on hunting estates or private parks; 21 are now included in natural reserves, where habitat conservation and protection from disturbance has been in many case effective but sometimes not.

References

(1) FASOLA,M., BARBIERI,F., PRIGIONI,C., BOGLIANI,G., 1981. Le garzaie in Italia, 1981. Avocetta 5:107-131.

(2) CRAMP,S. & SIMMONS,K.E.L. (eds) 1977. The birds of the Western Palearctic. Vol. I. Oxford University Press.

(3) MOLTONI,E., 1936. Le garzaie in Italia. Riv. Ital. Orn. 6:109-148, 211-269.

(4) WARNCKE,K., 1960. Die norditalienischen Reiherkolonien, 1960. Vogelwelt 81:129-141.

(5) BARBIERI,F., FASOLA,M., PRIGIONI,C., BOGLIANI,G., 1979. Le garzaie dell'Italia Nord-occidentale, 1981. Avocetta 3:3-28.

(6) LIPPENS,L. & WILLE,H., 1969. Le Heron Bihoreau, Nycticorax n. nycticorax, (Linné 1758) en Belgique et en Europe occidentale. Gerfaut 59:123-156.

(7) CRUZ,F. 1975. Revision de la actuales colonias de Ardeidas de España. Ardeola 21:65-126.

(8) DUHAUTOIS & MARION, L. 1982. Inventaire des colonies de herons arboricoles en France: status 1981. SNPN, Paris.

(9) BLOK,A.A. & ROSS,M., 1977. Blawe Reigercensus 1970-1976. Het Vogeljaar 25:205-223.

(10) HAFNER,H., 1977. Contribution à l'étude ecologique de quatre espèces de herons (Egretta garzetta L., Ardeola ralloides Scop., Ardeola ibis L., Nycticorax nycticorax L.) pendant leur nidification en Camargue. Thèse pour le grade de Docteur. Univ. Toulouse.

(11) FASOLA,M., BARBIERI,F., 1978. Factors affecting the distribution of heronries in Northern Italy. Ibis 120:537-540.

(12) FASOLA,M., GALEOTTI,P., BOGLIANI,G. & NARDI,P., 1981b. Food of Night Heron and Little Egret feeding in rice fields. Riv. Ital. Orn. 51:97-112.

(13) FASOLA,M. & GHIDINI,M., 1983. Use of feeding habitat by breeding Night Heron and Little Egret. Avocetta 7 (in press).

(14) FASOLA,M., 1982. Feeding dispersion in the Night Heron Nycticorax nycticorax and Little Egret Egretta garzetta and the information centre hypothesis. Boll. Zool. 49 (in press).

(15) FASOLA,M. (in press). Activity rhythm and feeding succes of nesting Night Herons Nycticorax nycticorax. Ardea.

DISCUSSION

Despite the clear relationship demonstrated between bird numbers and the area of ricefields the biggest population of herons is present at the end of the breeding season in June/July at which time birds stopped using the ricefields (Perrins; U.K.). Although many birds will leave the area very soon after fledging it is nevertheless clear that other natural wetland habitats are used at this time and may still be of great importance in ensuring successful breeding (Fasola; I). Hence protection of the remaining natural wetland habitat is essential (Hafner; F).

Herbicides are used widely in the Po valley, but use of pesticides is very local and only occurs when particular fields are very heavily infected by insect pests (Fasola). However if use of pesticides becomes widespread these could have a very important effect upon the prey populations, particularly amphibians (Evans; U.K.). During the course of the past ten years the use of pesticides such as gamma HCH and Parathion has become routine and the use by herons of ricefields in Camargue has greatly decreased (Hafner, F).

Although it appears likely that no immediate changes in agricultural practice will occur within the Po valley (Fasola) any such changes may have a dramatic effect upon the breeding populations of herons in Italy. Hence it is important that conservation agencies monitor agricultural practices in order that the detrimental effect of any changes in these may be identified and appropriate measures taken to reduce their impact (Kushlan; U.S.A.).

EUROPEAN PELICAN POPULATIONS AND THEIR CONSERVATION

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Summary

From a world total of seven species of pelicans two, the White pelican, Pelecanus onocrotalus L. and the Dalmatian pelican, Pelecanus crispus Bruch 1832, occur in Europe. The future survival there of both species is threatened. In addition that of P. crispus is endangered on a world level; not more than 1 380 breeding pairs remaining. In the European community, Greece is the only country where both species continue to breed. This paper reviews the current status of the breeding colonies there and considers their future conservation. An urgent need for long-term studies of the Greek populations, in order that conservation measures may be based upon a sound understanding of the ecological requirements of these birds, is identified.

1. INTRODUCTION

Among the seven species of pelicans known around the world (1) only two, Pelecanus onocrotalus L. and Pelecanus crispus Bruch 1832 are present in Europe.

The European-Asian population (Greece, Rumania, Turkey, USSR, Iran and India) of the White pelican, P. onocrotalus is estimated at 15 000 to 20 000 pairs, though the African population represents 75 000 pairs. The world population of P. crispus is between 530-1 380 breeding pairs at 19 colony sites from Eastern Europe to China (1).

These large birds were formerly widespread in Europe as is testified by numerous findings of subfossil bones in Great Britain, Denmark and Rumania (2), (3), (4). More significantly however Andrew (5) found several bones of young pelicans in Britain. These bones, from the pre-Roman Iron Age, were not ossified and hence indicate that a breeding population was present in western Europe at that time.

The decline of birds of this genus in this part of Europe is not documented, however in Central and Eastern Europe breeding colonies disappeared in the last century in Hungary, Yugoslavia, Rumania, Bulgaria and Greece (6), (7). This trend has continued in this century , and the last breeding colonies of White pelicans and Dalmatian pelicans are today restricted to Eastern Europe (Yugoslavia, Greece, Bulgaria and Rumania, see(8). Greece is the only country of EEC where breeding colonies of both species of pelicans are still located (9).

2. STATUS OF PELICANS IN GREECE

-Pelecanus onocrotalus

This species was not described as a breeding species in Greece until 1968 when breeding in Lake Mikra Prespa was found (10). Certainly this species bred there before 1968 (9). During the last 15 years an average of ca 100 pairs of White pelican bred at Mikra Prespa each year. In 1983, 59 breeding pairs were counted there (11).

-Pelecanus crispus

Of the nine breeding colonies then known in Greece, 6 disappeared at the end of the last century (12). In 1962, the Evros delta breeding colony was destroyed by fishermen and since this date no breeding has been observed there (12). Two breeding colonies at Lake Mikra Prespa and at the Gulf of Arta still persist.

Lake Mikra Prespa (40°45'N 21°06'E): These last 15 years, 40 to 120 breeding pairs have been censused (9). In 1983, 102 pairs were counted on four different islands located in reedbeds (11).

Gulf of Arta (39°00'N 21°00'E) : An average of ca 20 pairs bred in each of the last 15 years in this area. In 1983, 12 occupied nests were counted on a bare island located in a brackish lagoon (11).

3. PRESENT KNOWLEDGE ON THE NATURAL HISTORY OF THESE 2 SPECIES OF PELICANS

-Pelecanus onocrotalus

No scientific study has been carried out on White pelicans in Europe and Asia; the only available data for this species, are from studies carried out in Africa (13), (14), (15),(Crivelli & Mahé, unpublished data). At Mikra Prespa, White pelicans lay eggs (mean clutch size in 1983 at Mikra Prespa: 1,8 eggs) in April-May, and the young fledge in September. There is generally only one breeding colony at Mikra Prespa, in recent years located at Lake Viro, an inner lake in the northern reedbed.

Strictly piscivorous birds, the White pelicans do not feed in the Prespa area, apparently because of the absence of shallow waters on Mikra and Megali Prespa. Their feeding grounds remain unknown, however it is hypothesised that the feeding site(s) are located to the east of Edessa (80 km from Prespa) a landmark on their foraging trips.

The White pelicans are true migrants arriving at Lake Prespa at the beginning of April, and leaving this area in September-October. No White pelican winters in Greece. Their wintering grounds are not known for certain, but they may be located in Iraq (Tigris and Euphrates rivers marshes) and in Sudan (17).

The population dynamics, the life span, the age at sexual maturity and mortality rates of P. onocrotalus remain unknown.

-Pelecanus crispus

A summary of existing knowledge on the natural history of this species (18) showed that the detailed information on the biology of P. crispus is practically non-existent. In Mikra Prespa and Gulf of Arta Dalmatian pelicans lay eggs (mean clutch size: 1,7 eggs) mid-February to mid-March, and the young fledge end of June. In Mikra Prespa there are generally subcolonies in the southern and northern reedbeds. In Gulf of Arta the species is nesting on a bare island in a brackish lagoon.

The Dalmatian pelican fishes individually in deep waters on the Megali Prespa and Mikra Prespa in contrast to the communal fishing of the White pelicans. A peculiar fishing behaviour, in "distinct association" with Phalacrocorax carbo has been described on Mikra Prespa Lake (18).

The Dalmatian pelican is a wanderer, and winters mainly in Greece and Turkey (seven major wintering sites censused (17). Most of them are on sea coast, four of which are deltas.

As for White pelicans, practically nothing is known of the population dynamics of P. crispus (23).

4. THE PRINCIPAL CONSERVATION PROBLEMS

Both species of pelicans are threatened in Europe. More importantly P. crispus has been declared "vulnerable" by I.U.C.N. and I.C.B.P. (19), and it is a endangered species on the world level.

The decline of these birds is not recent and started with the Industrial Revolution and with the increasing pressure of human settlements. Extensive persecution and disturbance by man, which includes destruction of breeding colonies and shooting, together with the reclamation and cultivation of its specialized habitat are the major causes of the decline of these two species.

Nowadays, in Europe, the areas where pelicans still breed are among the most remote and wild regions which have retained the most diverse fauna. In Europe and elsewhere, some wetlands (e.g. Danube delta, Gulf of Arta) with a breeding pelican colony are presently threatened by human development inspite of the efforts of the International Conservation Agencies to preserve these areas.

There is no doubt that the disappearance of a pelican breeding colony now means the colony will not be replaced elsewhere because already all the suitable wetlands for these birds are occupied. All of the breeding colonies known today have existed for decades. The one exception; a P. crispus colony at Manyas Lake (Turkey) where artificial platforms have been built in willow trees to attract the birds to breed. Even more importantly, it is unlikely that birds from a destroyed colony would be able to breed elsewhere. First, there are probably no suitable breeding grounds which are not already occupied; and secondly, within existing breeding grounds it is probable that the islands are already fully occupied. In conclusion, all the pelican breeding colonies should be legally protected (20), and buffer zone should be created all around the breeding islands. As suitable breeding grounds may often be a limiting factor, a further step in the conservation of these species should be the building of artificial floating rafts to safeguard the breeding of these birds against flooding and mammalian predators. Such action would almost certainly improve the recruitment rate and the maintenance of the present colonies.

The other major factor necessary to ensure the survival of pelicans is the presence of an adequate food supply. Pelicans are dependent on the presence of sufficient fish to support both adult population and nestlings. Several striking examples (21), (22) (Crivelli & Mahé, unpublished data) have shown that the reproductive success drops when food supplies dwindle. In the future, with the increasing water pollution and the over-fishing by commercial fishing industry there is an important risk of depletion of the fish stocks on many feeding grounds of pelicans. In Greece it is essential in the near future to discover the feeding ground(s) of P. onocrotalus breeding at Mikra Prespa Lake, and to study physical and biotic features of these lakes or rivers in order to protect and manage them. A new conservation problem has arisen in the last five years in several countries (e.g. Israel, Rumania, Greece), where pelicans have begun foraging in aquaculture ponds. In such cases, the pelicans visiting these ponds are often shot. It is urgent to study quickly this problem and to quantify the real impact of pelicans in these ponds and to find practical solutions to prevent possible damage by these pelicans.

In summary, pelicans are facing serious conservation problems that should be resolved in the next twenty years, otherwise, there is a risk that these birds will disappear from the European sky and even, in the case of P. crispus, that the species become extinct.

A first practical measure is to begin long term studies on these two species to get the data that are necessary to define effective conservation and management policies. For various reasons, Greece is certainly the most suitable country where such long term study could be carried out.

Pelican breeding colonies should be effectively protected against disturbance by fishermen, bird-watchers and photographers and the birds themselves should be legally protected to prevent shooting, capture for commercial zoo and taxidermy enterprises.

The recovery of an endangered population of Brown pelicans, Pelecanus occidentalis, in the United-States in recent years has shown clearly that extensive well coordinated studies and a strong will to save these birds can successfully conserve the birds and their habitats.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

(1) CRIVELLI, A.J. & SCHREIBER, R.W. - Status of Pelecanidae. Biol. Conservation. In press.

(2) NEWTON, E.T. (1928) - Pelican in Yorkshire peat. Naturalist, London, 857: 167-168.

(3) HATTING, T. (1963) - On subfossil finds of Dalmatian pelican (Pelecanus crispus Bruch) from Denmark. Vidensk. Medd. Dansk naturh. Foren., 125: 337-351.

(4) KESSLER, E. (1978) - Nouvelles contributions concernant la présence du genre Pelecanus dans l'avifaune sousfossile de Roumanie. Nymphaea, 6: 181-182.

(5) ANDREWS, C.W. (1899) - On some remains of birds from the lake-dwelling of Glastonbury, Somersetshire. Ibis, Ser. 7: 351.

(6) REISER, O. (1905) - Ornis Balcanica I, II & III. Wien.

(7) AUMULLER, S. & KEVE, A. (1964) - Die einstige Verbreitung der Pelikane Pelecanus onocrotalus und crispus) im Karpaten und Wiener Becken. Wiss. Arb. Burgenland, 31: 5-32.

(8) CRAMP, S., SIMMONS, K.E.L., FERGUSON-LEES, I.J., GIMOUR, R., HOLLOM, P.A.D., HUDSON, R., NICHOLSON, E.M., OGILVY, M.A., OLNEY, P.J.S., VOOUS, K.H., & WATTEL, J. (1977) - Handbook of the birds of Europe, the Middle East and North Africa, 1. Ostrich to ducks. 721 pp., Oxford University Press.

(9) CRIVELLI, A.J. (1980) - The importance of Greece for the conservation of two species of Pelicans: Pelecanus onocrotalus and P. crispus Bruch 1832, Nature-Newsletter - Hellenic Society for Protection of Nature: 23-24, 36-39.

(10) BROSSELIN, M. & MOLINIER, A. (1968) - Visite au lac de Mikra Prespa (Grèce). Bureau MAR, duplicated report, 20 pp.

(11) CRIVELLI, A.J., BEASLEY, B.A. & ROSS, R.L. (1983) - Report on a trip to Yugoslavia and Greece (April-May 1983). Duplicated report, 8 pp. Tour du Valat, France.

(12) BAUER, W., HELVERSEN, Q., HODGE, M. & MARTENS, J. (1969) - Catalogue Faunae Graeciae, Pars Aves. Thessalonique.

(13) BROWN, L.H. & URBAN, E.K. (1969) - The breeding biology of the Great white pelican, Pelecanus onocrotalus roseus, at Lake Shala, Ethiopia. Ibis, 111: 199-237.

(14) GUILLET, A. & CROWE, T.M. (1981) - Seasonal variation in group size, and dispersion in a population of Great white pelicans. Gerfaut, 71: 185-194.

(15) GUILLET, A. & CROWE, T.M. (1983) - Temporal variation in breeding, foraging and bird sanctuary visitation by a Southern African population of Great white pelicans, Pelecanus onocrotalus. Biol. Conservation 26:

(16) CRIVELLI, A.J. - The waterbirds of Lake Mikra Prespa, North-western Greece. Nature-Newsletter - Hellenic Society for Protection of Nature. (in press).

(17) CRIVELLI, A.J. (1983) - Status, wintering, migration and conservation problems of Pelecanus onocrotalus and P. crispus in Europe. Proceedings IWRB Symposium on Conservation of Colonial Nesting Waterfowl.

(18) CRIVELLI, A.J. (1981) - The Dalmatian pelican, Pelecanus crispus Bruch 1832, a recently world endangered bird species. Biol. Conservation 20: 297-310.

(19) KING, W. (1981) - Endangered birds of the world. The ICBP Bird Red Data Book. Smithsonian Institution Press, Washington.

(20) TEMPLE LANG, J. (1982) - The European community directive on bird conservation. Biol. Conservation, 22: 11-25.

(21) SCHREIBER, R.W. (1979) - Reproductive success of the eastern Brown pelican, Pelecanus occidentalis. Contrib. Sci. Natur. Hist. Mus. Los Angeles county, 317: 1-43.

(22) ANDERSON, D.W., GRESS, F. & MAIS, K.F. (1982) - Brown Pelicans: influence of food supply on reproduction. Oikos, 39: 23-31.

(23) MICHEV, T. (1981) - The Dalmatian pelican (Pelecanus crispus Bruch) - Its numbers and population dynamics in the Srebarna Nature Reserve in southern Dobroudja. Proceedings Regional Symposium under Project 8 - MAB-UNESCO, 20-24 October 1980, Blagoevgrad, Bulgaria:

6. DISCUSSION

In one of the most important breeding areas of both P. onocrotalus and P. crispus in eastern Europe, the Danube delta, there are increasing pressures from a number of sources upon the bird populations. The future there is very uncertain and this highlights the needs to take immediate steps to study and conserve the populations in Greece.

American white pelicans breeding in the western USA have been shown to be contaminated by hydrocarbons. As the breeding areas are pollution free it is clear that these birds are contaminated in the wintering areas. Hence in these as in all migratory bird species attention must also be directed towards the wintering areas (Kushlan).

In the USA studies of the Brown pelican (Pelecanus occidentalis) have shown that there is a very clear positive relationship between the abundance of the food supply and breeding population size and nesting success. This indicates that not only pelicans but also other fish-eating birds such as many heron species are very good indicator species which may be used to monitor environmental quality. For this reason alone these species merit a lot of attention (Kushlan).

CREATION OF A BREEDING SITE FOR TREE-NESTING HERONS IN THE CAMARGUE, SOUTHERN FRANCE

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Summary

Several traditional breeding sites of tree-nesting herons (Egretta garzetta, Bubulcus ibis, Ardeola ralloides, Nycticorax nycticorax) have been deserted in the Camargue during the last 20 years. Most desertions were a result of human disturbance. New colonies established recently have contained fewer breeding pairs and are generally in less favourable habitats. A wood was therefore planted in an area with good feeding habitat, in order to provide another site possessing the requirements of tree-nesting herons. In 1977, seven years after the initial plantation the wood had reached the structure desired and attempts were made to attract Ardeidae, using living decoys, model egrets, artificial nests and nesting material. Captive birds which started nestbuilding and reproduced successfully in an aviary next to the wood attracted wild egrets and Night herons. In order to minimise disturbance, the captive birds were fed every second day only and after dark. Wild Night herons started nestbuilding in 1981 and were followed 12 days later by Little egrets and Cattle egrets. About 900 young were raised successfully in 225 nests of Little egrets, 35 nests of Cattle egrets and 56 nests of Night herons. A mixed colony established again in 1982 and 1983.

1. INTRODUCTION

In the Camargue Little egrets (Egretta garzetta), Cattle egrets (Bubulcus ibis, Squacco herons (Ardeola ralloides) and Night herons (Nycticorax nycticorax) nest together in mixed heronries. Four to six colonies are formed each year, one of them being generally established in a pine wood and the others in deciduous woods. Since the discovery in 1930 of mixed colonies of tree-nesting herons in this area (1) at least 11 breeding sites have been abandoned. Most cases of colony desertion are a result of human disturbance. Recent examples are one colony destroyed by the construction of the oil refineries of Fos-sur-Mer, and another colony destroyed by the owner of the wood because he was disturbed by the noise and smell. Nevertheless, in spite of the frequency of colony desertion, the number and distribution of colonies occupied each year has remained rather constant, because another colony is generally started in a similar habitat close to the old one when a site has been abandoned. However, new colonies established recently have contained fewer breeding pairs and quite frequently only one species. They are often in apparently less favourable habitats e.g.,woods of restricted size near busy roads and which are therefore exposed to both bad weather, strong wind in particular, and human disturbance. This suggests that there is a lack of suitable nesting sites. Furthermore because all sites are at present on private property there is no guarantee that they will remain. Therefore a wood was planted on 4 ha of former farmland on the Tour du Valat estate, which belongs to the Fondation Sansouire, a nature conservation organisation, in order to provide another breeding site possessing the requirements of the four species of tree-nesting herons. In a recent paper (2) we described the management of this wood from 1971 to 1978, the methods used to attract breeding herons and the successful outcome of the project.

2. PLANTING AND MAINTENANCE OF THE PLANTATION

In 1970 approximately 5 000 shoots, mainly ash (Fraxinus angustifolia) but also white poplar (Populus alba), elm (Ulmus minor) and willows (Salix spp.) were taken from several natural woods and kept for one year in a nursery. Meanwhile the area intended as the future colony site was prepared using as a guide information gathered from the other Camargue colonies. Protection from predation (for instance by surrounding water) and from wind were the principal criteria for site selection (3). The area was transformed into an artificial island 80 by 40 meters in size, oriented with its long axis into the prevailing winds and surrounded by an irrigable moat. The following autumn (1971) the shoots were densely planted on the island. Again the choice of trees, their distribution and density were based on former studies of the habitat structure in the colonies (4). The banks of the artificial lake as well as the surrounding fields were planted with the shoots which were left over and with Populus nigra italiae to give protection against the wind.

In the Camargue young trees are damaged by rabbits (Oryctolagus cuniculus) and rats (Ratus norvegicus). To prevent this wire netting was placed around every shoot and the wood patrolled regularly to check for damage. During the following years about 20 percent of the shoots planted died and in 1976, large gaps were filled by replanting some 1 000 two years old "trees" (ash and white poplars). Ploughing around each tree, manually where necessary, took place until 1975, fertilizing until 1976, and monthly irrigation was continued during the dry season until 1978. During this crucial period for the development of the wood (1972 to 1978), the few trees (mainly willows) badly infected with Cossus cossus L., a well known insect pest, were removed and burned.

3. METHODS USED FOR ATTRACTING THE HERONS

In 1977 the wooded island seemed to have reached the structure desired and it was decided to experiment with techniques for attracting Ardeidae. In doing this we were encouraged by the success of several previous attempts by naturalists who were familiar with the behaviour of colonially nesting herons and relied on their extreme sociability at the nest site. The best example is certainly the famous "Bird City" created in the Mississipi swamps at the beginning of this century by Edward McIlhenni (5). In this area a few decoys kept in an aviary were the origin of a small colony (5 nests) of Snowy egrets (Egretta thula) which built up within a few years to number thousands of Snowy egrets and other herons. In Germany success was achieved in establishing an artificial colony of Grey herons by constructing seven artificial nests and keeping three decoy birds nearby (6). In the Camargue the following techniques were used:

3.1. Live decoys

In February 1978 an aviary (10 by 12 metres) was built near the wooded island. Two dead trees holding several artificial nests each were put into this aviary and 10 birds lent by a zoo (Little egrets, Cattle egrets and Night herons) were released into the aviary to which were later added 5 Little egrets taken from nests elsewhere in the Camargue.

3.2. Model egrets

It has been shown that heron models attract free-flying birds (7). Furthermore a group of five models was more attractive than a single model (7) and it has already been suggested (8) that white plumage in Ciconiiformes is more effective than dark in bringing about aggregations in marshes. On the basis of this information 50 white polystyrene egrets were placed in the trees and in the artificial lake surrounding the island.

3.3. Artificial nests and nesting material

The presence of large quantities of dead wood (twigs) is a decisive factor in the establishment of a colony of tree-nesting herons (3), (9), (10). Since the wood was not sufficiently mature to provide nesting material, twigs were gathered in other places, broken into convenient lengths and deposited in several heaps on the island. In addition 65 nest-platforms were put in the highest trees on the island in the hope that they would serve as additional attractants.

4. RESULTS

4.1. Reproduction of the captive birds

In 1978 one pair of captive egrets built a nest in May and three eggs were laid and incubated until hatching. Two days after the first chick hatched however, the total nest contents were ejected either by the parents or by the other birds. Nevertheless during the following two years some of the birds bred successfully and seven Little egrets and six Night herons were fledged. At the age of about 80 days these were released with metal and colour rings.

4.2. Establishment of a roost

Wild birds (Little egrets, Cattle egrets and Night herons) started visiting the wood immediately after the decoys were released into the aviary. In November 1978, seven months after the beginning of the experiments, Little egrets and Cattle egrets started roosting, first on the roof of the aviary, and little by little on the wooded island. The roost was occupied throughout the two following years, under all weather conditions, indicating that at least the birds' requirements for roosting had been satisfied. In 1979 and 1980, although the roost was used throughout the winter, it was almost completely deserted in spring when the birds moved to breed at a large heronry of about 300 nests 4 km apart. Only a few non breeding birds continued to roost at the plantation. Later when most of the young egrets were fledged, the roost again became very important. In September 1980 the six existing roosts in the Camargue held 1 752 Little egrets and 1 872 Cattle egrets. 413 Little egrets were counted at this time in the artificially created roost (23 percent of the total Camargue population) and 422 Cattle egrets (22,5 percent). Numbers dropped drastically from October to December as cold weather commenced and the postnuptial departure began.

4.3. Establishment of a breeding colony

For the first time in 1980, two years after the beginning of the experiments, 3 pairs of wild Little egrets built nests (on the roof of the aviary !) and 9 young were raised successfully. Of these breeding birds, five had been taken in 1978 at the age of about 10 days from wild nests, then raised in the aviary and finally released (bearing colour rings) in spring 1979. However the sixth bird was an entirely wild one. These egrets were obviously strongly attracted by the captive incubating and displaying birds.

In 1981, one pair of the captive Little egrets had already started incubating on 20th of March (in the wild, clutches of Camargue Little egrets have to date never been recorded earlier than April). On March 24th 10 adult Night herons were seen on the roof of the aviary. The Night heron is, except when rearing young, a nocturnal forager (11) and it was therefore decided to feed the captive birds only every second day and after dark, when the Night herons which visited regularly the wooded island had left for the feeding areas. Undisturbed, the Night herons finally started nestbuilding and the first eggs were laid at the end of March. The nesting of Night herons was a great encouragement as this species is always the first to establish (generally by the end of March) in the Camargue heronries where it plays an important role in attracting other species (3). Numbers of roosting egrets (25 Little egrets and 35 Cattle egrets by end of March) increased daily at the beginning of April. 200 Little egrets and 50 Cattle egrets were counted on 12th April and the following day the birds started nestbuilding. During the breeding season this artificially created colony resisted well the frequent strong winds and thunderstorms which occurred and about 900 young were raised successfully in 225 nests of Little egrets, 35 nests of Cattle egrets and 56 nests of Night herons. In 1982 and 1983 a fine colony of the same species composition and similar numbers was again established on the island and it is reasonable to envisage this breeding site being active for many more years.

5. CONCLUSION

This management project has demonstrated that creation of breeding habitat for tree-nesting herons and its subsequent protection is a readily achievable goal. We have seen that in this area the distribution of heronries seems to follow certain principles as after colony desertion, another site is generally occupied in a similar habitat close to the old nesting place. A minimum distance of seven km between two colonies has been documented (distribution analysed since 1930, (3)). Thus, as would be predicted from this, the traditional heronry situated at four km from the artificial wood was abandoned in 1981. Thus we in effect moved a heronry rather than created a new one. Nevertheless the original aim of strengthening the security of these species in the Camargue was achieved, as the old colony site was one of the most vulnerable in the area. This part of the breeding population now benefits from security and tranquillity, yet remains in the same traditional sector located in an important feeding area. It seems clear to us that this process of attracting breeding herons from one area to another could be copied in other situations in order to increase the security of the heron population concerned or to reduce disturbance to human activity near the original colony site (see e.g. (6), (12)).

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7. BIBLIOGRAPHY

(1) GALET, L. (1931) - Notes sur la nidification en Camargue de l'Aigrette garzette, du Bihoreau et du Crabier, Egretta g. garzetta L., Nycticorax n. nycticorax L. et Ardeola r. ralloides Scop. Oiseaux R.F.O. 1: 54-57.

(2) HAFNER, H. (in press) - Creation of a breeding site for tree-nesting herons in the Camargue, Southern France. Manual of active Wetland and Waterfowl Management; Editor D.A. Scott, IWRB Slimbridge.

(3) HAFNER, H. (1977) - Contribution à l'étude écologique de quatre espèces de hérons (Egretta g. garzetta L., Ardeola r. ralloides Scop., Ardeola i. ibis L., Nycticorax n. nycticorax L.) pendant leur nidification en Camargue. Unpublished thesis. Toulouse.

(4) HAFNER, H. (1980) - Etude écologique des colonies de hérons arboricoles (Egretta g. garzetta L., Ardeola r. ralloides Scop., Ardeola i.ibis L., Nycticorax n. nycticorax L.) en Camargue. Bonn. Zool. Beitr. 31: 249-287.

(5) PETERSON, R.T. & FISHER, J. (1955) - Wild America. The Riverside Press Cambridge, Massachusetts. 433 pp.

(6) FINKENSTAEDT, Ch. & HECKENROTH, H. (1974) - Eine künstliche Koloniegründung beim Graureiher (Ardea cinerea). Vogelwelt 95: 227-231.

(7) KREBS, J.R. (1974) - Colonial nesting and social feeding as strategies for exploiting food resources in the Great Blue Heron (Ardea herodias). Behaviour 51: 99-134.

(8) KUSHLAN, J.A. (1977) - The significance of plumage colour in the formation of feeding aggregations of Ciconiiformes. Ibis 119:361-364.

(9) VALVERDE, J.A. (1955) - Essai sur l'Aigrette garzette (Egretta g. garzetta) en France. Alauda 23: 147-171 and 254-279.

(10) FESTETICS, A. (1959) - Oekologische Untersuchungen an den Brutvögeln der Saser. Vogelwelt 80: 1-21.

(11) WATMOUGH, B.R. (1978) - Observations on nocturnal feeding by night herons (Nycticorax nycticorax). Ibis 120: 356-358.

(12) DUSI, J.L. (1979) - Heron colony effects on man. Proc. Colonial Waterbird Group, 1979. Vol.3: 143-144.

8. DISCUSSION

Although hard management such as creation of breeding woods is often difficult to accept aesthetically (Meltofte; Dk) and must be used with caution in fragile ecosystems (Tamisier; F) such management may in future be essential in many areas (Dugan; U.K./F). For example in the Po valley there may, as a result of habitat destruction, soon be a shortage of available nesting sites (Fasola). The aim of the study in Camargue was to discover whether such planting could be successful and what were the best methods to use (Dugan). In the Sahelian zone of West Africa many populations of herons are threatened because the local human population has cut large numbers of trees for use as firewood. Hence in many regions the feeding areas remain but not the nesting sites and a programme of tree planting in specific sites would now be beneficial to heron populations in this region (Roux; F).

SESSION 2

HABITAT REQUIREMENTS DURING MOULT, MIGRATION AND IN THE NON-BREEDING AREAS

PURPLE HERON SURVIVAL AND DROUGHT IN TROPICAL WEST-AFRICA

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Summary

Survival rates for the first-year birds, the after-first-year birds and a reporting rate were estimated from ringing and recovery data of Purple Herons ringed as nestlings in The Netherlands in the period 1960-1977. These estimates were obtained by analysing the recovery categories shot and found separately.
The sum of the annual maximum monthly discharges of the rivers Niger and Senegal were used as a measure of drought in the wintering area during the birds stay there. The survival and reporting rates obtained from the shot and found recoveries were related to this measure of the drought.
It was found that both the survival rate of the after-first-year birds and the reporting rate obtained from the shot recoveries are low under dry and high under wet conditions.
The survival rates and reporting rate obtained from the found recoveries show no relationship with the drought conditions in tropical Africa. This can be explained by the poor representation of such recoveries in tropical Africa.
It could be shown with the help of a simulation model of breeding bird numbers that the variation in these numbers is caused by a variation in survival of the after-first-year birds due to the severity of the drought in the wintering area.

1. INTRODUCTION

The Purple Heron (*Ardea purpurea* L.) is a long-distance migrant. Moreau (1) mentions the semi-arid zone south of the Sahara as the wintering area of the West Palearctic birds. Recovery data from tropical Africa suggests that the Dutch Purple Herons winter even further south, i.e., mainly south of 10°N (2, 3).

In the semi-arid zone south of the Sahara (the Sahel area) the amount of rainfall is very variable. Den Held (2) found a negative correlation between the size of the Dutch Purple Heron colonies and drought in this area. The drought was measured by the sum of the maximum monthly discharges of the preceding year of the Niger and Senegal rivers. This correlation suggests that survival rates of the Purple Heron depend on the severity of the drought in this area. To check this hypothesis, in the present paper survival rates were estimated from ringing and recovery data and related to the discharge figures used by Den Held (l.c.) as mentioned above. To check whether these survival rates explain the variation in the numbers of breeding birds, the latter were simulated with a population model using the estimates of the survival rates.

2. MATERIAL

The recoveries of nestlings ringed between 1960 and 1977 and recovered dead before May 1st 1978 were used and divided into two categories: "shot" (killed intentionally) and "found" (killed unintentionally). The figures published by the Department Vogeltrekstation of the Institute for Ecological Research, of the number of birds ringed annually were used in the analysis. No initial data was chosen for the first year, and the initial data for second and subsequent years of life was 1st May.

The analysis covers 8.489 nestlings ringed, 163 of which were recovered as found and 168 as shot.

3. METHODS

The methods used for the analysis of survival rates are described in detail elsewhere (4), and will only be briefly outlined here.

Age-specific survival rates were obtained from the shot and found birds separately, with Cormack's (5) method, which also yields a reporting rate. To relate the discharges of the Niger and Senegal to the reporting rate and the survival rates, a method as proposed by North (6) is used. The discharge figures are taken from Den Held (2).

4. RESULTS

Before the results of the survival analysis are considered, some remarks must be made about the North-South distribution of the recoveries in the course of the year.

In the first place, a remarkably high proportion of the winter recoveries (December, January, February) come from Europe (found 100%; shot 70%), which shows that not all of the birds winter in Africa. Secondly, among the shot birds significantly ($P < 0.01$) more recoveries are made south of the Sahara than among the found group, which suggests that the shot birds represent the part of the population that migrates to this area better than the found birds do. Thirdly, among the recoveries of shot birds there is a remarkable difference between the first-year and after-first-year birds as to the time of recovery. Most of the first-year birds were recovered before December 1st, whereas a much smaller proportion of the after-first-years were recovered in that period of the year. This suggests that a considerable part of the first-year mortality occurs before December, i.e., before the birds arrive in the wintering area, which is not the case for the after-first-year birds.

When Cormack's (5) method is used to estimate age-specific survival rates from the recoveries of shot birds, it is sufficient to distinguish a first-year survival rate, an after-first-year survival rate, and a reporting rate. Consideration of the river discharges in relation to the first-year survival rate, the after-first-year survival rate, and the reporting rate, showed no significant relationship between these discharges and the first-year survival rate, but a significant relation between the discharges and the after-first-year survival rate and the reporting rate. When the discharges are large, the reporting rate and the after-first-year survival rate are large.

When Cormack's (l.c.) model is used to estimate age-specific survival rates from the recoveries of found birds, it again suffices to distinguish a first-year survival rate, an after-first-year survival rate, and a reporting rate. No significant relationship were found between the river discharges and these rates.

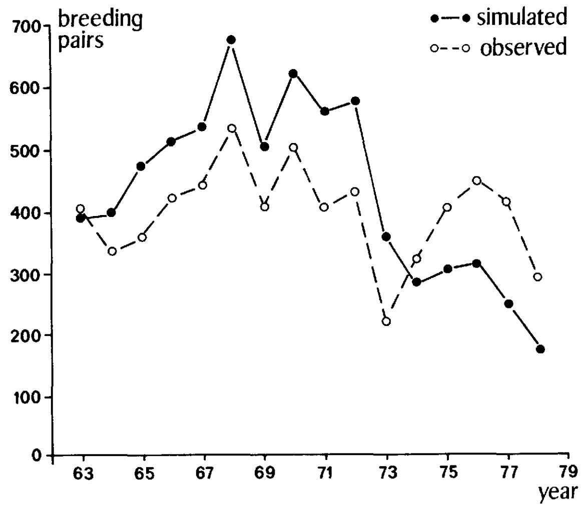

Fig. 1. Simulation of the combined number of breeding pairs in the colonies Nieuwkoop and Maarssen.

The survival rates obtained from the recoveries of shot birds are considered to represent the annual survival of the Dutch population better than those obtained from the found recoveries (see section 5). Therefore, only these estimates will be considered in this section. The relation between survival rates and colony size can be made clear using a simple population model described in detail by Cavé (4). This model can be used to calculate the number of breeding pairs expected in a given season. For this calculation the number of breeding pairs in the two preceding seasons and the survival rate of the after-first-year birds of the preceding year as expected from the river discharges are used. The survival rate of the first-year birds, as well as the reproduction rate are thought to be constants.

The number of breeding pairs of two adjacent colonies (Nieuwkoop and Maarssen in the Prov. Zuid Holland) have been recorded for many years. In 1961 and 1962 these colonies had, respectively 276 and 356 breeding pairs. From these two values of the colony size a value for 1963 can be calculated. From the observed value of 1962 and the calculated one of 1963 a value for 1964 can be obtained. Using the calculated values of 1963 and 1964 a value for 1965 can be found, and so on. These simulated numbers of breeding pairs for the years 1963—1978 are given in Fig. 1, together with the numbers observed. The resemblance between simulated and observed is striking ($r = 0.64$; $P = 0.007$), which shows that numbers of breeding birds are well explained by the model.

5. DISCUSSION

Den Held (2) found that the size of the Dutch Purple Heron colonies is positively correlated with the discharges in the preceding year of the Niger and Senegal rivers, which serve as a measure of the drought conditions in the wintering area. This drought is thought to affect the survival of the breeding birds in the wintering area. The relationship found between the river discharges and the survival rate, calculated from the recoveries of shot birds, is in keeping with this view. No relationship was found between the river discharges and the survival rates of the after-first-year birds calculated from the recovery category found. This is because in tropical Africa the recoveries of found birds are poorly represented.

Den Held's (2) finding that the Dutch Purple Heron colonies fluctuate in relation to the severity of the drought in tropical Africa, implies that a substantial part of the breeding birds spend the winter in that area. Nevertheless, it has been found that a large proportion of the winter recoveries come from Europe and northern Africa. This can be explained by assuming that a dead bird has a much greater chance of being recovered in Europe or northern Africa than in tropical Africa. When in a given year mortality is high in tropical Africa, a small portion of the total mortality of that year occurs in Europe, and when mortality is low in tropical Africa a larger portion of the annual mortality occurs in Europe. Consequently, a low reporting rate is to be expected in years with high mortality in tropical Africa, and a high one in years with a low mortality in tropical Africa. Mortality is high in Africa south of the Sahara when the discharges of the Senegal and Niger are low, and visa versa. Consequently, a low reporting rate for the year as a whole is to be expected when the discharges are small and a high one when the discharges are large. This is exactly what has been found with the recoveries in the category shot. It is, therefore, clear that the North-South distribution of the winter recoveries overestimates the numbers wintering in Europe. This is especially true for the recovery category found since recoveries of this kind are practically absent from tropical Africa. This implies that the survival estimates obtained from the shot category represent the yearly variation in survival due to wintering conditions better than those obtained from the found category.

The survival rate of the first-year birds calculated from the recoveries of shot birds is not significantly related to the river discharges. This is an unexpected finding, because the survival rate of the after-first-year birds is related to these discharges and both first-year and after-first-year birds winter in tropical Africa. However, the first-year birds were mainly recovered before December 1st, if the summer, autumn and winter recoveries are included, which is not the case for the after-first-year birds. This suggests that a larger portion of the mortality of the first-year birds occurs before December and before their arrival in the wintering area, which would explain why the relationship between the survival rate of the first-year birds and the river discharges is weaker than the relationship between the survival rate of the after-first-year birds and these discharges. However, a similar difference in the numbers recovered (first-year/after-first-year) is not present in the found category.

It has been argued above that the survival estimates obtained from the shot category can be accepted and those obtained from the found category have to be rejected. Using the survival estimates of the shot category, the numbers of breeding pairs of the two best known colonies in The Netherlands could be well simulated (Fig. 1). However, both the number of breeding pairs in these two colonies (2) and the survival rate of the after-first-year birds depend on the river discharges of the previous year. Consequently, the survival rate of the after-first-year birds and the number of breeding pairs are correlated ($r = 0.62$; $0.01 > P > 0.001$), which leads to the correlation of observed and simulated numbers. It is not correct, however, to conclude from this that the simulation is only a restatement of the correlation between breeding bird numbers and river discharges. The simulation model constitutes a series of numbers of breeding pairs depending by means of reproduction and survival on the previous ones. Such a chain of causes and effects is thought to underly the dynamics of a population. Therefore, it is concluded from the simulation model that the variation in breeding bird numbers is caused by a variation in the survival of the afterfirst-year birds, which in turn depends on drought conditions in the wintering area. The high correlation between observed and simulated figures showed that this explanation is satisfactory.

6. REFERENCES

(1) MOREAU, R.E. (1972) - The Palearctic-African bird migration systems. Ac. Press. London.

(2) HELD, J.J. den.(1981) - Population changes of the Purple Heron in relation to drought in the wintering area. Ardea 69: 185-191.

(3) KOOY, H. van der. (1976) - De trekwegen en overwinteringsgebieden van vogel 400 (Purperreiger). Wageningen. Landbouwhogeschool, afd. Natuurbeheer, Rapport 336.

(4) CAVE, A.J. (1983) - Purple Heron survival and drought in tropical West-Africa. Ardea 71: 217-224.

(5) CORMACK, R.M. (1970) - In: R.A. Fordham 1970. Mortality and population change of Dominican Gulls in Wellington, New Zealand. J. Anim. Ecol. 39: 13-27.

(6) NORTH, P.M. (1979) - Relating Grey Heron survival rates to winter weather conditions. Bird Study 26: 23-28.

THE CONSERVATION OF HERONS DURING MIGRATION AND IN THE WINTERING AREAS : A REVIEW OF PRESENT UNDERSTANDING AND REQUIREMENTS FOR FUTURE RESEARCH

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Summary

Four categories of data are identified as necessary for the informed conservation of herons along their migration routes and in their wintering areas. The information currently available within each of these categories is reviewed. Ringing evidence is examined to reveal the course of the autumn and spring migration and the location of the principal wintering areas. Similarly recoveries in winter and existing census data are together used to show that in excess of 95% of Little egrets and Night, Purple and Squacco herons spend the mid-winter months in tropical West Africa. The absence of a detailed understanding of the ecological requirements of these birds during migration and in the wintering areas is highlighted and it is urged that steps be taken to achieve such an understanding. It is argued that future conservation of herons during the non-breeding season will be dependent for their success upon the existence of such a sound foundation.

1. INTRODUCTION

Within the wetland regions of western Europe, one of the great natural spectacles during the spring and summer months is provided by the large populations of herons which breed there each year. However as for most bird groups dependent upon wetland habitats the future of these populations is vulnerable. To date the emphasis of efforts to protect this future has been directed towards conservation of breeding sites, or management of feeding habitats around the breeding colonies. However while current knowledge of these subjects, particularly the latter, remains very sparse and much further work is needed, a third problem, the protection of herons during migration and on their wintering grounds, has so far received little consideration. It is the aim of this paper to highlight the need to rectify this deficiency.

In order that a future programme for the conservation of the wintering grounds and migration routes used by European breeding herons may be soundly based it is necessary to obtain the answers to four main questions:
-i) What regions do the birds use (a) during migration (b)in winter ?
-ii) Which of these are most important (a) in terms of total numbers of birds using the areas (b) in terms of recruitment to the breeding population ?
-iii) Within these areas what are the most important habitats used ?
-iv) What factors limit the use of these habitats and areas by these birds and their survival ?
Below I review current ability to answer these questions and suggest what future approaches may be most valuable in filling gaps in our knowledge.

2. WHAT REGIONS DO THE BIRDS USE ?

During the course of the past 50 years large numbers of herons have been ringed as nestlings in the Camargue (Table I). The subsequent reco-

Table I : Numbers of nestlings of four species of heron ringed in Camargue 1930-1982.

Egretta garzetta	Nycticorax nycticorax	Ardea purpurea	Ardeola ralloides
3 514	1 514	4 709	286

veries (Table IIa)indicates that many Little egrets, mainly juveniles, leave the Camargue in August, soon after the end of the breeding season, and move to the neighbouring coast of the Languedoc. This movement is followed by migration further south to Spain and North Africa where the first birds are recorded in September, and subsequently to tropical West Africa, the location of 2 (13%) of the winter recoveries (Fig. 1). In contrast to these migratory individuals the recoveries also show that some birds, both adults and juveniles, remain in the Camargue during the winter. During the period of spring passage in March and April all recoveries are from Italy, and all are of adult birds.

The pattern of recoveries for the Purple heron *Ardea purpurea* and Night heron *Nycticorax nycticorax* (Table IIb,c) is similar to that observed in the Little egret. However there are fewer recoveries in winter from the Mediterranean basin; only three recoveries for *A. purpurea* and two for *N. nycticorax*. In contrast there are four records of Purple heron from West Africa (Fig.2) at this time. However no Camargue ringed Night heron has yet been recovered south of the Sahara. This distribution of recoveries of Camargue Purple herons matches closely that reported for Purple herons ringed in the Netherlands (1, 2).

Finally, although only a small number of Squacco herons *Ardeola ralloides* have been ringed, the recoveries (Table IId)indicate, as for the other species, an autumn passage along the Languedoc coast and wintering in West Africa south of 12°N (Fig.3).

3. WHICH ARE THE MOST IMPORTANT AREAS IN TERMS OF NUMBERS AND RECRUITMENT?

Although the ringing data indicate what areas are used by the four heron species the recovery rate of ringed individuals cannot be used to quantify heron use of these areas. This recovery rate of dead birds is dependent upon species use of an area, and finding rate of dead birds. Hence because the latter, finding rate varies greatly between localities and habitats the recovery data do not provide a reliable quantitative index of bird use. However because of their often dispersed feeding distribution, their frequently limited visibility on the feeding grounds; in the case o the Little egret their frequent use of ditches and other sheltered feedin sites, in the case of Purple heron and Squacco heron their cryptic colour ation, and in the case of the Night heron the nocturnal feeding habit; it is extremely difficult to obtain accurate counts of the number of individuals of each of these four species on the feeding grounds. Consequently there are at present no good quantitative data documenting the use of the Mediterranean basin by herons outwith the breeding period. Thus it is not known how many birds use particular areas during the passage periods, or overwinter there. The one exception to this is the Camargue where Little egrets have been censused by counting birds arriving at nocturnal roosts (Fig.4). Thus although these data provide little information on habitat use they do provide an accurate assessment of the number of birds using the area. Nevertheless despite the limitations of existing census data it is possible to combine counts from a number of sources to obtain an indication of the number of herons which overwinter in the Mediterranean. The resulting totals (Table III) suggest that despite the small number of recoveries from West Africa the vast majority of adults and young of all species leave the Mediterranean basin and overwinter south of the Sahara.

Given the current limited understanding of the population dynamics of heron populations the importance of different areas for future population recruitment must be treated cautiously. Nevertheless the data presented in Table II indicate that although during autumn passage juveniles form a high proportion of birds recovered, very few have been recovered in the spring after ringing. These data suggest that a high proportion of juvenile birds do not return in their first year. Thus although further study is clearly essential in order to provide more precise data it is at present important to recognise that of those juveniles which migrate south many, possibly the majority,remain in West Africa for their first summer. Consequently the security of the areas used at that time, the end of the dry and beginning of the wet season, may be of crucial importance to recruitment to, and hence the long-term survival of, European heron populations.

4. WHAT ARE THE MOST IMPORTANT HABITATS USED ?

As described above the difficulties involved in reliably censusing herons on the feeding grounds have resulted in a very poor understanding of what habitats are of importance to the birds outwith the breeding period.At the present moment the Heron Specialist Group of the International Council for Bird Preservation & the International Waterfowl Research Bureau has placed particular emphasis on these problems. Firstly by seeking to identify what areas in the Mediterranean are of most importance to passage and wintering birds and hence merit more detailed study. Secondly by seeking to focus attention on the wintering areas south of the Sahara where no detailed studies of heron ecology have yet been carried out. In particular it is important that such studies should seek to identify what environmental changes may occur in future years, to understand the likely effect of these upon the bird populations, and to identify what management measures may be necessary in order to reduce the detrimental effect of such changes. Of the environmental changes which are most likely to occur the most obvious is a reduction in the water flow to natural wetland areas following river barrage construction. However there are others which are less obvious. For example in some parts of West Africa ricefields provide artificial wetlands of importance to herons. The precise reasons for the frequently intensive use of this habitat are at present unknown.However it is clear that changes in agricultural practice, if they affect the prey populations present in these ricefields, may have a marked effect upon the value of these **to** populations of wetland birds.

5. WHAT FACTORS LIMIT THE USE OF PARTICULAR AREAS AND HABITATS DURING THE NON BREEDING SEASON, AND THE SUCCESS AND SURVIVAL OF HERONS THERE ?

Within the Mediterranean wintering areas severe cold weather is the environmental factor which is most likely to exercise a limiting effect upon overwinter survival. However although during the winter of 1979-80 many Cattle egrets *Bubulcus ibis* were found dead during severe weather in Camargue (13) and in the following summer the population of breeding birds showed a marked decrease from 1979, no Little egrets were found dead during the same period, nor are there any historical records of severe winter mortality of Little egrets in the region. Thus although it is clear that low temperatures will result in elevated energy demands of wintering birds, present evidence suggests that mortality of Little egrets during periods of severe cold weather is low.

In west Africa the most important environmental factor likely to affect overwinter survival is drought. Den Held (2) has shown that the size of a number of dutch colonies of Purple heron is positively correlated with rainfall in the Sahel region. Similarly Cavé (1) has shown that mortality there is greater in dry years. However despite the pioneering value of this work it is clear that there is an urgent need to understand the reasons for the correlation observed.

6. CONCLUSION

Despite the limited information available the data presented here highlight three crucial points: (i) The breeding population of herons in Camargue is heavily dependent during migration upon wetlands in Spain, Italy and North Africa. This is also true for the population of Purple herons breeding in the Netherlands. (ii) The majority of these birds winter in sub-saharan Africa, many south of 10°N. (iii) An understanding of factors affecting overwinter survival and recruitment to the breeding population, including of what habitats are of most importance to these herons on migration and in the wintering areas, is not currently available.

It is to be hoped that increasing awareness of the dependence of the long-term survival of European heron populations, upon secure migration resting sites and wintering areas, will lead to an increase in study of these areas. Only in this way will the required understanding of appropriate conservation measures be obtained.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

(1) CAVE, A.J. (1983) - Purple heron survival and drought in Tropical West Africa. *Ardea* 71: 217-224.

(2) DEN HELD, J.J. (1981) - Population changes of the Purple heron in relation to drought in the wintering area. *Ardea* 69: 185-191.

(3) HAFNER, H. (1982) - Counts of overwintering Little egrets and Cattle egrets in the Camargue. pp. 79-80, Annual Report, Station Biologique de la Tour du Valat (1982).

(4) CHELINI, A., BOLDREGINI, P. & HAFNER, H. (1976) - Dénombrement aérien d'Anatidés et de Foulques dans la lagune de Venise et dans la partie nord du delta du Pô. Report to IWRB, 5 pp.

(5) FASOLA, M., BARBIERI, F., FRIGONI, C. & BOGLIANI, G. (1981) - Le Garzaie in Italia, 1981. *Avocetta* 5: 107-131.

(6) HAFNER, H. (1982) - Annual census of tree-nesting herons. p. 73 in Annual Report, Station Biologique de la Tour du Valat (1982).

(7) ENA, V. & PURROY, F.J. - Censos invernales de aves acuaticas en España. Enero 1978, 79 y 80. ICONA, Madrid, 63 pp.

(8) FERNANDEZ CRUZ, M. (1975) - Revision de las actuales colonias de Ardeidas de España. Ardeola 21: 65-126.

(9) RUFINO, R. (1982) - Portuguese wetlands of International Importance for Waterfowl. Report to IWRB, 11 pp.

(10)JOHNSON, A.R. & BIBER, O. (1974) - Dénombrements de la sauvagine hivernant le long de la côte atlantique du Maroc en janvier 1974. Report IWRB, 14 pp.

(11)JOHNSON, A.R., JONG, A. de & DIERMEN, J. van (1975) - Dénombrement de la sauvagine en Algérie en janvier 1975. Report IWRB, 21 pp.

(12)GOLDSCHMIDT, B. von & HAFNER, H. (1973) - Dénombrements de la sauvagine en Tunisie et dans le Nord-est de l'Algérie. Report IWRB, 27 pp.

(13)BREDIN, D. (1983) - Contribution à l'étude écologique d'Ardeola ibis(L) héron gardeboeufs de Camargue. Thèse de Troisième Cycle, Univ. Paul Sabatier, Toulouse. 317 pp.

Table IIa: Recoveries of Little Egrets *Egretta garzetta* ringed as nestlings in Camargue, southern France.

Month of recovery		J		A		S		O		N		D		J		F		M		A		M		J	
Adult/juvenile		j	a	J	a	J	a	J	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a
FRANCE																									
Camargue	s	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Languedoc	s	-	-	2	-	2	-	-	-	-	2	..	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	5	1	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPAIN	s	-	-	-	-	-	1	-	-	1	1	2	2	1	1	-	1	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ITALY	s	-	-	1	-	-	-	1	-	-	1	1	-	-	-	-	-	-	2	-	2	-	1	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
	?	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
NORTH AFRICA	s	-	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WEST AFRICA	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-

Means of recovery : s = shot or captured ; f = found dead ; ? = unknown.

Table IIb:Recoveries of Purple Herons <u>Ardea purpurea</u> ringed as nestlings in Camargue, southern France.

Month of recovery		J		A		S		O		N		D		J		F		M		A		M		J	
Adult/juvenile		j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a
FRANCE																									
Camargue	s	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	f	1	-	4	1	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	2
	?	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Languedoc	s	-	-	4	1	1	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	f	1	-	4	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SPAIN	s	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
	f	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ITALY	s	1	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	1	3	-	5	-	1	-	-
	f	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2	-	1
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NORTH AFRICA	s	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-
	f	-	-	-	-	3	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WEST AFRICA	s	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	-	1	-	-	1	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Means of recovery : s = shot or captured ; f = found dead ; ? = unknown.

Table IIc:Recoveries of Night Herons <u>Nycticorax nycticorax</u> ringed as nestlings in Camargue, Southern France.

Month of recovery		J		A		S		O		N		D		J		F		M		A		M		J	
Adult/juvenile		j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a
FRANCE Camargue	s	-	-	1	-	-	-	1	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Languedoc	s	1	-	4	-	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	?	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
SPAIN	s	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ITALY	s	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NORTH AFRICA	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WEST AFRICA	s	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Means of recovery : s = shot or captured ; f = found dead ; ? = unknown.

Table IId:Recoveries of Squacco Herons <u>Ardeola ralloides</u> ringed as nestlings in Camargue, southern France.

Month of recovery		J		A		S		O		N		D		J		F		M		A		M		J	
Adult/juvenile		J	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a	j	a
FRANCE																									
Camargue	s	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	f	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Languedoc	s	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	f	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
SPAIN	s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
ITALY	s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
NORTH AFRICA	s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
WEST AFRICA	s	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–
	f	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Means of recovery : s = shot or captured ; f = found dead ; ? = unknown

Table III: Estimates[1] of breeding and wintering population size of four species of heron in seven countries of the western Mediterranean.

Country	Sources[2]	*Egretta garzetta*		*Nycticorax nycticorax*		*Ardea purpurea*		*Ardeola ralloides*	
		n° birds January	n° breeding pairs	n° birds January	n° breeding pairs	n° birds January	n° breeding pairs	n° birds January	n° breeding pairs
Italy	4 ;5	116(1976)[3]	6 650(1981)	0	17 350	0	480+	0	270+
France (Camargue only)	3 ;6	467(1974-1983)	1 547(1968-1982)	0	576	0	1 108	0	77
Spain	7 ;8	359(1978-1979)	4 224(1964-1974)	0	2 122	0	44+	0	244
Portugal	9	?	5 000(?)	0	240	0	95+	0	10+
Morocco	10	246(1974)	?	0	?	0	?	0	?
Algeria	11	164(1975)	?	0	?	0	?	0	?
Tunisia	12	70(1973)	?	0	?	0	?	0	?
Total winter population (x)		1 306		0		0		0	
Total autumn population (y)[4]		69 684		81 152		6 908		2 404	
% of autumn population (x/y) which overwinters		1.9		0.0		0.0		0.0	

1. The years to which the data refer are given in parentheses after the values for the Little Egret.
2. Numbers given refer to the reference list at the end of the text.
3. Winter counts for Italy are for the Po delta and the Lagoon of Venice only.
4. The total autumn population is determined by adding an estimated production of 2 offspring per pair to the total number of breeding birds.

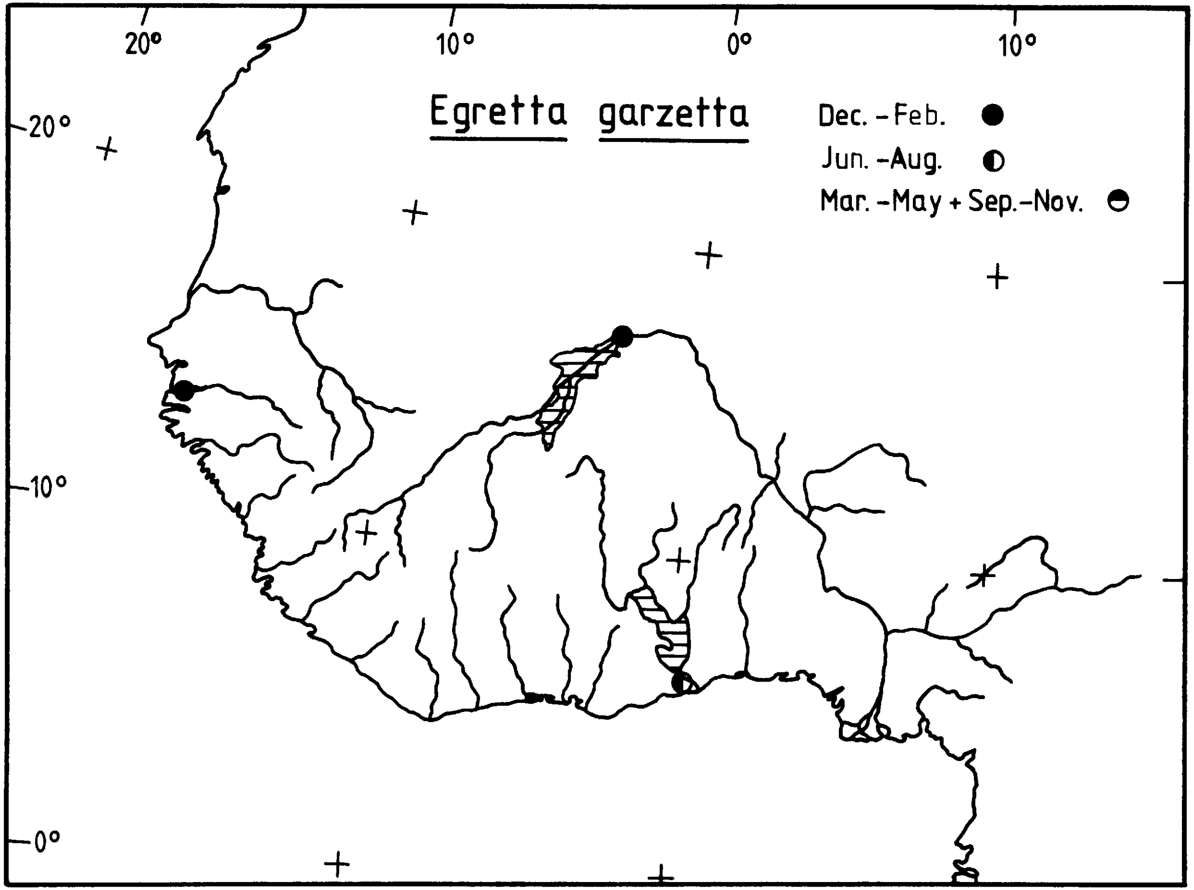

Fig. 1 : Recoveries in tropical West Africa of Little egrets *Egretta garzetta* ringed as nestlings in the Camargue, southern France.

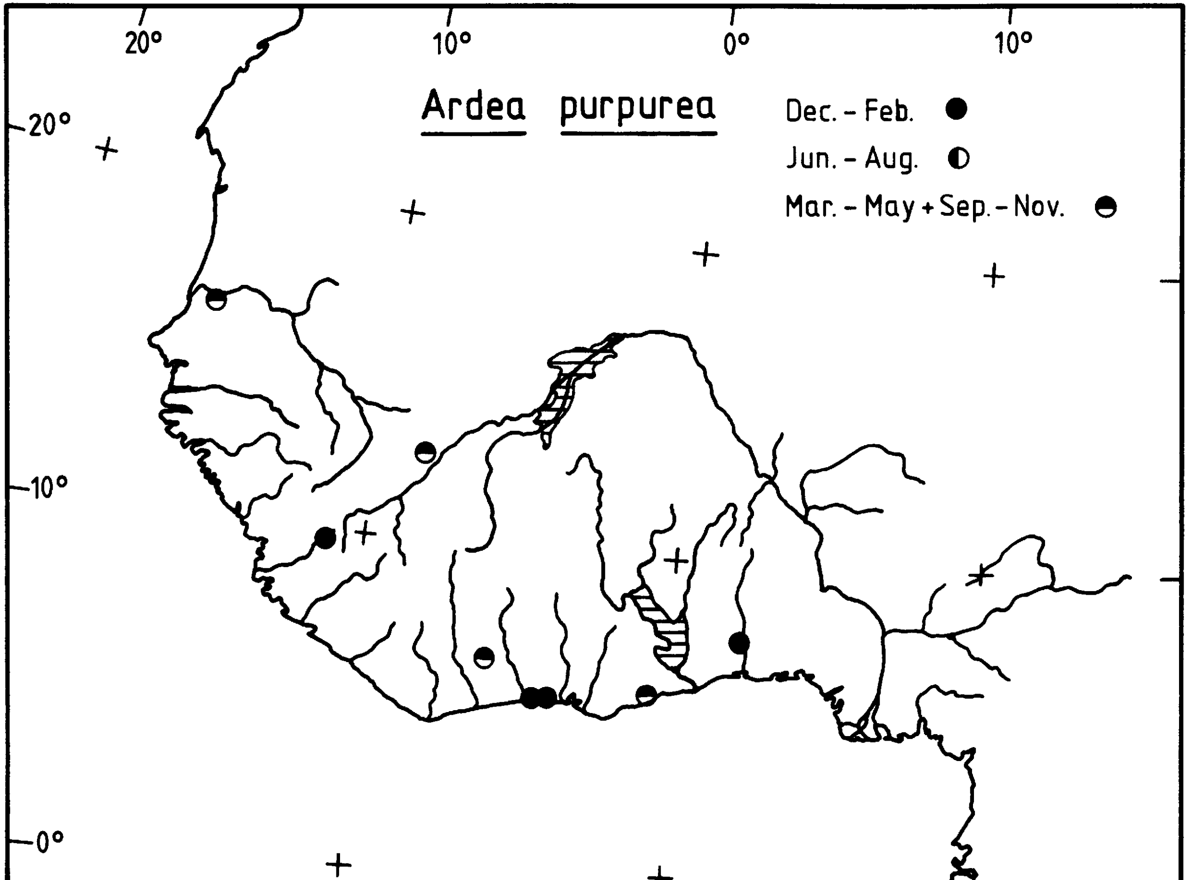

Fig. 2 : Recoveries in tropical West Africa of Purple herons *Ardea purpurea* ringed as nestlings in the Camargue, southern France.

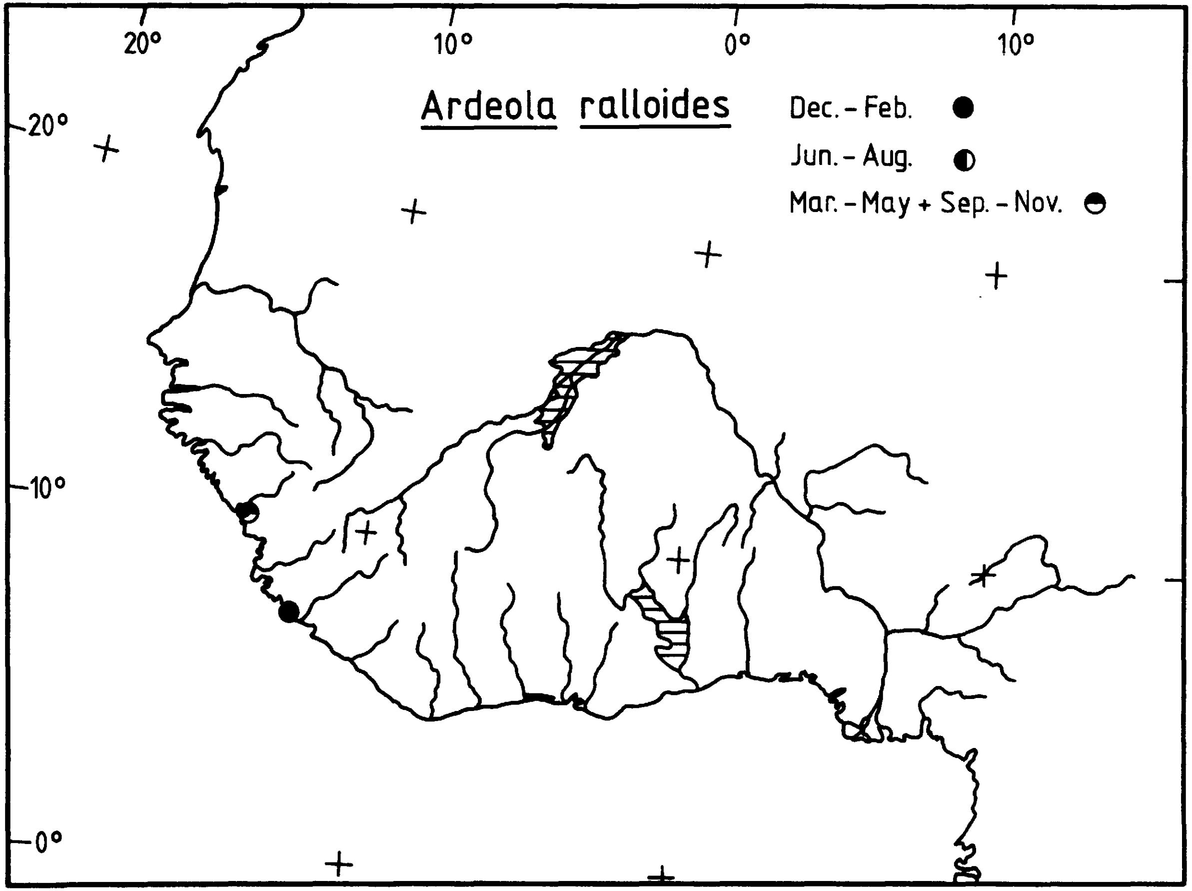

Fig. 3 : Recoveries in tropical West Africa of Squacco herons <u>Ardeola ralloides</u> ringed as nestlings in the Camargue, southern France.

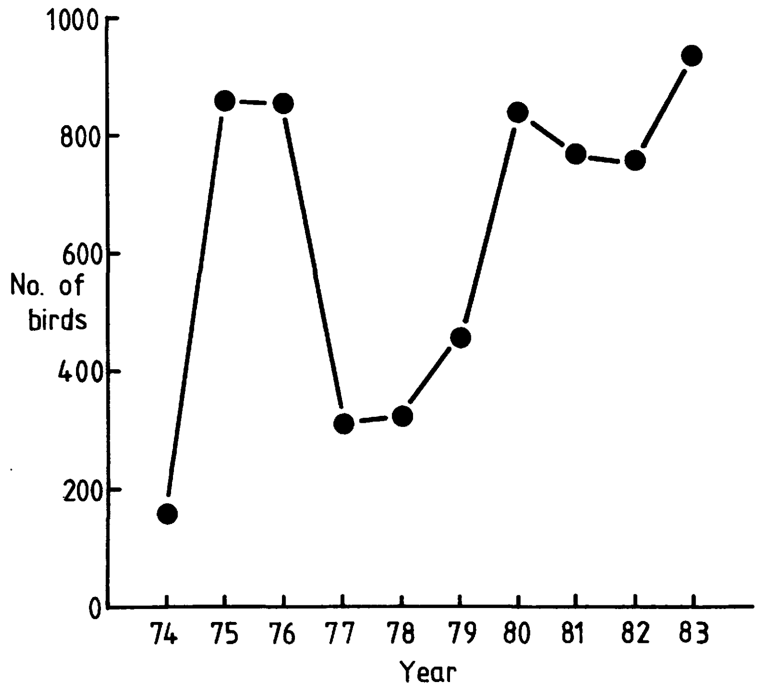

Fig.4 : January counts of Little egrets <u>Egretta garzetta</u> in Camargue, southern France. Data from Hafner (3).

CATTLE EGRET WINTERING IN THE CAMARGUE

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Summary

The Cattle egret is a new arrival in the Camargue, as both breeding and wintering species. This heron which came from tropical countries has had to adapt to the cold conditions which prevail in Camargue during winter. At this time it abandons its summer feeding habitats; wetlands and halophytic meadows, for meadows and some cultivated areas. It is usually associated with large mammals in summer but gives up the association in winter and uses different hunting methods. Its diet also changes; it is largely insectivorous in summer but feeds mainly on small mammals in winter. These changes in foraging method and in diet are related to changes in prey availability. The observed flexibility in the foraging behaviour of the Cattle egret in response to changes in availability of its prey help explain its establishment in Camargue and suggests that its range expansion in Europe is not yet complete.

1. INTRODUCTION

The Cattle egret, *Ardeola ibis* (L), is a new arrival in the Camargue. The first breeding success of 2 pairs was recorded in 1969 (1). By 1982 there were about 450 pairs. This establishment in the Camargue is part of an intercontinental spread of the species. In 1970 the first few birds wintered in this region and this number has increased to around 300 in 1981-82.

The aim of the study described here was to try to understand how a species which was resident in tropical countries could survive the cold winters of the Camargue. The field work was carried out from autumn 1979 to autumn 1981.

2. FEEDING HABITATS

Every ten days the number of birds using different feeding habitats were recorded along a standard survey route of 114 km. Four principal habitat types were recognised:

(i) halophytic meadows; characterised by *Salicornia sp* , *Arthrocnemum sp.* and *Limonium sp.*

(ii) meadows; characterised by gramineous plants.

(iii) dry cultivated ground: stubble fields and ploughed areas.

(iv) wetlands: marshes (usually dry after mid-summer) and rice-fields.

The results (Fig. 1) show large differences in feeding habitat use during the course of the year. In the middle of the winter, during the freezing period (which varies from year to year and in 1980-81 was from December to February), Cattle egrets abandoned their summer habitat of halophytic meadows and wetlands. They moved to cultivated ground if this was available, otherwise to meadows. Between the summer and the coldest part of the winter their use of feeding grounds was intermediate.

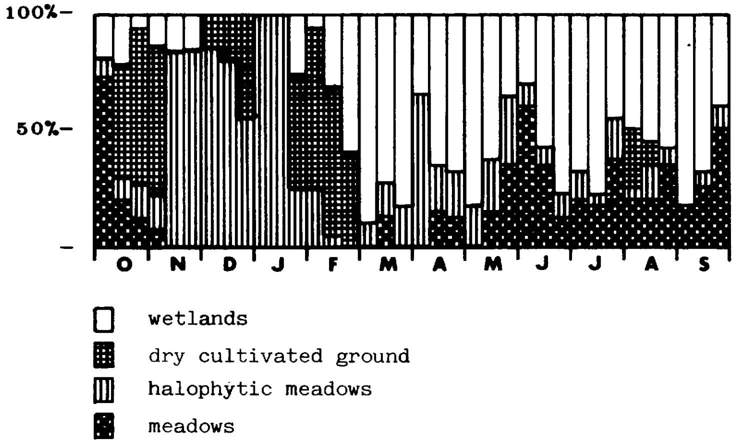

Fig. 1 : Percentage utilisation of the different feeding habitats in 1980-81

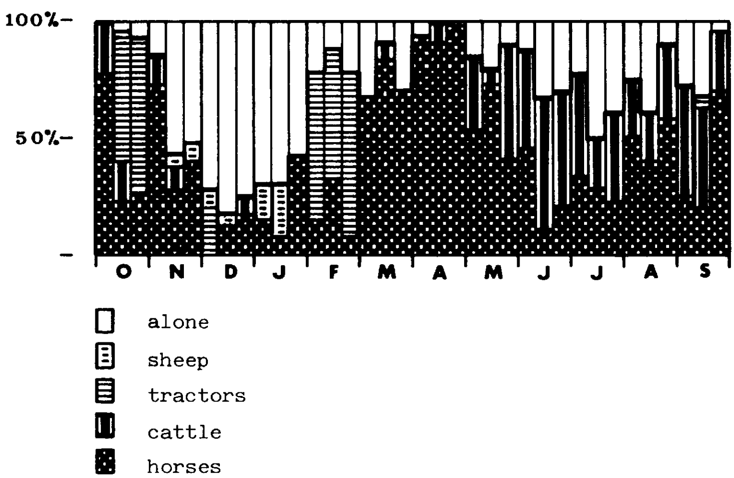

Fig. 2 : Percentage utilisation of the different associations nn 1980-81.

3. FEEDING ASSOCIATIONS AND HUNTING METHODS

The Cattle egret characteristically follows large mammals and catches the insects they disturb. These associations were recorded at the same time as the feeding habitat observations; the results are shown in Fig. 2. In the summer most of them were associated with horses and cattle. In the winter they abandoned these, but some still used sheep and tractors when available.

The commonest hunting method was the capture of prey whilst on the move either "walking slowly, walking quickly or running" (2) and (3); the stand and wait method was uncommon. However in the Camargue (Fig. 3) in some winters the stand and wait method was the one most commonly used during the freezing period. In winter they often stayed motionless for more than twenty minutes, but in summer this hunting method was never observed.

4. THE DIET

The Cattle egret is widely known to be mainly insectivorous, with in some places a high proportion of frogs in its diet. This has already been shown to be true for the Camargue during the breeding period, June to July (4).

In this study direct observations, lasting on average 17 minutes in winter and 9 in summer, didn't give the precise species composition of the adults diet, but instead its main characteristics (Fig. 4). In the summer they catch mainly insects and a few frogs, but in winter their diet changes and varies each winter. During the freezing period they become carnivorous eating a variable proportion of earthworms and mammals. A pellet analysis (5) indicates that the mammals eaten are mainly rodents (voles and mice). Either side of the freezing period they eat insects and vertebrates, mainly frogs, and in spring lizards as well.

5. DISCUSSION

The changes in feeding habitats, feeding methods and diet can be explained by changes in the prey availability. Direct observations of prey intake, feeding success and foraging effort (Fig. 5) were used to relate the behaviour and ecology of Cattle egrets to changes in prey availability.

In summer, large numbers of grasshoppers, locusts and other terrestrial and aquatic insects are available. The herons need a lot of food to rear their nestlings. They obtain the large amount of food necessary by catching large numbers of small prey. They are well adapted to hunt these small prey and this explains their low failure rate.

During the freezing period the birds require a lot of energy for thermoregulation. They are diurnal and therefore only have a short period of daylight in which to feed, only ten hours in December. The difference in the feeding rate between '79-'80 and '80-'81 can be explained by the fact that the first freezing period was quite short (December only) and not too cold, but the second was rather long (continuing in to January and February) and severe. The diet during the first winter consisted of earthworms and rodents. Associations with mammals would be detrimental to the capture of these prey (5), whilst in summer this association is profitable. The high failure rate is due to the capture of rodents which are unusual and fast prey and have to be caught by the stand and wait method which is also unusual. To catch large numbers of earthworms, which are scarce at the soil surface, a large number of steps is required, resulting in a high hunting effort. During the second winter which was very long, cold and dry, earthworms were unavailable. The Cattle egrets diet was virtually all rodents

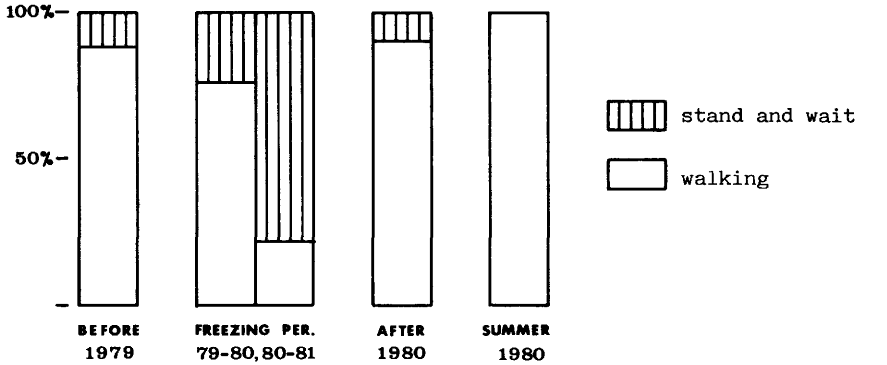

Fig. 3 : Percentage utilisation of the different hunting methods

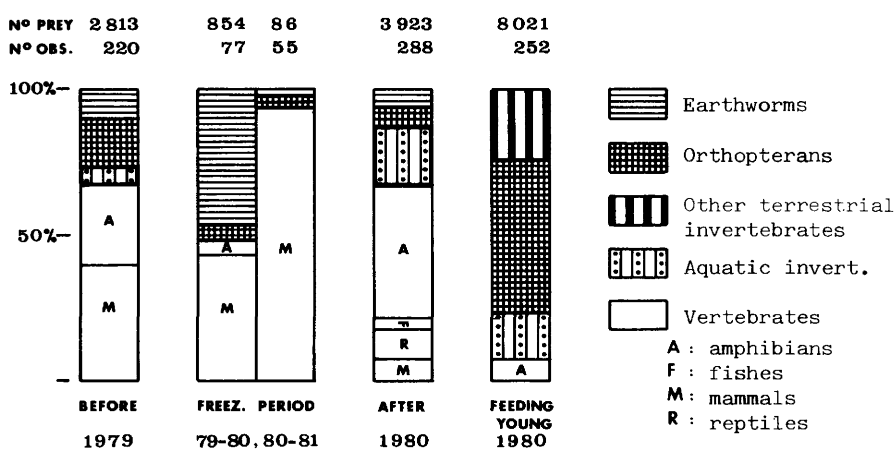

Fig. 4 : Percentage composition of diet (dry weight)

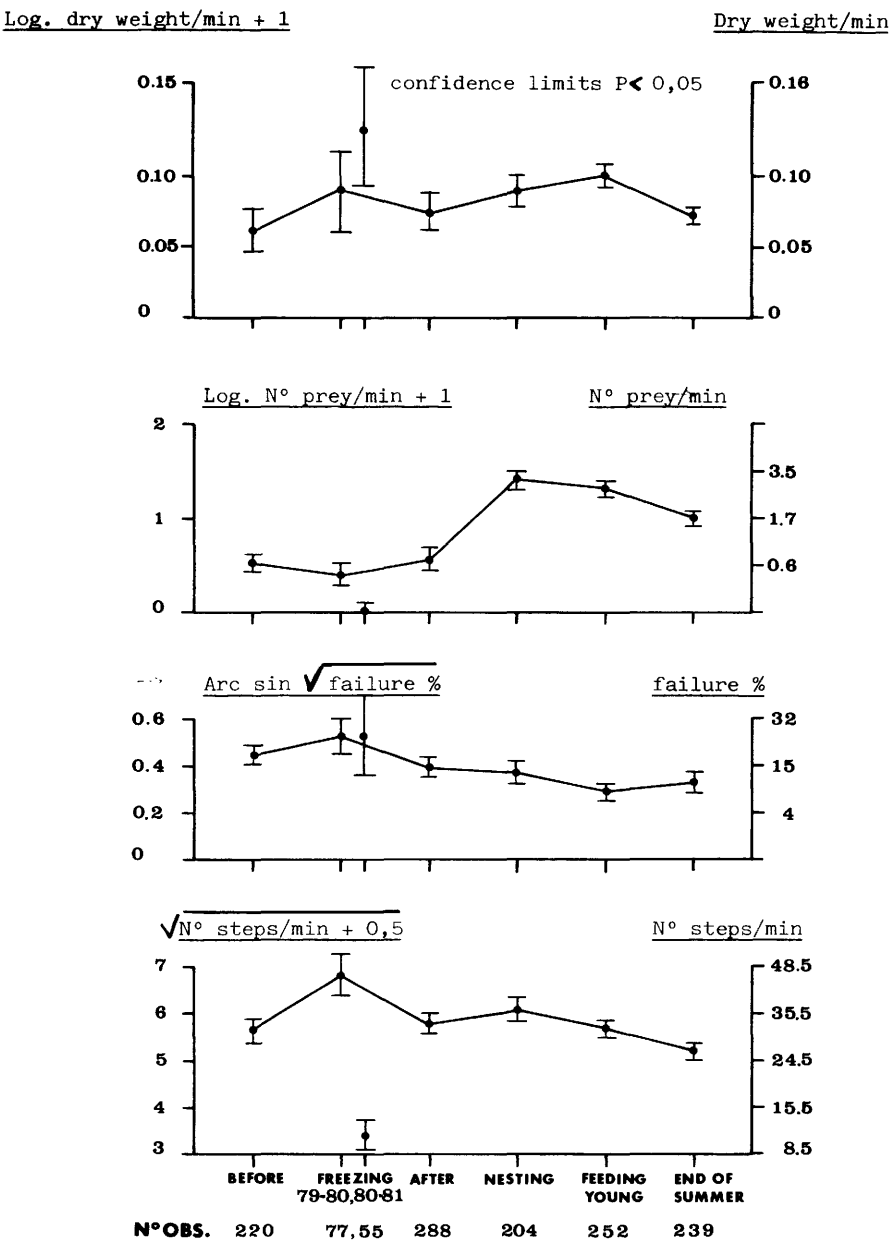

Fig. 5 : Variation of parameters during the year (confidence limits $P < 0,05$

and this explains the very low numbers of prey and the very high failure rate. The low number of steps is explained by the fact that they use the stand and wait methcd to catch rodents.

6. CONCLUSIONS

The Cattle egret solves the problem of wintering in the Camargue by its flexible foraging behaviour. When its normal prey is unavailable it is able to exploit other food sources even though these occur in different habitats. This heron is now well established in the Camargue as both a breeding and wintering species. Its range expansion in Europe is not yet complete as suggested by its recent establishment probably in the West of France (6).

7. REFERENCES

(1) HAFNER, H. (1970) - A propos d'une population de hérons gardeboeufs en Camargue. Alauda 38, 249-254.

(2) SIEGFRIED, W.R. (1971) - Feeding activity of the Cattle Egret. J. Appl. Ecol. 8, 447-468.

(3) KUSHLAN, J.A. (1978) - Feeding ecology of wading birds. Wading birds, research report n°7, National Audubon Soc.: 249-297.

(4) HAFNER, H. (1977) - Contribution à l'étude écologique de 4 espèces de hérons en Camargue. Thèse Fac. Sc. Toulouse.

(5) BREDIN, D. (1983) - Contribution à l'étude écologique d'Ardeola ibis, héron gardeboeufs de Camargue. Thèse Fac. Sc. Toulouse.

(6) MARION, L. & MARION, P. (1982) - Le héron garde-boeufs (Bubulcus ibis) niche dans l'ouest de la France; statut de l'espèce en France. Alauda 50/ 161-175.

GREY HERONS AND FISH FARMS IN THE CAMARGUE, SOUTHERN FRANCE

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Summary

Of the six species of colonial nesting heron which breed in the Camargue analysis of chick diet has indicated that the Grey heron is the only one which might cause damage to fish stocks in the recently created fish farms of this area. During the course of the past ten years a strong increase in the size of the breeding population of this species has been documented throughout France. A total of 9 313 nests were counted in 1981, against only 3 303 in 1974. During this same period the number of pairs breeding in the Camargue increased nine times;from 57 nests in 1974 to 515 nests in 1981. In 1983 684 breeding pairs were censused indicating that the Camargue population is still increasing. During the course of the population increase Grey herons have, with increasing frequency, been seen in fish farms. However, although it is known that fish are important in the diet of the species, the nature and level of predation by Grey herons in the fish farms of the Camargue are not known precisely. Consequently it is urged that accurate information be collected to determine the amount and seriousness of any damage caused before attempts are made to scare birds, a potentially expensive exercise.

1. INTRODUCTION

In several countries which are members of the European Community fish culture is an expanding activity. In most cases this is centered in wetland areas known for their populations of piscivorous birds. Not surprisingly this has led to complaints about damage by birds to fish yields. In the Camargue, southern France, one of the most important breeding areas for herons in western Europe, fish farms have recently been established. Six colonially nesting species breed there each year. In 1983 numbers recorded were: Little egret *Egretta garzetta* (2 460 pairs), Purple heron *Ardea purpurea* (1 240 pairs), Grey heron *Ardea cinerea* (684 pairs), Cattle egret *Bubulcus ibis* (407 pairs), Night heron *Nycticorax nycticorax* (390 pairs), Squacco heron *Ardeola ralloides* (84 pairs).

Although numbers of some species particularly Little egret and Night heron fluctuate strongly from year to year, those of Grey heron have been increasing continuously since the first breeding record of four pairs in 1964 (1). With a total breeding population of approximately five thousand pairs each year numbers of adults and young may at the end of the breeding season attain 20 000 individuals. Although fish farmers dislike the presence of such large numbers of herons claims of damage are rarely if ever supported by a factual foundation. In contrast studies of food delivered by adults to nestlings of the six species have shown that it is most unlikely that five of the six species cause production losses in the fish farms of the Camargue. Only the chicks of Grey heron were fed on commercial fish and only in small quantities (2). However since this study the breeding population of the Grey heron has increased throughout the whole of France and it is now appropriate to reexamine the level and nature of predation by this species in the fish farms. Furthermore there is a need to obtain data on the diet of birds during the non-breeding season, a period for which there are no existing data.

2. THE GREY HERON IN FRANCE

Three surveys were carried out throughout France by the S.N.P.N. (Société Nationale de Protection de la Nature) in 1968, 1974 and 1981 (Fig.1). According to these data (Fig.1) 64 colonies were found in 1968 and 2 032 nests counted (3). In 1974 3 303 nests were counted in 79 colonies (3) and the last census in 1981 revealed 9 313 nests in 155 colonies (4). Both the number of colonies and the number of nests per colony have increased (Table I).

Table I : Size distribution of all Grey heron colonies in France

N° of nests in colony	1974	1981
2 to 20	32	59
21 to 90	31	70
91 to 250	6	23
350 to 1 100	1	3

after Duhautois and Marion (4)

In the Rhone delta (Camargue and neighbouring areas) annual censuses from 1968 to 1975 (5) and from 1979 to 1983 (6), show a spectacular increase (Fig.1). From 1974 to 1981 the number of nests increased no less than 9 times compared with 2,8 times in the whole of France. Data from 1983 shows that this recently established population is still increasing.

3. THE FISH FARMS IN THE CAMARGUE

At present 6 to 7 fish farms are active each year. However the total surface of the fish ponds used varies greatly from one year to another e.g. a maximum of 1 020 hectares in 1981 and only 655 hectares in 1982.

Typically, of basins designed for the farming of carp (Cyprinus carpio), those in the Camargue are characterised by their large expanse (average of 110 ha) and shallow water (average depth 1 m).

Surface vegetation is dominated by reed (Phragmites communis) which surrounds the ponds and also develops in some very shallow parts in the middle. However this vegetation is generally restricted to narrow belts.

Drainage of the ponds, in order to permit harvesting of the fish, normally takes place in early spring. However the precise date is dependent upon the decision of individual owners and is not coordinated between farms.

The main commercial species is the mirror carp (Cyprinus carpio) but other fish species are either introduced or enter accidentally into the ponds, mainly eels (Anguilla anguilla), mullet (Mugil sp.), pike perch or zander (Lucioperca zandra), pike (Esox lucius), and rudd (Scardinius erythrophtalmus).

During the autumn and winter most of the fish farms are used for hunting on two to three days a week. The revenues obtained in this way can be very considerable.

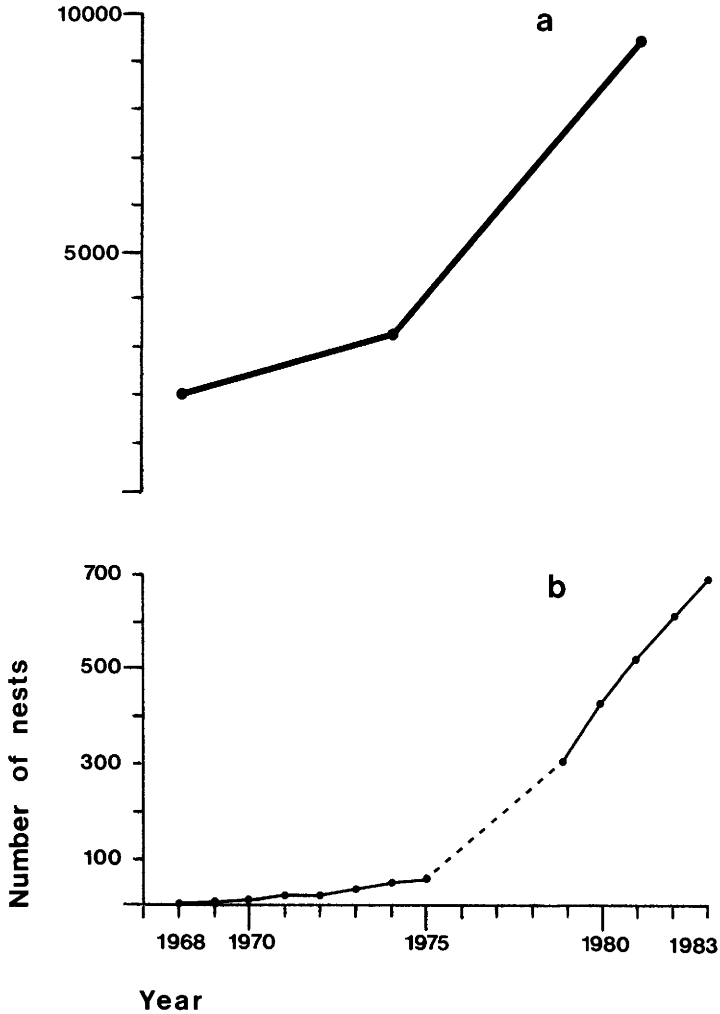

Fig. 1 : Estimated total number of breeding pairs of Grey herons (a) in France,(b) Rhone delta.

4. THE GREY HERON IN THE FISH FARMS OF THE CAMARGUE

Up until the present time fish farmers in the Camargue have been concerned mainly by the presence of 3 000 to 4 500 cormorants (Phalacrocorax carbo sinensis) from November to March (7). However, with the continuous increase in numbers of Grey heron this species is seen more and more frequently in certain fish ponds. The diet of Grey heron chicks in the Camargue has been studied by Moser (8). In 173 regurgitates examined fish represented 98,6% of the total dry weight (t.d.wt.). Carp (45,9% t.d.wt.) were the most important prey followed by eel (40,1%) and mullet (10,3%). However although these data reveal the importance of fish to breeding Grey herons, the only commercial fish, mirror carp, was recorded very infrequently ($<$1.0% t.d.wt.). These data suggest that the adult herons caught most of the fish in the natural marshes rather than in the artificial fish ponds. Indeed many of these natural marshes dry out in the summer and fish as well as other prey which are unable to escape become suddenly concentrated in small quantities of water. Hence it appears that during the breeding season the natural marshes offer better conditions for feeding than artificial fish ponds (2). Nevertheless our understanding of the feeding ecology of Grey herons during the non-breeding season, the period when most herons are seen in artificial fish ponds, is very poor. Because herons usually feed only in shallow marshes, it is mainly during the state of drainage for harvesting,that fish stocks become vulnerable to predation by these birds. However while control of predation may be fairly easy in small basins (for instance in trout farms of the United Kingdom) the very extensive ponds in the Camargue represent more of a problem. At the request of fish farmers experiments in 1983 have shown that Grey herons can be dissuaded by playing distress calls through loud-speakers. Additional techniques are available for experimentation although their success varies according to the situation and the nature of the problem. However, before concentrating on scaring methods, it is necessary to assess precisely the nature and the level of predation by Grey herons in the fish farms throughout the year. In particular, although existing data shows an increased use of fish farms during the non-breeding season (9) there is no information from recent years on the sizes of fish selected at fish farms and of any preferences for commercial fish. Consequently in autumn 1983 a study will be started to examine the nature and extent of the impact of Grey herons in the fish ponds of the Camargue. This work will be complementary to the the terminating study of the impact and control of predation by cormorants. The results will provide precise information on any damage caused and enable advice to be given on how damage can be minimised without destroying birds.

5. BIBLIOGRAPHY

(1) BLONDEL, J. (1965) - Le Héron cendré (Ardea cinerea L.) nicheur en Camargue. L'Oiseau et R.F.O. 35: 59-60.

(2) HAFNER, H. & MOSER, M. (1980) - Les hérons et la pisciculture en Camargue. Bull. Scien. & Techn. O.N.C.. Bulletin spécial Aquaculture-Zones humides: 255-260.

(3) YEATMAN, L. (1976) - Atlas des oiseaux nicheurs de France. Société Ornithologique de France, Paris.

(4) DUHAUTOIS, L. & MARION, L. (1982) - Inventaire des colonies de hérons arboricoles en France: Statut 1981. Document SNPN, Paris.

(5) WALMSLEY, J.G. (1975) - The development of a breeding population of Grey herons *Ardea cinerea* in the Camargue. *Terre et Vie* 29:89-99.

(6) HAFNER, H., JOHNSON, A. & WALMSLEY, J. (1982) - Compte rendu ornithologique camarguais pour les années 1980 et 1981. *Rev. Ecol. (Terre & Vie)* 36: 573-601.

(7) IM, B.H. & HAFNER, H. (1982) - Sur les oiseaux piscivores dans la pisciculture en Camargue. *Bulletin de l'Association Toulousaine d'Ichtyologie Appliquée* N°14: 13-19.

(8) MOSER, M. (in press) - Resource partitioning in a community of herons and egrets. Ph.D. thesis, University of Durham.

(9) IM, B.H. & HAFNER, H. (1982) - Nouvelles données sur les oiseaux piscivores dans les exploitations piscicoles de Camargue. Stat. Biol. Tour du Valat. Rap. dactyl. 30 p.

GREY HERONS AT TROUT FARMS IN ENGLAND AND WALES

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SUMMARY

A possible threat to the numbers of Grey herons breeding in England and Wales is identified. An increase in the ringing returns from fish farms indicate that trout farmers are shooting this protected species in order to safeguard their fish stocks. Results from a survey of 23 fish farms are extrapolated and discussed in terms of productivity and mortality rates for the heron throughout Britain. It was found that the birds shot on fish farms represent approximately 36.5% of the predicted post fledging mortality for the species each year. The effects of this persecution is reported for a number of heronries based near fish farms. The numbers and size of fish taken by different age classes of heron were recorded. The birds were found to take on average 370 g of fish per day and they are highly selective in the fish they take. These results are discussed objectively in terms of financial losses to the fish farm. A study of the behaviour of the birds on fish farms shows that the herons use specific areas with identifiable characteristics. Using this information several methods of protecting fish stocks without killing the birds were developed. Emphasis is placed on those methods which impede fishing activity since these are probably the most cost effective.

1. Introduction

The English and Welsh breeding population of grey herons *Ardea cinerea* has fluctuated around 4100 (2250-5400) pairs, falling after severe winters and rising after a series of mild ones (1). The numbers were not seriously affected by organochlorine pesticides, despite high HEOD and DDE contamination with associated egg-shell thinning and shell breakage in eastern England (2). Ringing recoveries nevertheless indicated an increased mortality rate among immatures and adults during the "organochlorine pesticide era", 1955-75 (3). Had not the heron been given legal protection from 1954 it is possible that the British population would have declined rapidly.

In view of the situation, reports of many herons being shot at trout farms in the 1970s gave rise for concern. In the 1963-76 period, there was an increase over previous years in the proportion of ringing recoveries resulting from shooting at fish farms (3). This prompted the RSPB to investigate, in the first place, the number of trout farms allegedly suffering damage from predation by herons and the extent to which the birds were shot. Subsequently the research focused on the numbers and behaviour of herons at trout farms, the damage incurred and ways of alleviating the problem. The study was carried out by J.F.B. over three years, 1978-80, with much of the detailed work at a large farm.

2. Extent of shooting of herons at trout farms

In 1979 there were about 240 trout farms in England and Wales. A third of the total was situated in seven counties in southern England. From an admittedly small sample of 23 farms, there was evidence that not only were herons shot at most of the larger farms (output of > 20 tonnes p.a.) but more were shot at such farms. By extrapolation it was estimated that 4600 ± 1000 herons may have been shot at trout farms in a year with nearly 45% at the larger establishments (Table I).

Table I - Estimation of numbers of herons shot at trout farms

Production, tonnes of fish p.a.	0-20	21-50	51+
No. farms	139	63	38
Estimated % farms at which herons shot	36	75	80
Estimated no. herons shot/ farm with shooting	11.8	40.7	68.9
Estimated herons shot	592	1929	2094

That 104 corpses of shot herons were examined at one large fish farm between April and September lends support to reports of high numbers killed at certain farms to protect fish. In this sample 31.7% of the victims were in adult/sub adult plumage, 16.3% were in immature (first summer) plumage and 52% were juveniles. Very few herons are shot on trout farms at other times of year.

3. Effect of shooting on productivity and mortality rates

The breeding population of 5400 pairs of herons in England and Wales in 1977 would have been expected to rear 12,474 young (2.31 per nest). From the above data it is estimated that shooting of adults would have resulted in 2148 (17.2%) potential fledglings dying in the nest. The 2400 juveniles assumed shot would have represented 23.2% of the young fledged.

Extrapolating from the estimate of the total number of herons shot at trout farms and the proportions of three age classes in the shot sample, it is estimated that 752 immatures and 1463 adults were shot in a year. Together with the juveniles this represents 36.5% of the predicted annual post-fledging mortality. Mortality rates of the different age classes are given in Table II.

Table II - Annual mortality rates of the grey heron

	Juvenile	Immature	Adult
Predicted annual mortality (%) (Mead *et al* 1979)	55.9	46.9	30.3
Estimated mortality due to shooting at trout farms (%)	32.6	30.4	16.8
Proportion of annual mortality (%)	41.6	35.2	44.7

4. Effects of persecution on local heronries

There were two heronries within 10 km of trout farm under observation and at which herons were being heavily persecuted. In 1979 the 33 adults shot could have represented 30% of local breeding population of 55 pairs. The 54 shot juveniles could have accounted for a high proportion of young fledged at these heronries. Persecution at the level reported in 1978 and confirmed in 1979 might be expected to have had a detectable effect on the local population. The trout farm started in 1970.

At one of the heronries the number of occupied nests changed little between 1968 and 1980, ranging from 6 to 14. At the other, there was also relative stability (14-20 nests) over the years 1968-76 but after moving to another site there was a sharp increase to 47 and 42 nests in 1979 and 1980 respectively.

Over half the herons recorded leaving the larger heronry at first light during May headed towards the trout farm. About 40 well-grown nestlings at this heronry were dye-marked but there were surprisingly few sightings of these birds at the farm, indicating that the juveniles were supplemented by immigrants from other heronries.

An attempt was made to examine the effects of persecution over a wider area. The number and size of heronries and the breeding population fluctuations over the period 1968-80 for three adjacent counties, Dorset, Hants and Wilts, with 50 trout farms were compared with those in Devon and Somerset with only 25 in 1979. That year the latter two counties had 619 occupied nests at 45 heronries, 27 (57%) of which had 10 or more nests. Dorset, Hants and Wilts, on the other hand, had only 349 nests at 19 heronries, 10 (53%) of which exceeded 9 nests. The population fluctuations, as shown by changes in nest counts between one year and the next, exhibited similar patterns in both areas. There was an average increase of 9.4% (Dorset, Hants, Wilts) and 5.7% (Devon, Somerset) over the first 5 years and an average of less than 1% change in both areas for 1975-80. The lower heron population in Dorset, Hants and Wilts may, however, reflect persecution in the interests of game fishing over a long period, not merely shooting at trout farms.

5. Effect of predation by herons on trout farm yields

At the large trout farm where the study was undertaken there were 55 ponds. 80.2% of both adult and immature herons (n=383) and juveniles (n=172) attempted to fish at ponds containing trout of 170-227 g. The respective proportions at ponds with smaller trout (28-170 g) was only 18.0% and 19.8%. Juveniles were observed taking fry which were largely ignored by adults. Very few herons were recorded at ponds with brood fish (0.91-2.27 kg). Taking into account the relative numbers of ponds with fish of different weight classes and the way herons distributed themselves on the trout farm in relation to the river bank, gathering ground and disturbance (see behaviour section), the birds were highly selective over the fish they attempted to catch (adults and immatures: $X^2_{(4)} = 148.7$; juveniles: $X^2_{(4)} = 71.9$; both $P < 0.001$).

In June and July, over the early morning period (0300-0700 hrs GMT) when virtually all the fishing at the trout farm took place, the adult herons had a catching rate 3.4 times that of the juveniles (5.0 compared with 1.48 fish per hour). Adults were also more successful in capturing larger fish and this resulted in them taking 6.2 times the weight of fish (922 g compared with 149 g per hour). With a slower fishing rate, juveniles tended to spend longer periods at the farm and this may have increased their vulnerability to shooting.

Observations on a captive bird and the analysis of gut contents of 40 individuals shot by fish farm staff indicated that the daily food requirement of an adult heron was about 370 g. This was within the range, 330-500 g, recorded in foreign studies (4). The requirement is equivalent to two 170-227 g trout suitable for the table. When feeding young the intake may double.

From data obtained on their numbers, distribution and feeding rate, it was estimated that herons took approximately 1814 kg of fish from the trout farm between April and September. At a sale price of 60p per pound (454 g) this represented a financial loss of about £2400 a year during the main period of predation.

In addition, fish farmers are concerned about the injuries inflicted by herons on trout which are then unsaleable. In sorting 65,713 kg of trout prior to marketing, 493.5 kg (0.75%) were discarded for various reasons. Only 40 (2.1%) of the 1934 rejected trout were considered to be injured by herons. £2500, the total cost of the loss due to herons, was but a small proportion of the revenue to be expected on a farm with a 500+ tonnes output a year. Much greater losses at the study farm were caused by mass deaths due to disease and oxygen deprivation. 10,000 trout of a size suitable for the table market may die within hours if a pond ceases to receive a good flow of well oxygenated water. Such losses, though occurring only once or twice a year, may represent £6000 to a fish farmer.

These figures relate to one of the largest trout farms in Britain. The majority of fish farms are, however, a great deal smaller (output less than 20 tonnes p.a.) and are visited by fewer herons and therefore suffer fish losses from predation which are substantially less in both quantity and proportionally.

6. Behaviour of herons at a trout farm

Herons largely confined their visits to the fish farm to the early morning before the staff came on duty at 0700 hrs GMT. In April and May, the mean number of herons in the vicinity, including adjacent trees, at any one time from first light until they were disturbed at 0700 hrs was 6.5 ± 4.7 (n counts = 160). In June and July, with numbers swelled by juveniles, the mean significantly increased to 10.0 $\pm$ 5.6 (171), while in August the mean declined significantly to 7.1 $\pm$ 4.0 (65). The main fishing activity did not start until about sunrise and continued until 0700 hrs or in June and July, 0630 hrs. Throughout this period a quarter to a third of the herons present around the trout farm were engaged in fishing.

Though there was a minor increase in the number of herons observed around the farm in the evening, few attempted to fish then. Observations using an image intensifier showed that small numbers visited the farm at night, especially when there was moonlight, but there was no evidence of feeding. Though many of the herons probably obtained most of their daily food requirements in the early morning visit, the surrounding flood plain with numerous ditches and channels provided good opportunities for feeding during the rest of the day.

Before coming onto the trout farm itself the herons usually congregated in certain trees within 500 m of the perimeter and approached the ponds via the river bank. 62.5% of the 555 herons recorded attempting to fish were at a line of 20 ponds closest to the river and the trees in which the majority of the birds assembled. The inflow end of the ponds was a particularly favoured site for fishing.

Since the herons tended to fish from the banks of the ponds rather than wading into the water, the nature of the earth banks influenced where the birds fished. A captive bird demonstrated that a heron's maximum reach with neck outstretched was 35 cm. The banks of few ponds on the trout farms exceeded this height above water level. Significantly more herons than expected attempted to fish where the bank gradient was less than 40° ($P < 0.01$) but they also favoured steep-sided ponds in which the water approached the top of the bank ($P < 0.05$).

Typically the grey heron is a solitary feeder but at the trout farm the birds were frequently gregarious when fishing at ponds heavily stocked with fish. Feeding aggregations may enable individuals to spend more time feeding and less on the alert. Painted silhouettes of herons in the fishing posture tended to act as decoys.

7. Protection of trout stocks

Shooting herons as a way to reduce damage is unlikely to be cost effective, especially since the most vulnerable birds are the juveniles which are relatively inefficient predators and tend to take the small fish. Moreover, the shot birds were probably rapidly replaced by immigrants. One of the main aims of the project was to find ways of alleviating the damage without fish farmer having to risk prosecution for killing a protected bird.

Caging is effective in excluding predators and reducing the risk of parasites transmitted by birds. It is, however, relatively expensive and therefore not readily acceptable, particularly on farms with many pools to be protected. Scaring devices such as scarecrow, streamers and aerial flashing lights are only temporarily effective. Audio-scaring has been used successfully in Israel against night herons *Nycticorax nycticorax* and may repay further investigation (5).

Deterrents which impede fishing activities of herons and thereby reduce damage are a third type of option. Netting along the banks was effective but considered by fish farmers to be expensive and a hindrance when working the ponds. A simpler alternative was strands of polypropylene twine, stretched between posts along the earth banks. After testing the strands at different heights it was concluded that two, at 20 and 35 cm above the ground, prevented most herons from reaching a feeding position at the water's edge. Also effective when positioned on the water around the pond's edge was a chain of white polyethylene floats (8 cm in length and 10.5 cm in diameter) spaced less than 30 cm apart along a length of twine. It was necessary to protect promontories, particularly at the favoured inflow end, with strands of twine as well as floats. The cost of the floats were approximately £25 and the strands of twine only £2 per 30 m x 9 m pond (6).

To reduce predation by herons, ponds should be steep-sided (> 45°) which means reinforced banks and the water level should be more than 35 cm below the top of the bank and out of reach of herons. A screen of tall vegetation between ponds limits the view of herons attempting to fish and therefore tends to make them wary. It is particularly important to keep fish of a size (170-227 g) most vulnerable to predation by herons, in ponds subject to most human disturbance and furthest away from a river bank or other access points for herons.

Under the Wildlife and Countryside Act of 1982 there is provision for the licensed killing of herons doing serious damage. Such licences should only be issued if it can be shown that deterrents have been tried and failed. Fish farms are subject to planning approval and this should only be given if the farm is designed to minimise damage by herons and other fish predators.

8. References

(1) Reynolds, C.M., 1979. The heronries census: 1972-1977 - population changes and a review. Bird Study 26 : 7-12

(2) Cooke, A.S. , Bell, A.A. and Haas, M.B., 1982. Predatory birds, pesticides and pollution, ITE, Monks Wood

(3) Mead, C.J., North, P.M. and Watmough, B.R., 1979. The mortality of British Grey Herons. Bird Study 26 : 13-22

(4) Cramp, S. and Simmons, K.E.L., 1977. Handbook of the Birds of Europe, the Middle East and North Africa: the Birds of the Western Palearctic. Vol. 1. : Ostrich - Ducks: Oxford University Press

(5) Spanier, E., 1980. The use of distress calls to repel night herons (N. nycticorax) from fish ponds. J.Appl.Ecol. 17 : 287-294

(6) Meyer, J., 1980. Room for bird and fish: RSPB's survey of heron damage. Fish Farmer. November

CONCLUDING DISCUSSION

In introducing the papers collected here attention is drawn to three questions central to the conservation of European heron populations. To conclude it is instructive to reflect upon the extent to which the information presented allows us to answer these questions. Firstly it is clear that for colonial herons nesting both in trees and in reed-beds as well as for pelicans, there is a good understanding of the characteristics of nesting sites which favour successful nesting. Furthermore it has been shown that habitat management to create or maintain nesting sites can be an effective tool in the conservation of these species. However in contrast present understanding of the feeding requirements of breeding herons is very poor. To improve this situation we can adopt two approaches. The first, described by Kushlan, is that of detailed study of the way in which populations use particular foraging areas. In this way, the factors which limit feeding and hence breeding success can be identified and procedures appropriate for successful management determined. This detailed approach has proved of great success in the Everglades of southern Florida and would be appropriate in many areas in Europe which are already under protection but where the detailed effect of management practices upon feeding and breeding success are not understood e.g. Coto Doñana (Spain) and Camargue (France). The second type of research study which will rapidly further understanding of the feeding requirements of breeding herons, is examination of the relationship between colony size and the area of different habitat types located within the foraging range of the colony. Fasola has described some work of this type. However more work of a more detailed nature is required in order to identify the effect of different habitat types upon the size and species composition of different colonies. Provided with the precise information that such study will yield it will be possible to make quantitative predictions of the effects of loss or deterioration of habitat quality upon colony size as well as of the effects of any compensatory habitat management. Thus this work will yield to governments and other organisations concerned with wetland development quantitative predictions of the effect of development upon populations of breeding herons and how management may reduce any detrimental effects.

It is hoped that during the course of the next few years studies of the type described will greatly improve our understanding of the ecological requirements of herons. The need for such work is urgent as, especially within the Mediterranean region, there are ever increasing demands upon wetland areas from agriculture and industry. At present the numbers of one species, the Purple heron Ardea purpurea, may already be limited by shortage of adequate breeding habitat (Moser). However others have declined for unknown reasons. In particular the size of the European breeding population of the Squacco heron Ardeola ralloides has declined in recent years (Smart; U.K.). In the Camargue the distribution of this species is heavily influenced by the presence of permanent freshwater marshes, the principal feeding habitat. Hence its decline elsewhere may be related to recent changes in the water regime of other wetlands, especially in Spain (Dugan). The types of study of heron feeding requirements advocated here will be of major importance in identifying both whether this is so and what management of wetland habitats would be appropriate in order to improve feeding conditions and hence breeding success.

In discussing the wintering areas used by migratory European herons it has been emphasised that the majority of herons breeding in western Europe winter in tropical West Africa. However a more detailed understanding of the migration routes and the final destinations used is lacking and there is an urgent need to document these. Nevertheless through analysis of breeding population trends in the Netherlands and of ringing recoveries it has already been shown that one major factor leading to mortality in the wintering area is drought. Thus even although much further information is required on the location of wintering areas used it is clear that study of how water shortage leads to heron mortality and hence whether proposals for river management will increase this mortality should be an urgent priority. Indeed studies of this type may increasingly deserve priority over further documentation of bird distribution. For example in the Sahel region of Africa the major wetlands are already well known yet our understanding of the ecological requirements of birds using these areas is poor. There is currently a great need to further this understanding in order that the likely effects upon these populations of future changes to the natural environment and appropriate measures which will reduce the extent of detrimental changes, may be identified. One period of year when there is still need for much further exploratory work is during the late dry and early wet season from March to June. There is increasing evidence that many, and perhaps most, herons in their first summer remain in Africa rather than migrating northwards with the breeding adults (Cavé, Dugan) and it is just at this time that drought conditions become most severe. What areas and habitats are used by herons at this time are unknown yet protection of these environments may, because of their value to juvenile birds, be essential for future recruitment to the European breeding populations and hence their long-term security.

With increasing awareness of the importance of Africa to the future well-being of the European breeding populations of many bird species there are currently indications of an expansion of research in Africa. It is hoped that the current Migratory Birds Campaign of the International Council for Bird Preservation and the International Waterfowl Research Bureau will provide additional stimulus to this (Woldhek; NL). However while further study is essential the increasing threats to natural habitats in Africa suggests that where important sites are already known but not protected, priority ought to be directed towards achieving such protection (Smart, U.K.). In this context it is of great importance that within the framework of development projects, especially those funded by international organisations such as the World Bank or the E.E.C., studies should be made to identify the effects of such development upon the natural environment and funding provided in order to study ways in which detrimental impact upon the environment may be reduced (Evans).

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