Colonial waterbirds and their habitat use in the Danube Delta

as an example of a large-scale natural wetland

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Summary

During the breeding seasons of 2001 and 2002 two comprehensive surveys of colonially breeding waterbirds (Pelecaniformes, Ciconiiformes and Charadriiformes) were carried out in both the Romanian and Ukrainian parts of the Danube Delta. Apart from being the first time in history that this internationally important area for these groups of birds was comprehensively surveyed, the aim of this study was also to obtain some insight in which are the crucial factors responsible for site selection and population size of colonial waterbirds. By helping to unravel the relationships between feeding and breeding habitats and distribution and size of the colonies, we hope to contribute to both the sustainable development of the relevant bird populations in the Danube delta itself and to finding clues of how to spatially plan and design wetland restoration measures in other, more degraded wetland areas elsewhere.

Pelecaniformes and Ciconiiformes

In 2002, the most completely covered year, a total of 209 colonies was found, holding almost 40,000 breeding pairs of 13 species. The most abundant species were Great Cormorant (22,787 pairs), Pygmy Cormorant (9,341 pairs) and Great White Pelican (4,150 pairs). Among the wading birds, remarkable figures included 3,340 pairs of Glossy Ibis, 2,964 pairs of Black-crowned Night-heron, 1,725 pairs of Little Egret and 1,279 pairs of Squacco Heron (Table 1). It seemed reasonable to assume that for most of the species involved the survey was rather complete, except for Purple Heron, a notoriously skulking breeding bird of inundated Reed beds, of which colonies are hard to find, both from the ground and during aerial surveys. From the total of 236 different colony sites, located during both years, the vast majority was situated in trees (148). A further 60 were found in inundated Reed beds, 16 in Reed beds with sparse trees, 10 on bare ground on islets and two on floating aquatic vegetation. All colony sites were, therefore, well protected against access by terrestrial predators (e.g. Red Fox) and generally well out of the way of human influence. For Little Egret and Squacco Heron, two examples of not very far ranging species with well-defined and different feeding grounds, the proximity of suitable feeding habitats (as mapped for the area by Hanganu et al. 2002) to the colony sites was of some influence on colony size. For the much farther ranging Dalmatian Pelican, a similar relationship was suggested. This and, even more, the fact that most colonies were situated close to the numerous smaller lakes and ponds in the central part of the delta, indicate that, besides safety of the actual breeding site, the availability of feeding areas also played an important role. Probably, the decisions of potential breeders take place on different scale levels. Firstly, a global selection of a suitable area is made on the basis of availability of good feeding grounds within a daily flying range (e.g. 50-60 km for pelicans and up to 10 km for smaller herons). The farthest ranging species also generally have the highest food requirements and therefore actually need larger feeding areas. For these species, colonies may get established all over the area, but for smaller herons and ibises the area becomes largely confined to the central part. Within this ‘flyable’ range, the safest and most isolated sites will be chosen as colony sites. Then, the actual colony sizes will depend on both the availability of safe

nest sites within each colony and the carrying capacity in terms of food availability within the daily flying range from the colony site.

Table 1.
Estimated total numbers of colonial breeding waterbirds in the combined Romanian and Ukrainian Danube delta in 2001 and 2002. Details are provided on number of colonies, mean colony size (including standard deviation) and maximum colony size.

		2001						2002					
species		total of pairs	no. of colonies	mean colony size	std	min	max	total of pairs	no. of colonies	mean colony size	std	min	max
Great White Pelican	*Pelecanus onocrotalus*	3520	2	1760	2461	20	3500	4160	3	1387	2160	100	3880
Dalmatian Pelican	*Pelecanus crispus*	454	3	151	217	4	400	420	4	105	197	1	400
Great Cormorant	*Phalacrocorax carbo*	16161	14	1154	1265	80	4500	22787	30	760	923	10	3500
Pygmy Cormorant	*Phalacrocorax pygmeus*	8740	12	728	704	70	2500	9341	14	667	700	1	2100
Great Egret	*Casmerodius albus*	307	10	31	23	2	70	730	27	27	30	1	100
Grey Heron	*Ardea cinerea*	513	14	37	77	2	300	588	29	20	17	2	85
Purple Heron	*Ardea purpurea*	450	2	225	177	100	350	399	15	27	42	1	147
Little Egret	*Egretta garzetta*	1985	12	165	171	5	500	1725	24	72	73	1	250
Squacco Heron	*Ardeola ralloides*	2405	12	200	194	10	500	1279	16	80	101	4	350
Cattle Egret	*Bubulcus ibis*	12	1	12		12	12	3	1	3		3	3
Black-crowned Night-heron	*Nycticorax nycticorax*	2140	11	195	115	20	300	2964	27	110	138	2	500
Eurasian Spoonbill	*Platalea leucorodia*	218	7	31	30	3	80	339	9	38	33	5	100
Glossy Ibis	*Plegadis falcinellus*	2055	10	206	160	30	500	3340	12	278	236	20	650
Pontic Gull	*Larus cachinnans*	1202	6	200	278	6	750	1685	9	187	262	5	800
Black-headed Gull	*Larus ridibundus*	852	3	284	255	2	500	3030	12	253	352	30	1335
Mediterranean Gull	*Larus melanocephalus*	200	1	200		200	200	219	1	219		219	219
Gull-billed Tern	*Gelochelidon nilotica*	5	1	5		5	5	10	2	5	4	2	8
Sandwich Tern	*Sterna sandvicensis*	2700	3	900	361	500	1200	3700	2	1850	71	1800	1900
Common Tern	*Sterna hirundo*	4687	7	670	861	12	2000	5943	5	1189	1342	10	3263
Little Tern	*Sterna albifrons*	65	3	22	25	3	50	64	2	32	10	25	39
Whiskered Tern	*Chlidonias hybridus*	1405	7	201	302	20	850	3895	18	216	468	5	2000
Black Tern	*Chlidonias niger*	3	2	2	2	0	3	10	1	10		10	10
Collared Pratincole	*Glareola pratincola*	313	3	104	169	3	300	34	2	17	7	12	22
Black-winged Stilt	*Himantopus himantopus*	96	5	19	18	5	50	70	3	23	38	1	67
Pied Avocet	*Recurvirostra avosetta*	63	6	11	8	2	21	241	6	40	70	3	180
White-tailed Lapwing	*Vanellus leucurus*	7	1	7		7	7	1	1	1		1	1

Charadriiformes

For colonially breeding gulls, terns and waders, the Danube delta proved to have lost much of its original values. Although the surveys were rather better designed for localising and assessing the numbers of pelicans, cormorant and large wading birds, the numbers of breeding gulls, terns and waders were surprisingly low. In 2002 almost 19,000 pairs of colonial Charadriiformes were counted in no more than 64 different colonies. The most abundant species were Common Tern (5,943 pairs), Whiskered Tern (3,895 pairs), Sandwich Tern (3,700 pairs in just two Ukrainian sites), Pontic Gull (3,340 pairs) and Black-headed Gull (3,030 pairs) (Table 1). The formerly common breeding birds Gull-billed Tern and Slender-billed Gull were either extremely scarce (5-10 pairs, only on the Ukrainian side) or no longer found at all. The loss of active delta formation at two of the three mouths of the Danube, together with the cutting off from the Black Sea of the southern former lagoon area of Razim/Sinoe, has resulted in the loss of existing small islands with little or no vegetation and sufficient protection against predation and disturbance. These island pioneer situations seem to have been crucial in providing safe and suitable breeding sites for the ground-nesting birds from this group. Islands have disappeared by erosion and vegetation succession has proceeded towards higher and denser stands, unsuitable for ground-breeding species. Most of the breeding gulls and terns were, therefore, found along the coast of the still intact secondary delta on the Ukrainian side. The northernmost Chilia branch still carries enough sediment to allow for active sandbar formations at its mouth, which hold large colonies of gulls and terns. However, the present carrying capacity of the Danube for gulls, terns and waders in terms of food availability is likely to be severely under-used, due to lack of breeding sites.

Discussion and implications

In spite of the shortcomings of the fieldwork related to the enormous size and the inaccessibility of the territory to survey, we have been able to come forth with a number of suggestions on how to improve future surveys, particularly for gulls, terns and waders. Moreover, we have developed a conceptual model that attempts to explain the actual spatial distribution of the colonies and their sizes by a hierarchical sequence of 'choices' that the birds seem to make in dependence of their specific food requirements and their need for safe breeding sites. Thus, it turns out that the relative completeness of the array of colonial Pelecaniformes and Ciconiiformes in the Danube delta is a result of the combination of a large-scale and relatively untouched wetland with, on a smaller scale, sufficient spatial variation in gradients to provide both safe breeding sites and sufficient food within daily reach. There may, however, be some conflict with human fisheries, particularly if in the future commercial fisheries would strongly increase. For Charadriiformes, on the other hand, safe breeding sites are scarce and both species diversity and total numbers remain well below the potentials. The only exception to this is the Whiskered Tern, which probably maintains its main European stronghold here.

It is argued that the considerations on site selection and spatial configuration of feeding and breeding habitats as found in the Danube delta are not only relevant to formulate and execute an effective management of the area for the sustained conservation of its ornithological values. They may also be fundamental in restoration attempts for man-made river systems such as the Dutch Rhine and Meuse delta area. Spatial planning of these attempts should not only focus on local conditions but also take into account the actual and potential configuration of wetland habitats on a larger scale.

1 General introduction

1.1 Background

From 1993 onwards the Netherlands Institute for Inland Water Management and Wastewater Treatment (RIZA), the Romanian Danube Delta National Institute (DDNI) and the Romanian Danube Delta Biosphere Reserve Authority (DDBRA) have combined their efforts in an extensive co-operative research programme directed at hydrology, geomorphology and ecology of the large and relatively unspoilt European wetland area of the Danube Delta (*e.g.* Drost & Stiuca 1998). Later on, co-operative research has also been carried out in the active Ukrainian part (along the northern Kylia branch) of the Danube Delta by RIZA and the Ukrainian Danube Delta Biosphere Reserve (DDBR). Since then, a lot of information has become available on the spatial distribution of the various important features that can be used to characterise wetland habitats.

Thus, one of the first products of the joint venture was the publication of a comprehensive vegetation map of the entire Romanian part of the area (Hanganu *et al.* 1994). Meanwhile, this vegetation map has been extended to the entire transboundary Danube Delta Biosphere Reserve, by including comprehensive information on vegetation types inside the Ukrainian part as well (Hanganu *et al.* 2002). As attention has been focused as well on matters of soil, hydrology, water quality, eutrophication and aquatic ecology (*e.g.* Munteanu 1996, Trache & Menting 1995, Gherghisan & Oosterberg 1995, Kappers 1996, Van der Molen 1996, Oosterberg *et al.* 1997, Buijse *et al.* 1997), it has now been possible to provide an ecosystem map of the entire Romanian Danube Delta indicating clusters of vegetation and water types into habitat types (Gâstescu *et al.* 1999). As more and more information is becoming available on aquatical ecological gradients in lakes (Oosterberg *et al.* 2000) and general information on the Ukrainian parts of the Delta (e.g. Zhmud 1999), an extension towards a comprehensive transboundary map of terrestrial and aquatic habitat types of the entire Danube Delta region (both Romanian and Ukrainian) should also come within sight.

1.2 Why now focus on birds?

A next logical step is to try to shed more light on the ecological significance for higher trophic levels of the spatial patterns studied so far (*e.g.* size, connectivity, gradients, etc.) of the mosaic of aquatic, amphibian and terrestrial habitat types in the relatively still untouched situation of the Danube Delta. The ecological coherence of the network of these habitats may be studied adequately by focusing on waterbirds and their specific habitat needs. The Danube Delta is well known to hold one of Europe's finest and most complete arrays of marshland and wetland bird communities (Lintia 1955, Paspaleva *et al.* 1985, Munteanu *et al.* 1994, Marinov & Hulea 1996). Elsewhere in Europe, the natural wetlands of virtually all lower river reaches have been so much reduced and heavily modified by man that marshland and wetland bird communities have become subject to population losses or even extinctions due to destruction and fragmentation of habitats (*e.g.* Hoffman *et al.* 1996, Den Boer 2000, Foppen 2001, Van Eerden *et al.* 1997). The most striking examples of the dependence of wetland birds on large and ecologically coherent natural landscapes are generally found among the larger colonially breeding waterbird species (*e.g.* Alieri & Fasola 1992, Hafner & Fasola 1992, Farinha & Leitão 1996, Nager *et al.* in press). Being large and conspicuous, they need quiet, undisturbed and predator-free sites to settle. Besides that, they also need to find enough food for themselves and their offspring within a day's flying range for a prolonged period of at least three months (*e.g.* Lack 1968, Cramp & Simmons 1977, Wittenberger & Hunt 1985, Del Hoyo *et al.* 1992, 1996, Debout *et al.* 1995, Platteeuw & Van Eerden 1995, Platteeuw *et al.* in press).

Using habitat maps as backgrounds, it should be illustrative to try to find out which (combinations of) biotic and abiotic factors, related to scale and/or richness in gradients, enable this large and relatively untouched wetland area to hold large and healthy populations of most of the larger colonial waterbird species. For some species in this category the Danube Delta even constitutes the most important breeding haunt in either entire Europe or even the western Palearctic (*e.g.* Dalmatian Pelican *Pelecanus crispus*, Pygmy Cormorant *Phalacrocorax pygmeus* and Glossy Ibis *Plegadis falcinellus*). In (pre)-historic times, other large delta areas in Europe have been holding a similar diversity and similar numbers of these colonial waterbirds (*e.g.* Brouwer 1954, Van Eerden *et al.* 1997), before mass land reclamations and radical changes in land use towards intensive agriculture purposes wiped out most of these wetlands.

Value for Europe

Nowadays, only relatively small and scattered patches of wetland still remain along most European lowland river reaches, which over the last few decades of the 20th century has called for the wish to restore and/or rehabilitate wetland systems in order to preserve biodiversity. An enhanced insight into the factors governing the establishment and size of breeding colonies of large wetland bird species will allow these initiatives to name attainable nature targets in their aim at ecological restoration of large-scale downstream wetland systems and specify the means to reach them. One of these means may be the connection with necessary flood protection measures, such as the re-connection of floodplains, water retention basins, etc. to cope with both surpluses of water in the wet season and scarcity of it in the dry season. Even when similar scales cannot be attained, a better understanding of the spatial relationships between bird distribution and numbers and their feeding and breeding habitats may provide means to help establish favourable conditions for re-colonisations.

Value for Danube Delta

In the meantime, the exact identification of both colony site and feeding habitat requirements of these apparently vulnerable larger colonial waterbirds will enable Romanian and Ukrainian authorities to actively preserve, protect and even stimulate the very factors that prove to be crucial to the viability of these birds' populations. This will prove particularly important, when it is realised that for many of the species involved (e.g. Dalmatian Pelican, Pygmy Cormorant and Glossy Ibis) the Danube delta holds the most important breeding population on a European or even a worldwide scale. In both Romania and the Ukraine, ecological restoration measures are considered as well and a better insight in the habitat needs of precisely these vulnerable bird species may provide valuable clues to which factors need to be focused on in spatial planning and design of nature development projects within the Danube delta area (Fig. 1.1).

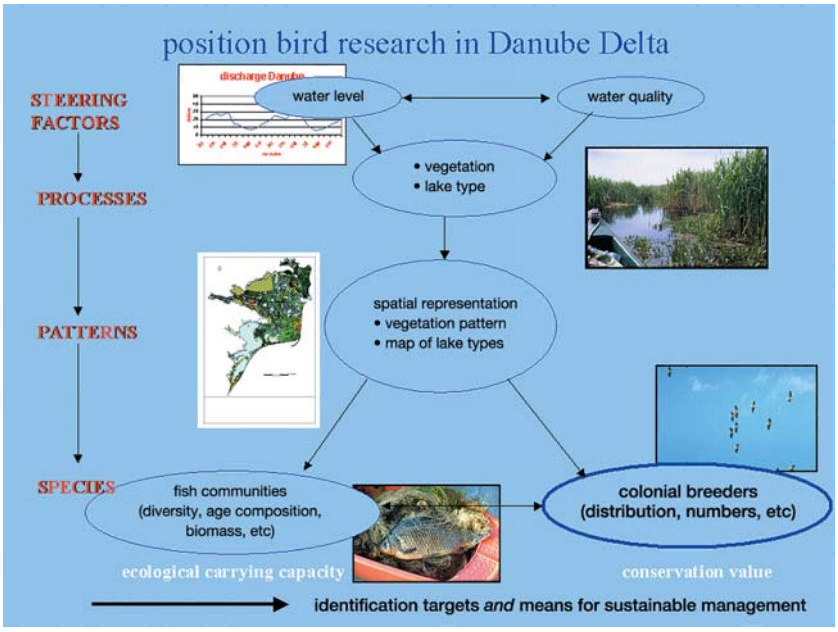


Fig. 1.1
Positioning of the relevance of studies on colonial and mainly piscivorous wetland birds in the Danube delta. Abiotic factors like water level fluctuations cause, in interaction with water quality, differences in morphodynamics and thus create a spatial pattern of habitats characterised by different levels of connectivity to the main river with varying levels of water quality, biological productivity and different species of plants and animals. Here several different fish communities develop, which in their turn form the food base for many of the colonial waterbirds, which constitute both an important conservation value for the area (e.g. EU Bird Directive) and potential competitors with local human fisheries (which calls for sustainable management). On the other hand, within the spatial patterns of lakes and vegetation types these species also have to find their safe nesting sites.

1.3 Aims of the study

The aims of the present study are primarily:
- to localise and survey all colonies of 13 species of Pelecaniformes and Ciconiiformes;
- to enter these data into a GIS-based database;
- to analyse the data in relation to habitat type;
- to identify the habitat characteristics determining site and size of colonies.

Secondary aims are to obtain, for the first time, a simultaneous set of quantitative data on the population sizes of each of these 13 species of colonial waterbirds and to assess the possibilities and difficulties of surveying and censusing these colonies. In view of the fact that Romania, as a candidate member of the European Community, will have to comply with the EU Bird Directive, it will be necessary to formulate the conservation targets for the so-called Special Protection Areas (SPAs). In order to comply with the maintenance of the required favourable conservation status for qualifying bird species, these conservation targets will be the basis for sustainable management of the area. Moreover, although the Bird Directive does not explicitly ask for regular monitoring of qualifying bird species, the obligation of delivering regular progress reports to the European Committee will certainly be served with the availability of regular and (more or less) comprehensive surveys of the colonial birds.

During the fieldwork it was decided to register and assess other bird colonies found as well. These consisted of gulls, terns and some species of waders (*e.g.* Pied Avocet *Recurvirostra avosetta*, Black-winged Stilt *Himantopus himantopus* and Collared Pratincole *Glareola pratincola*). However, since these species may not all breed colonially, their preferred nesting habitats do not completely overlap with those of Pelecaniformes and Ciconiiformes and the seasonal timing of the surveys was not adequate for this group. The results therefore cannot be considered as complete as those obtained for pelicans, cormorants and wading birds.

1.4 Acknowledgements

This study would not have been possible without the assistance of many people. First of all we want to thank the people who assisted us in the field, by taking us in boats and showing us the colonies: Tănase Ceico, Paul Cîrpaveche (Partizani), Gheorghe Bucur (Murighiol), Gheorghe Băcescu (Salcioara), Octavian Piriu, Eduard Axente (Sfîntu Gheorghe), Benone Maftei and Vasile Amariei (both Mihai Viteazu). More assistance in the field was obtained from other observers, like Pierre Defos du Rau, Yves Kayser, Andreas Krantz, Gerben Van Geest and Joep De Leeuw. Hospitality was received from Tănase and Felicia Ceico in Tulcea and their family in Crisan, Dr. Vasile Oţel in Maliuc, Elena Kiss in Tulcea, Elena Zhmud in Vilkovo and Vasile Amariei in Grindul Lupilor. We also want to thank the DDNI driver Tifran Oprea, who patiently drove us with the institute's van to wherever we wanted to go in search of bird colonies. At the DDNI office logistics and administration were adequately and efficiently taken care of by Mircea Staras and Iulia Orlatan, while at DDBR Alexander Voloshkevitch provided his support. It was Mihai Marinov from DDNI who introduced the first author to the second, and thus contributed to the basis of this joint venture. During the set-up of the programme, the encouragement and enthousiasm of people like Wouter Iedema, Grigore Baboianu, Boris Alexandrov, Alexander Voloshkevitch and the support of the project leaders Willem Oosterberg and Mircea Staras were fundamental for carrying through. Later on, the project also benefited from the support and critical comments from the second project leader Tom Buijse. The analyses of food choice of the different bird species used and referred to in this report have been carried out by the second author in close co-operation with his Hungarian colleagues Rékási József and Sterbetz István, for which we are very grateful. While elaborating the data, assistance was obtained from Boris Teunis, Jaap Daling and Ute Menke. The latter also assisted by facilitating the data on the vegetation mapping carried out before in the international Danube Delta Biosphere Reserve, together with Jenica Hanganu. Water table fluctuation data, as well as geographical information, was obtained from Adrian Constantinescu. The final version was commented on by Tom Buijse. All these people significantly contributed to the success of this survey and the authors wish to express their thanks for all services rendered.

2 Material and methods

2.1 Study area

The Danube, the second-largest river of Europe, discharges into the Black Sea on the border of Romania and Ukraine in a characteristic delta area, which up until the present day has maintained much of its original natural features. In order to preserve these unique ecological values, most of its territory has been assigned the status of an international Biosphere Reserve stretching out over the two countries and covering some 580,000 ha (Fig. 2.1). Much of the previous work carried out by DDNI, DDBRA, DDBR and RIZA has provided us with excellent information on the geographical, physical and ecological situation of the present-day Danube Delta area. Thus, hydrological and ecological diversity of the delta's freshwater systems were described, analysed and modelled by Oosterberg *et al.* (2000), while a comprehensive vegetation map of the entire international Danube Delta Biosphere Reserve was published by Hanganu *et al.* (2002), of which an aggregated version has been used for some of the spatial analyses performed on the collected data of breeding colonial birds (Fig. 2.2).

The delta is formed by three main branches. The highest discharges (over 10000 m^3/s) generally occur in spring, the lowest (2200-3000 m^3/s) in autumn (Oosterberg *et al.* 2000, Hanganu *et al.* 2002). The mean annual discharge (c. 7000 m^3/s) throughout the years is remarkably constant. The sediment load of Danube water has decreased dramatically during the 20th century, down from approximately 67.5 million tonnes per year in 1920-1960 to a mere 29.2 million tonnes per year in 1980-1990. This decrease is largely due to the sharp increase in reservoirs and dams upstream. The delta area itself consists of a virtually perfect triangle, enclosed by the outer two branches (Chilia in the north and Sfîntu Gheorghe in the south; Fig. 2.1). This triangle is composed almost entirely of a virtually untouched wetland area with lots of smaller and larger freshwater bodies interspersed with vast reed beds, woodland and shrubs (Fig. 2.2; Hanganu *et al.* 2002). In the northwest, a large part (the Pardina) has been reclaimed for agricultural use as late as the 1970s and other human influences include the digging of canals for shipping and the existence of artificial fishponds. The latter are not in use any longer. The highest density and diversity in smaller and larger water bodies is found in the central and northern parts of the delta, particularly between the central branch (Sulina) and the northern Chilia branch and just south of the Sulina branch (Fig. 2.1). Some sandy outcrops of marine origin occur in the easternmost part of the delta. Further south two large former lagoons are situated, lakes Razim and Sinoe, which have been separated from the Black Sea and have since become fresh. Active delta formation nowadays only proceeds along the Chilia branch (having the highest discharge and consequently the highest sediment load) on the Ukrainian side of the border. Here a 'secondary delta' is still being formed. Further upstream, the Ukrainian side of the original Danube floodplain has been converted to agricultural land. However, this landscape is still marked by the presence of some large and shallow freshwater lakes, fringed by extensive riparian vegetation zones, as can be appreciated in the true-colour satellite map of the area (Fig. 2.3). Hydrologically and ecologically these lakes are still connected to the Danube Delta, although they are not (yet) included within the boundaries of the Biosphere Reserve.

2.2 Field surveys

All of the fieldwork has been carried out during the breeding seasons of 2001 and 2002, during the periods of 15 May - 15 June 2001, 13 April - 18 May 2002 and 3 - 11 June 2002. Fieldwork aimed to localise and assess breeding colonies of pelicans, cormorants, herons, spoonbills and ibises, gulls, terns and waders all over the Romanian and Ukrainian territories of the Danube Delta area. In 2001 the entire period of fieldwork was dedicated to the larger Romanian part of the delta, in 2002 part of the

Fig. 2.1.
The Romanian and Ukrainian Danube Delta Delta area with topographic names.

Fig. 2.2.
Vegetation map of the entire territory of the Romanian and Ukrainian Danube Delta Biosphere Reserve, based on the work of Hanganu *et al.* (2002).

- seashore vegetation
- coastal dune vegetation
- saltmarsh vegetation
- inland dune vegetation
- dry steppe vegetation
- grassland on river levee
- reedmace vegetation
- sedge vegetation
- reed vegetation
- vegetation of reed and trees
- salinated reed vegetation
- reed and trees on plaur
- dune forest
- floodplain forest
- floodplain bushes
- floating aquatic vegetation
- submerged aquatic vegetation
- clear water
- turbid water (algae or silt)
- agricultural polder

0 15 30 kilometers

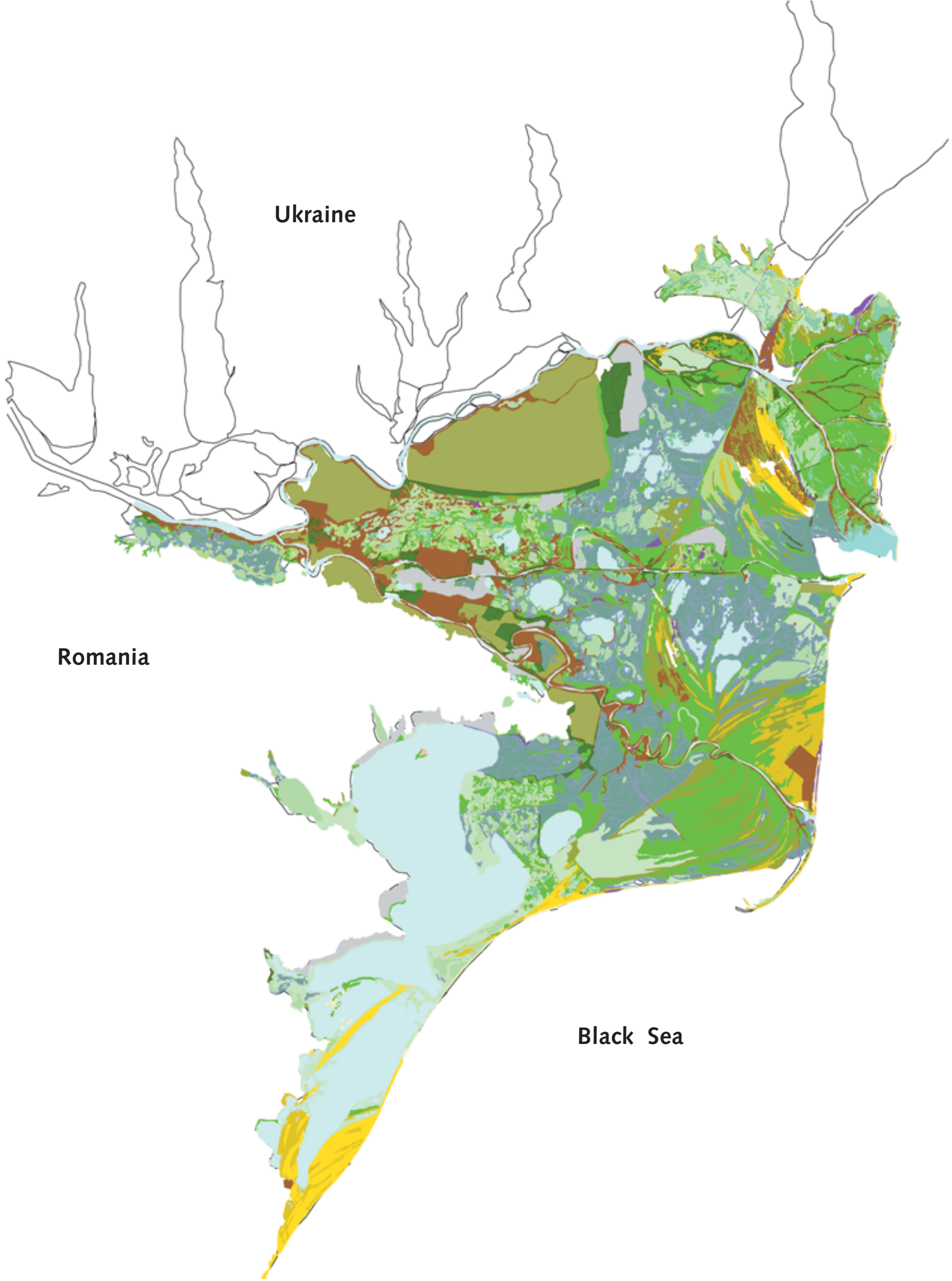


Fig. 2.3.
Satellite images (true-colour) of international Danube Delta area. Differences between water bodies (dark) and natural vegetation (green) and agricultural landscapes (reddish) are clearly distinguishable.

fieldwork was carried out on the Ukrainian side of the delta (30 April - 9 May 2002). In Romania only the territory within the boundaries of the Danube Delta Biosphere Reserve was surveyed, while in the Ukraine also a number of wetland sites outside these boundaries were included, particularly along the reed-fringed banks of some larger lakes.

In spring 2001, the fieldwork was mainly carried out by J. Botond Kiss (DDNI) and Maarten Platteeuw (RIZA), with help from Ceico Tănase and Eduard Axente (both DDBRA) and Paul Cîrpaveche, Gheorghe Băcescu, Benone Maftei and Vasile Amariei (all DDNI). Between 7 and 14 June the Romanian-Dutch fellowship was temporarily joined by Nicolas Sadoul (Tour du Valat) and Pierre Defos du Rau (Office National de la Chasse et de la Faune Sauvage). In April/May 2002 again J. Botond Kiss and Maarten Platteeuw participated in most of the fieldwork. From 22 April till 9 May they were assisted by Michael Ye. Zhmud (Ukrainian DDBR), both during Romanian and Ukrainian field visits. Field assistance on the Romanian side was received by the same persons as during the first year. During the second period of survey in June 2002, fieldwork was carried out by J. Botond Kiss, Nicolas Sadoul and Yves Kayser (Tour du Valat).

2.2.1 Ground-based colony counts

Ground-based searches for and counts of colonies have been carried out on 19 days in 2001 (10 days in May and 9 in June) and on 31 days in 2002 (11 in April, 9 in May and 11 in June). Most ground-based surveys were done from small and slim motorboats with a draught of about 20 cm. With this type of vessel it was possible to enter many of the colony sites in order to make assessments on bird attendance, species composition, total nest numbers and some physical characteristics such as vegetation, water depth etc.. The exact geographical position was measured by GPS. Whenever possible, additional data on clutch size (*e.g.* with ground-nesting gulls), brood size (in some cormorant colonies) or on diet composition (on the basis of ejected fish remains) were recorded as well.

Traditionally well-known colony sites were relatively easy to find, thanks to the experience of the field workers. The actual entrance of these sites and the subsequent assessment of the numbers and species of the breeding birds present were, however, rather more problematic. Particularly in 2002, when the water table was markedly lower, many colonies could not be visited completely from the ground. In these cases, overview impressions obtained from climbing surrounding trees had to be combined with direct counts from the ground to get an overall estimate of the bird numbers present. In some instances, additional information on extent and/or size, or exceptionally even location, of the colonies was obtained from local wardens.

Locating new or not previously known colony sites during ground-based surveys proved to be much more difficult. A very high proportion of the terrain of the Danube Delta consists of almost impenetrably dense and extensive Reed beds, hardly if at all interspersed by either water or other vegetation types (*cf*. Hanganu *et al.* 2002), and consequently cannot be surveyed comprehensively from the ground. Due to lack of proximity of gradient-rich feeding sites and lack of safe nesting trees, it would seem unlikely that these extensive Reed monocultures hold many colony sites, but particularly of some unobtrusive species like the Purple Heron *Ardea purpurea* colony sites have probably been missed. Very much the same applies for the enormous array of middle-sized and small lakes in the central part of the Delta, which proved to be impossible to explore entirely. Here, the most likely species to be missed because of incomplete ground coverage was the Whiskered Tern *Chlidonias hybridus*, a characteristic breeding bird of lakes covered by floating leaf aquatic vegetation (Nymphaeids or *Stratiotes*).

2.2.2 Aerial surveys of the colonies

The sheer size of the Danube Delta area and its difficult accessibility made it clear from the outset of the project that any attempt at a comprehensive overview of the area's breeding colonial birds should include aerial surveys. These surveys were considered necessary to remedy the shortcomings of ground-based surveys mentioned above, namely the difficult access to and the overview conditions on the known colony sites as well as the difficulty of finding new or unknown sites in the immense vastness of inaccessible wilderness.

Aerial surveys were carried out on four days during the two breeding seasons of 2001 (8 June) and 2002 (8 May, 13 May and 6 June). In all cases, the plane was a double-winged engine (type Antonov), normally used for spraying the fields with pesticides. Visibility was only good from the co-pilot's seat, where a window could be opened.

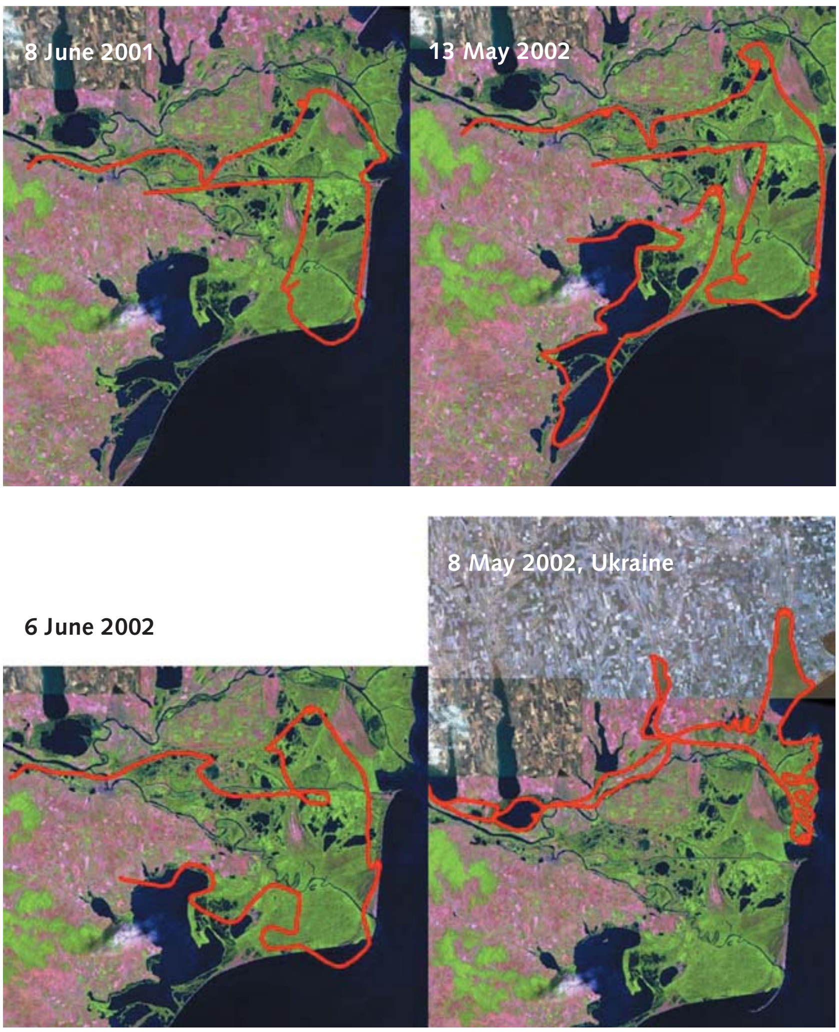


Fig. 2.4.
Approximate routes followed during the aerial surveys for breeding bird colonies in the Danube Delta in 2001 and 2002. The 2001 route over the Romanian side was determined by an attempt to cover all known colony sites from previous years. In 2002 approximately the same route was flown twice, with an additional flight over the southern lagoon area aimed at localising unknown sites. All Romanian routes were chosen based on the field experience of J.B. Kiss. The 2002 Ukrainian route aimed at localising all known and potential colony sites within the boundaries of the Biosphere Reserve as well as along the marshy fringes of the larger Danube lakes. This route was chosen based on the field experience of M.Ye. Zhmud.

Additional observations were made from the right-hand side of the plane through little and rather dirty windows, but these only allowed a rather blurred view of reality.

The first flight took place on 8 June 2001 and covered the entire central and northern part of the Romanian Danube Delta, south to the mouth of the Sfîntu Gheorghe branch, the Sachalin peninsula and lake Lejai. The entire area further south, including Holbina and the former lagoon systems of lakes Razim and Sinoe, remained uncovered. This flight lasted for a total of four hours (take-off at 9:01 h and landing at 14:03 h) and was performed at varying heights, mainly between 100 and 200 m. The route went from upstream of Tulcea eastwards, north of the Sulina branch, over the colonies of Purcelu, Nebunu and Martinca, close to Mila 23, then down to Obretinu Mic and north again towards Rosca-Buhaiova. From there it led eastwards until the Ukrainian border, then again southwards along the coast to the town of Sulina and then further south along the coast to Sfîntu Gheorghe. South of Sfîntu Gheorghe the Sachalin peninsula was surveyed, after which slightly further west the well-known colony sites at lake Lejai (Dalmatian Pelican *Pelecanus crispus*) and Crasnicol-Belciuc (Great Cormorant *Phalacrocorax carbo*) were checked. From there the route went back northwards to lake Bondar and finally west again to Tulcea Airport (Fig. 2.4). A total stretch of about 280 km of Danube Delta was covered by this flight. This aerial survey was completely covered by video with the intention to be able to control the visual counts by means of video-taped images. Evidently, the cameraman was seated in the co-pilot's seat. Whenever a colony was found, some circling was performed around the colony, always maintaining the birds to the right-hand side of the aircraft. Observers were Nicolas Sadoul, Pierre Defos du Rau, J. Botond Kiss and Maarten Platteeuw. Checks of the videotape with the field estimates made by Nicolas Sadoul and Maarten Platteeuw were carried out afterwards by the latter.

The second day of aerial surveys was 8 May 2002 and was completely dedicated to the Ukrainian side of the Danube Delta. During three consecutive flights of 2 hour 3 minutes (9:37 h till 11:40 h), 1 hour 55 minutes (12:08 h till 13:59 h) and 2 hours 15 minutes (16:31 h till 18:46 h),

Observers preparing to get on board the Antonov for an aerial survey, 8 June 2001.

respectively, the wetland areas of lake Chitai and the island Yermakov and the secondary delta (first flight), lake Sasyk and the Stentsovsko Zhebriansky Plavni (second flight) and the easternmost wetlands of Izmail National Park island and the lakes Kugurluy, Kartal, Kagu and Yalpuch (third flight) were covered. During these flights, two observers were seated near the pilot and the third observer watched from the right-hand side of the plane. Relatively little attention was paid to the verification of breeding bird numbers and species composition of colonies already visited from the ground. Therefore, later on the ground-based estimates were assumed to be the more correct ones. 'New' colony sites found received a more complete attention, including a best possible assessment of both species composition and total number of occupied nests. Observations were carried out by Michael Ye. Zhmud, J. Botond Kiss and Maarten Platteeuw.

The third day of aerial surveys was 13 May 2002, again referring to the Romanian side of the Danube Delta. This time two separate flights were carried out, lasting for 4 hours 24 minutes (9:41 h till 14:05 h) and for 2 hours 11 minutes (16:21 h till 18:32 h) respectively, covering subsequently the same area as last year's survey and the area further south, including Holbina and the lakes Razim and Sinoe and their reed-fringed banks (Fig. 2.4). The morning flight covered a stretch of about 314 km, the afternoon flight about 213 km. Observations were carried out by Maarten Platteeuw, the route and orientation were performed by J. Botond Kiss. The fourth day of aerial survey was 6 June 2002. During a four-hour flight, most of the Romanian Danube Delta was covered, from Parches in

Fig. 2.5.
Map of the Romanian/Ukrainian Danube Delta Biosphere Reserve, showing the transects covered by systematic counts of foraging colonial birds during ground-based surveys in both years together.

the west and the Ukrainian border in the north to lake Lejai and the NE part of lake Razim in the south (Fig. 2.4). This flight covered a stretch of about 320 km. Observers were Yves Kayser and Nicolas Sadoul, making independent numerical assessments for each colony site, while J. Botond Kiss again performed the orientation.

2.2.3 Ground-based transects

While carrying out the ground-based surveys in search of breeding colony sites, good track was kept of the routes (Fig 2.5). On these routes, all individuals of the target species (*e.g.* all colonial Pelecaniformes, Ciconiiformes and Charadriiformes) were counted. The results of these counts were expressed in densities per km covered, in order to produce approximate maps for each species of the feeding distribution during the breeding period. Clearly, most of the central, lake-rich part of the Danube delta was covered (*cf*. Fig. 2.5) and thus it is assumed that a reasonably reliable impression was obtained of the distribution of feeding colonial birds.

2.3 Food studies

Over the past 35 years, many stomachs of birds collected inside the Romanian range of the Danube Delta, mainly by regular hunting, have been analysed for food remains (Kiss *et al*. 1978, 1997, Kiss 1997, 1998, Kiss & Rékási 2002, 2003, Navodaru *et al.* 2003b, J.B. Kiss, unpublished). In these analyses, all identifiable food items inside the stomachs have been collected and identified to the lowest biological taxon possible. Of the birds, date and locality of collection were recorded, as well as (whenever possible) sex and age. For the purpose of this study, a special examination

Table 2.1.
Summary of colonial Pelecaniformes and Ciconiiformes of which stomach analyses of food choice have been carried out in the Romanian Danube Delta (J.B. Kiss, unpublished).

		sex			age			season				total
	scientific name	male	female	sex unknown	adult	juvenile	subadult	spring	summer	autumn	winter	
Great Cormorant	*Phalacrocorax carbo*	5	8	4	14	0	3	7	7	0	3	17
Pygmy Cormorant	*Phalacrocorax pygmeus*	11	34	22	60	7		0	26	36	5	67
Grey Heron	*Ardea cinerea*	2	1	0	3	0	0	2	1	0	0	3
Purple Heron	*Ardea purpurea*	14	10	4	23	5	0	1	18	9	0	28
Great Egret	*Casmerodius albus*	2	1	1	4	0	0	0	0	0	4	4
Little Egret	*Egretta garzetta*	4	3	1	8	0	0	7	0	1	0	8
Squacco Heron	*Ardeola ralloides*	9	4	4	16	1	0	6	7	4	0	17
Black-crowned Night-heron	*Nycticorax nycticorax*	6	6	21	29	4	0	10	2	11	10	33
Eurasian Spoonbill	*Platalea leucorodia*	1	0	0	1	0	0	1	0	0	0	1
Glossy Ibis	*Plegadis falcinellus*	11	17	5	20	13	0	2	12	14	5	33

Table 2.2.
Summary of colonial Charadriiformes of which stomach analyses of food choice have been carried out in the Romanian Danube Delta (J.B. Kiss, unpublished).

		sex			age			season					total
	scientific name	male	female	sex unknown	adult	juvenile	subadult	spring	summer	autumn	winter	unknown	
Collared Pratincole	*Glareola pratincola*	2	2	0	0	4	0	0	0	4	0	0	4
Black-headed Gull	*Larus ridibundus*	36	13	24	55	18	0	15	8	48	1	1	73
Pontic Gull	*Larus cachinnans*	1	4	2	1	6	0	3	1	3	0	0	7
Common Tern	*Sterna hirundo*	38	34	15	82	5	0	3	60	21	0	3	87
Whiskered Tern	*Chlidonias hybridus*	8	4	4	16	0	0	1	7	8	0	0	16

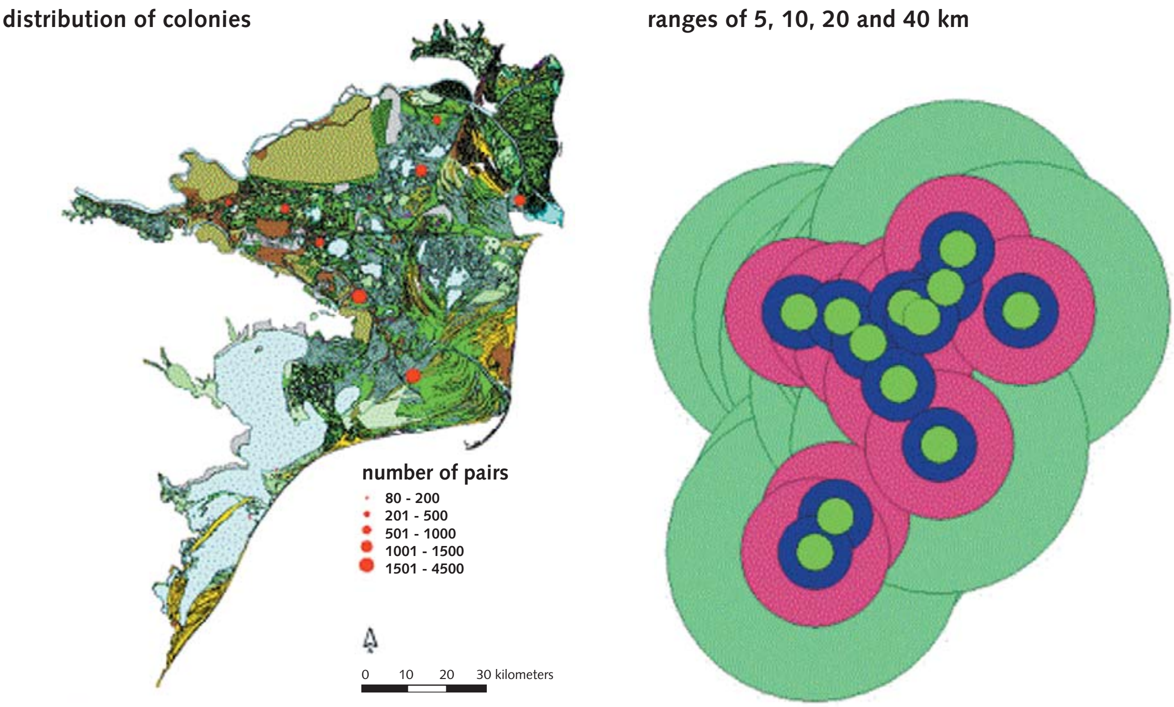
was made of the analyses carried out on colonially breeding Pelecaniformes and Ciconiiformes (Table 2.1) and on colonially breeding Charadriiformes (Table 2.2).

2.4 Data analysis

The spatial analysis of the sites and sizes of the bird colonies was carried out in a GIS (Geographical Information System). All colony sites were plotted as accurately as possible. For those colonies visited from the ground, these plottings took place on the basis of GPS measurements, while the colonies which were only seen from the air or of which information was obtained from others were plotted as well as possible. Besides the exact site of the colonies, their species composition as well as the most reliable estimate of apparently occupied nests in 2001 and in 2002 were included in the database.

The vegetation map compiled by Hanganu *et al.* (2002) for the entire transboundary Danube Delta Biosphere Reserve (Fig. 2.2) was used as one of the most important backgrounds for interpretation of the site choice by

Fig. 2.6.
An example (Great Cormorant colonies in 2001) of how the spatial analysis of the surroundings of colony sites has been approached. On the basis of the distribution of colony sites and the vegetation type map (left), the theoretical daily feeding ranges were calculated for flying distances of 5, 10, 20 and 40 km (right). Within each of these circles the exact surface areas of suitable feeding habitat could be calculated and related to the size of the respective colonies.



Great Cormorant Phalacrocorax carbo

the colonial birds. One of the main analyses was focused on the availability of suitable feeding grounds in the immediate surroundings of the located colony sites. In order to do this, the amounts of suitable feeding area within different ranges from the identified colony sites were calculated in GIS (as shown in Fig. 2.6 for the Great Cormorant). Thus, correlations could be looked for for each species between the size of the colonies and the amount of available feeding habitats within the most likely flying range for each species.

Bird's view of Hrecisca colony of Great White Pelican.

3 Field surveys and reliability of estimated breeding numbers

Because of their top position in the food web, birds are suitable as indicators of environmental changes, such as climate, landscape, pollutants, prey stocks etc. (Morrison 1986, Furness & Greenwood 1993, Kushlan 1993). Bird counts, the most widespread form of monitoring, aim at detecting population fluctuations in time (Koskimies & Väisänen 1991). It is generally assumed that variation in counts reflects the environmental conditions encountered by birds. Therefore, bird counts appear to be useful for describing the health of a population or of the environment. Finally, evaluation of human impact on the environment appears to be the main goal of this kind of monitoring within the framework of conservation.

However, all census techniques suffer from several types of additive errors (missing data, visibility or counting errors) and detection of demographic trends in bird populations can be statistically difficult. The reliability of estimated breeding numbers depends on several biases which vary at both temporal and spatial levels (Verner 1985, Koskimies & Väisänen 1991, Bibby *et al*. 1992). At the site level, estimated numbers at one time vary in regard to the real numbers in function of the methods used and the site characteristics. Secondly, the maximum numbers of breeding pairs in a given year depend on the moment of the census with respect to the phenology of the reproduction. Thirdly, at the regional level, numbers can be viewed as the sum of the numbers of each colony detected. Then, the bias is directly linked to the detection probability of the colonies and refers to the coverage of the overall region. We aim in this chapter to estimate the reliability of the survey realised in the Danube Delta Biosphere Reserve in 2001 and 2002, mainly in the Romanian part, by examining the biases encountered at the three levels. This analysis allows us to propose proposals and recommendations for future surveys.

3.1 Pelecaniformes and Ciconiiformes

As always with field estimates of breeding bird numbers, the question arises, up to which point the final results can be considered reliable. In the case of colonial Pelecaniformes and Ciconiiformes in the Danube delta, the reliability of the population estimates depends basically on two questions:

1. Have all colonies of the 13 target species actually been localised?
2. How good are the estimates of breeding pairs in each of the colonies found?

The first question addresses the matter of difficulty in localising all colonies in a vast and inaccessible territory as the Danube delta and its potential influence on the total numbers of breeding birds estimated. It concerns the completeness of the survey. The second question regards the difficulties of correctly estimating breeding bird numbers in a colony, once the latter has been found.

Due to the huge size of the Danube delta and the inaccessibility of much of its territory, it is logistically almost impossible to cover the entire area by ground surveys, either by boat or on foot, within any single breeding season. Therefore, 'new' (formerly unknown) colony sites will only be found during these surveys by coincidence, because of direct clues from observed bird movements in the field or thanks to information provided by local guards or fishermen. This, of course, means a tremendous drawback for obtaining a sufficient degree of certainty for the assumption that all, or at least most, colonies will actually be found during any single season. In the present study, this drawback has been recognised and has been the main reason for including aerial surveys in both years.

Moreover, the objective of the census was to estimate maximum possible numbers. Therefore, we chose to cover the delta not at random but focusing on areas known to be favourable in the past or to be presently occupied by birds, or estimated suitable for the settlement of colonies (stratified sampling). Are the colonies detected representative of the total numbers in the area?

3.1.1 Completeness of the survey

The combined total of colony sites of Pelecaniformes and Ciconiiformes found in the Danube delta during the seasons of 2001 and 2002 amounts to 77, 33 of which were only seen during aerial surveys (= 43%). Most of these 33 sites (25; 76%) were not previously known to hold breeding pairs of pelecaniform and/or ciconiiform birds. In contrast, from the 44 colony sites which were found during the ground surveys, only 12 sites (= 27%) involved previously unknown ones. In summary, this means that 25 out of 77 localised colonies (= 32%) would have remained unknown if only ground surveys had been carried out and that 68% of the 'new' sites was found during aerial surveys (N = 37). It may therefore be concluded that aerial surveys contribute significantly to discover formerly unknown colony sites.

The contribution of newly discovered sites to the total population estimates of the Danube delta, however, generally proved to be less substantial. For all species together, 10% of the breeding pairs were found in new colonies in 2002 and 13% in 2002 (Table 3.1), in spite of the fact that in 2001 10% of the colony sites were 'new' (N = 30) and in 2002 53% (N = 72). Large species-specific differences occur in the contribution of new colony sites to the total estimates of breeding pairs (Table 3.1). Thus, Great White and Dalmatian Pelicans were never found breeding outside known colony sites, while in 2001 46% and in 2002 even no less than 89% of all Great Egrets were registered in formerly unknown sites. For the two cormorant species, the minimum contribution of new sites was nil (in 2001 for Great Cormorant) and the maximum was 29% (in 2001 for Pygmy Cormorant) (Table 3.1).

In general, it would seem that all or most of the breeding pelicans and cormorants are likely to be found in the traditionally known colonies, while among the wading birds large percentages might be breeding on new sites. This would seem to be particularly true for Great Egret *Casmerodius albus* (up to 89%) and Purple Heron (up to 65%), both species that are frequently found breeding inside inundated Reed *Phragmites australis* beds and apparently do not need trees (Great Egret) or even tend to avoid them (Purple Heron). The likelihood of finding a 'new' colony site in Reed beds is much lower than of localising one in tree stands or on bare islets. Localising a Reed bed colony of Great Egret, in its turn, is easier than finding one of Purple Heron, which due to its predominantly brownish plumage is far less conspicuous among the Reed stands. On population

Table 3.1.
Numbers of breeding pairs estimated at formerly unknown colony sites ('new') and traditionally known sites ('old') and the contribution of 'new' sites to the total population estimates in 2001 and 2002.

	new	old	population in 'new' colonies (% of total)
spring 2001			
Great White Pelican	0	3520	0
Dalmatian Pelican	0	454	0
Great Cormorant	0	16161	0
Pygmy Cormorant	2500	6240	29
Great Egret	140	167	46
Grey Heron	37	476	7
Purple Heron	0	450	0
Little Egret	200	1785	10
Squacco Heron	500	1905	21
Cattle Egret	0	12	0
Black-crowned Night-heron	300	1840	14
Eurasian Spoonbill	0	218	0
Glossy Ibis	200	1855	10
total	3877	35083	10
spring 2002			
Great White Pelican	0	4160	0
Dalmatian Pelican	0	420	0
Great Cormorant	3105	19682	14
Pygmy Cormorant	271	9070	3
Great Egret	653	77	89
Grey Heron	195	393	33
Purple Heron	259	140	65
Little Egret	346	1379	20
Squacco Heron	115	1164	9
Cattle Egret	0	3	0
Black-crowned Night-heron	837	2127	28
Eurasian Spoonbill	135	204	40
Glossy Ibis	500	2840	15
total	6416	41659	13

level, it may thus be concluded that missing colony sites is unlikely to occur for pelicans and will have a limited influence on estimates for cormorants. However, for Great and particularly for Purple Herons this factor is likely to lead to considerable underestimates. Other heron species seem to be more confined to well-known colony sites (Table 3.1) and therefore would seem to be less subject to underestimation. Eurasian Spoonbills *Platalea leucorodia*, which frequently breed on the ground, tend to shift colony sites quite often (in 2002 no less than 40% of the breeding population was found on new sites; Table 3.1). However, these birds prefer more open situations than herons and are quite conspicuous due to their white plumage. Finally, the Glossy Ibis *Plegadis falcinellus*, like the smaller herons, mostly breeds on the traditionally known spots.

3.1.2 Reliability of the counts

The counts themselves are, of course, also subject to many mistakes. During ground-based surveys one of the major drawbacks is the fact that in many colonies it is extremely difficult to obtain good overviews over the entire nesting area. Although some colonies can be visited almost entirely by boat or even on foot, thereby allowing an almost exact count of nests per species, most colonies can only either be visited partly or, worse, be overlooked partly, often by climbing surrounding trees (Fig. 3.1). In these instances, it was often only barely possible to obtain a rough impression of the total amount of nests in combination with an equally rough estimate of the species composition that actually produced the overall assessment of the size and species composition of the site. In some colonies that could not be visited or overlooked over their entire surface area, additional information could be obtained from local guards who had been visiting the area on other occasions (*e.g.* the colony of Climova in 2001 by courtesy of Gheorghe Bacescu from Murighiol).

Fig. 3.1.
Observer climbing a tree to obtain a better overview over a tree-based colony of cormorants and wading birds on the Romanian side of the Danube delta.

Table 3.2.
A comparison between ground and aerial survey for the same colonies counted in both ways during the two seasons. Mean colony sizes (number of pairs/nests) and corresponding standard deviations are given, as well as the number of times in which either of the counts yielded the highest results.

		ground count	air count	ground count higher	air count higher	both counts equal
Great Cormorant	mean	714.46	766.54	5	7	1
Phalacrocorax carbo	standard deviation	626.13	553.62			
	number of colonies	13	13			
Pygmy Cormorant	mean	482.31	842.31	2	11	0
Phalacrocorax pygmeus	standard deviation	418.27	644.16			
	number of colonies	13	13			
Grey Heron	mean	19.40	14.60	7	6	2
Ardea cinerea	standard deviation	23.30	13.03			
	number of colonies	15	15			
Great Egret	mean	3.88	8.13	1	5	2
Casmerodius albus	standard deviation	4.04	6.51			
	number of colonies	8	8			
Little Egret	mean	118.17	116.25	4	7	1
Egretta garzetta	standard deviation	156.40	71.45			
	number of colonies	12	12			
Squacco Heron	mean	139.23	90.38	5	8	0
Ardeola ralloides	standard deviation	195.76	74.26			
	number of colonies	13	13			
Black-crowned Night-heron	mean	133.33	150.00	5	9	1
Nycticorax nycticorax	standard deviation	123.67	149.52			
	number of colonies	15	15			
Eurasian Spoonbill	mean	7.89	17.00	4	5	0
Platalea leucorodia	standard deviation	13.56	15.95			
	number of colonies	9	9			
Glossy Ibis	mean	254.00	220.50	5	5	1
Plegadis falcinellus	standard deviation	233.76	224.88			
	number of colonies	11	11			

For most colonies another check on the correctness of the figures obtained during the ground surveys was possible in both years during the aerial surveys. However, it has to be kept in mind that accurate counts from the air proved to be almost as difficult as from the ground. Particularly the smaller species of wading birds (*e.g.* Squacco Heron, Black-crowned Night-heron and above all Glossy Ibis) proved to be extremely difficult to see, since they tend to nest quite low in the trees. The advantage of the aerial survey, on the other hand, was that at least all colonies spotted could be overseen entirely.

For nine species, estimates of colony sizes were obtained within one season by both ground and aerial surveys. In five of these the mean colony size as estimated from the air was larger than the mean ground estimate (*e.g.* for Great and Pygmy Cormorant, Great Egret, Black-crowned Night-heron and Eurasian Spoonbill; Table 3.2). The other four species (Grey Heron, Little Egret, Squacco Heron and Glossy Ibis) were counted in on average higher numbers during ground surveys. In general, the differences

Table 3.3.
A comparison of the aerial surveys of the central Romanian Danube Delta Biosphere Reserve of 13 May 2002 and 6 June 2002. Mean colony sizes and corresponding standard deviations are given, as well as the frequency with which either of the counts provided the highest figures.

species		aerial survey 13 May	aerial survey 6 June	highest count on 13 May	highest count on 6 June
Great White Pelican	mean	1800	1960	1	1
Pelecanus onocrotalus	standard deviation	2404	2715		
	N	2	2		
Dalmatian Pelican	mean	400	1308		
Pelecanus crispus	standard deviation	0	0		
	N	1	1		1
Great Cormorant	mean	1240	679	3	2
Phalacrocorax carbo	standard deviation	1293	955		
	N	5	5		
Pygmy Cormorant	mean	150	975		4
Phalacrocorax pygmeus	standard deviation	173	731		
	N	4	4		
Grey Heron	mean	14.4	11.2	2	1
Ardea cinerea	standard deviation	19	11		
	N	5	5		
Great Egret	mean	0.5	2		1
Casmerodius albus	standard deviation	0.7	2.8		
	N	2	2		
Little Egret	mean	94	153.4	2	3
Egretta garzetta	standard deviation	93	96		
	N	5	5		
Squacco Heron	mean	61	86	2	3
Ardeola ralloides	standard deviation	119	73		
	N	5	5		
Black-crowned Night-heron	mean	54	226	1	3
Nycticorax nycticorax	standard deviation	83.8	203		
	N	5	5		
Eurasian Spoonbill	mean	12.5	11.25	1	3
Platalea leucorodia	standard deviation	25	7.8		
	N	4	4		
Glossy Ibis	mean	34	278		5
Plegadis falcinellus	standard deviation	65	260		
	N	5	5		

in mean colony size estimated in the two ways were not very different, with the exception of Pygmy Cormorant and Great Egret, which were both significantly better seen from the air. Aerial surveys gave higher estimates than ground surveys in 63 cases, ground surveys were higher in 38 cases and in eight cases the results were exactly the same (Table 3.2).

Important differences also existed between individual observers. Both during ground surveys and aerial assessments large differences in estimates of occupied nests occurred within the same count, although in the latter case the differences tended to be greater. Due to the difficulty of obtaining good overviews, it was generally assumed that the highest estimates were the closest approximation to the true numbers. Only in a few special cases, where evident misidentifications appeared to have occurred, the lower numbers were taken to be better estimates. A very special case was presented by the colony of Lejai, where on 6 June 2002 no less than 1308 apparently occupied nests of Dalmatian Pelican were counted (Table 3.3), more than twice as many as were counted on 13 May. This astonishingly high estimate was not adopted as the most likely one, because in view of all knowledge on previous years it was considered to be highly unlikely that so many nests would actually exist (pers. comm. A. Crivelli).

In the breeding season of 2002 aerial surveys were carried out on the Romanian side of the Danube Delta Biosphere Reserve on two quite different dates, on 13 May and on 6 June, in order to eliminate some of the bias of date. These two counts yielded very different results, due to the phenology of the different species. The 13 May survey was probably carried out too early in the breeding season, since eight out of 11 species, were counted in on average higher numbers in June (Table 3.3). Only Great Cormorant, Grey Heron and Eurasian Spoonbill, all three notoriously early breeders, were found in higher numbers in May. The differences were particularly high in the later breeding species: Pygmy Cormorant, Little Egret, Squacco Heron, Black-crowned Night-heron and Glossy Ibis. For all these species, the highest counts have been assumed to be the better ones. Moreover, it is concluded that, although for some species the months of April and May might provide better estimates than counts later in the season, the best estimates of all species are likely to be obtained in the first week of June.

3.2 Charadriiformes

3.2.1 Colony detection and the coverage of the Danube Delta Biosphere Reserve

The Danube delta was covered from the ground or from the air. From the ground, the percentage of the area surveyed was a function of visibility, which depended on:

I) limited accessibility;

II) the presence of vegetation masking partly the area from the point of observation, as it was the case in the Reed beds;

II) the surface area to cover from the point of observation, the opposite side of very large lagoons, such as Zmeica, not being visible.

However, except for long distance, the presence of birds flying up and down was a good indicator of the presence of a colony, even if the area was only partially visible. From the plane, the detection probability depended on the size of the colony, a colony below hundred pairs being almost undetectable, and on the route of the plane.

In 2001, the lagoon area of the Romanian Danube Delta Biosphere Reserve has been partly covered from the ground, whereas the fluvial and coastal areas were covered by plane on 8 June and by boat (*cf.* Fig. 2.5). However, regarding their environmental characteristics or their past use known from literature, several sites not visited seemed favourable for breeding Charadriiformes. One of us (JBK) has estimated the possibility of missing small, medium or large colonies in these areas in regard to their habitats (Table 3.4). Two areas, Grindul Chituc-Edighiol and Buhaz Zaton, are large and poorly visited for a long time due to the difficult access and may have hosted large colonies. However, concentrations of birds were not observed in the vicinity of the former one and it seemed plausible that no large colony was present in 2001. On the contrary, several hundreds and thousands of Sandwich Tern *Sterna sandvicensis* were observed not far from Buhaz Zaton area, on the Sachalin peninsula on 30 May and 8 June 2001 respectively. We did not know whether Buhaz Zaton presented potential nesting sites (principally island isolated from predation) and if a colony was present there. Otherwise, it was expected that the probability to miss large colonies was small.

Table 3.4.
Sites not covered during the 2001 census, which may be favourable for breeding colonial Charadriiformes (excepted Whiskered Tern), numbers (small: < 50 pairs, 50 < medium < 500 pairs, large: > 500 pairs) and probability of occurrence. All colony site names with their co-ordinates are given in Appendix 1.

Sites	Species concerned	Numbers	Probability
IN THE LAGOON AREA			
Sites used in the past			
Nuntasi lake	None	No	Sure
Istria lake	All species	Small	Likely
Grindul Saele	Black-winged Stilt, Pied	Medium	Likely
	Avocet, Collared Pratincole	Small	Likely
Lunca-Jurilovca	Black-winged Stilt	Small	Likely
Sarinasuf	Pied Avocet, Black-winged Stilt	Small	Unknown
Holbina I and II	All except Collared Pratincole	Medium	Unknown
Grindul Lupilor	Black-winged Stilt	Small	Unknown
Potential sites:			
Grindul Chituc, Edighiol	All species	Large	Unknown
Lake west of Sinoe	All species	Medium	Unknown
Zmeica lake	Black-winged Stilt	Small	Unknown
Agighiol	All species	Small	Unknown
Coseni lake	Pied Avocet, terns and Black-winged Stilt	Small	Unknown
Leahova lakes	Terns	Medium	Unknown
Grindul Perisor	Collared Pratincole	Small	Unknown
IN THE FLUVIAL AND COASTAL AREA			
Sites used in the past			
Caraorman	Black-winged Stilt, Pied Avocet	Small	Unknown
Sulina	Black-winged Stilt	Small	Unknown
Letea	Black-winged Stilt	Small	Unknown
Chilia veche	Black-winged Stilt	Small	Unknown
Somova	Common Tern	Small	Unknown
Dranov	None		Likely
Potential sites:			
Buhaz Zaton area	All species except Collared Pratincole	Large	Unknown

Except for Caraorman area, all the areas not covered in 2001 were covered at least partially in 2002 from the ground or by plane on 13 May and 6 June (cf. Figs 2.4 and 2.5, Table 3.5). As expected, only 3 small colonies were discovered in the area not covered in 2001. In the same time, two small colonies and a medium one absent in 2001 were discovered in 2002, whereas two small colonies from 2001 were absent in 2002. Our efforts were concentrated on wetlands and surrounding areas. However, the Collared Pratincole is the species least attached to wetlands and may breed at a certain distance to these habitats. Thus, we discovered a colony of 22 pairs in a sunflower field near Sinoe town in 2002. This species would need a specific effort of exploration in arid habitats and agriculture land surrounding wetlands.

Moreover, the Romanian Danube Delta Biosphere Reserve was not covered completely in 2001 and 2002. During the aerial survey, the area covered by the plane was about 500 m width and the route distance was 208 km, 527 km and 320 km for 8 June 2001, 13 May and 6 June 2002 surveys, respectively. Thus, we covered about 104, 263 and 160 km^2 respectively, which represented approximately 1.7, 4.2 and 2.5 % of the surface area of the Romanian Danube Delta Biosphere Reserve. However, since the routes were chosen to cover most of the suitable breeding habitats (stratified sampling), the percentages of coverage were actually much higher.

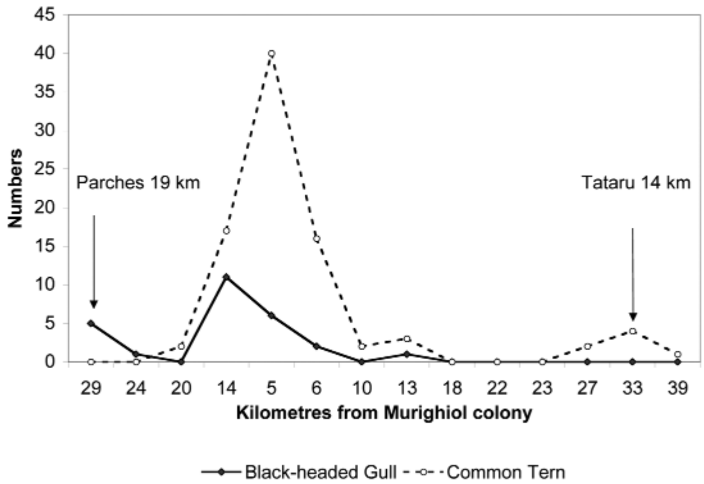
Table 3.5.
Methods used for the survey, factors limiting the detection of the colony and numbers of breeding pairs (small: < 50 pairs, 50 < medium < 500 pairs, large: > 500 pairs) for each site covered during the survey in 2001 and 2002 in the Romanian Danube Delta Biosphere Reserve. All colony site names with their co-ordinates are given in Appendix 1.

Sites Methods	Coverage	Limiting	Presence in factors	2001	2002
LAGOON AREA					
Visited in 2001 and 2002					
Grindul Saele	Ground	Partly	Large	Small	Small
Murighiol lake	Ground	Entirely	No	Large	Large
Plopu lake	Ground	Entirely	No	Small	Small
Sinoe lake	Ground	Entirely	No	Medium	Medium
East Sinoe Town	Ground	Entirely	No	0	Small
Vadu	Ground	Entirely	No	Large	Large
Insula Bisericuta	Ground	Entirely	No	0	Small
Visited in 2002 only					
Babadag lake	Ground	Partly	Vegetation	-	Small
Enisala sugar basin	Ground	Entirely	No	-	Small
Nuntasi lake	Ground	Partly	Large	-	0
Istria lake	Ground	Partly	Large	-	0
Sarinasuf	Ground	Partly	Vegetation	-	0
Agighiol	Ground	Partly	Vegetation	-	0
Grindul Chituc	Ground and Aerial	Partly	Large	-	0
Zmeica lake Ground and	Aerial	Partly	Large	-	0
Lunca-Jurilovca	Aerial	Partly		-	0
Holbina	Aerial	Partly		-	0
Coseni lake	Aerial	Partly		-	0
Leahova lakes	Ground and Aerial	Partly	Large	-	0
Grindul Perisor	Aerial	Partly		-	0
FLUVIAL AND COASTAL AREA					
Visited in 2001 and 2002					
Parches SE	Aerial	Entirely		0	Medium
Sf Gheorghe Tataru	Ground and Aerial	Partly	Vegetation	Small	0
Sachalin	Ground and Aerial	Entirely	No	Small	0
Sulina	Aerial	Partly		0	0
Letea	Aerial	Partly		0	0
Chilia veche	Aerial	Partly		0	0
Somova	Aerial	Partly		0	0
Visited in 2001 only					
Hrecisca	Ground	Partly	Access	Small	-
Visited in 2002 only					
Tataru lake Ground	Partly	Access		-	Small
Dranov	Aerial	Partly		-	0
Buhaz Zaton area	Aerial	Partly		-	0

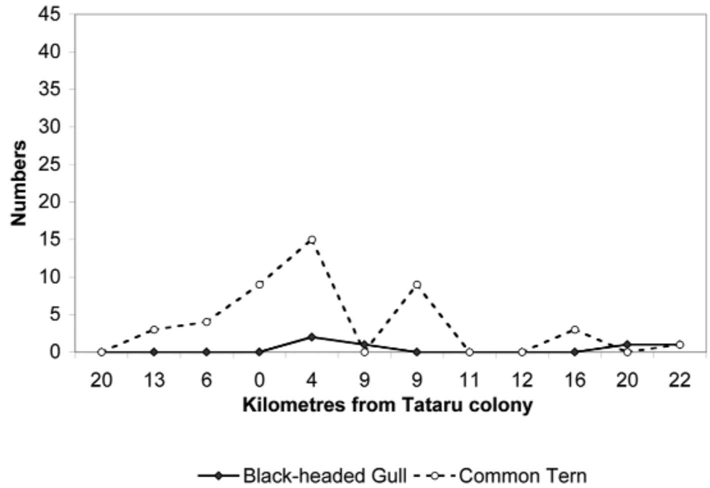
Line transect method
Because the area covered by the surveys is small with respect to the total surface area of the Danube Delta Biosphere Reserve, one may ask if the present counts are representative of the real numbers breeding there. The fluvial ecosystem was the part of the delta less well covered due to the low accessibility. On 12 and 13 June 2002, we went by boat respectively from Tulcea to Sfîntu Gheorghe, via the Sfîntu Gheorghe arm of the Danube, and from Sfîntu Gheorghe to Crisan, via Tataru canal, Tataru lake, Rosu lake, Puiu lake, Lumina lake, Vatafu-Imputita canal and Crisan canal. Bird counts were realised from the boat and reported for each section of the route delimited by clear landmarks (intersection with canal, villages, lakes etc.). The Pontic Gull, the Black-headed Gull and the Common Tern were the only ground nesting species observed along these transects. The distance between the middle of each section and the nearest known colony was calculated from GIS and the numbers of individuals on each section were plotted in Fig. 3.2.

Fig. 3.2.
Numbers of Black-headed Gull and Common Tern observed on each section of the transect expressed in km to the nearest colony.
Graph A: 12 June transect from Tulcea to Sfîntu Gheorghe.
Graph B: 13 June transect from Sfîntu Gheorghe to Crisan.

A



B



Black-headed Gull and Common Tern numbers increased when the distance to the colony decreased. Over 15 kilometres from the colony, very few birds were observed. For these species, this distance is chosen to represent the upper limit to forage from the colony (Brandl & Gorke 1988, Fasola &

Bogliani 1990). Near Tulcea, about 29 kilometres away from Murighiol, several Black-headed Gulls were counted, whereas several Common Terns were observed near Sfîntu Gheorghe 33 kilometres away (Fig. 3.2B). This can be explained by the presence of nearer colonies, 19 km away in lake Parches for the former species and 14 km away in lake Tataru for the latter.

The distribution of birds in relation to the Tataru colony was similar along the second transect (Fig. 3.2B). However, Common Tern numbers were more than two times smaller than along the preceding transect but the Tataru colony was also distinctly smaller than the Murighiol colony. The extreme scarcity of Black-headed Gulls here may be explained by their absence in Tataru colony.

Because the presence of foraging birds is related to the distance to the nearest colony, line transects seem to be a good method, for at least these two species, to locate the presence of potential colonies in areas where the accessibility or visibility is reduced. Then, we can conclude that there was no significant sized colony of these two species at the south of the Sulina arm.

The Pontic Gull was largely more dispersed over the area covered. No clear relationship was identified between the number of individuals and the distance to the nearest known colony (Figure 3.3). This can be due to the large foraging distance of the species (up to 30 kilometres) and the presence of non-breeding birds wandering in the delta, such as was observed all along the coastal area. The presence of not detected colonies may be another explaining factor. However, Reed beds are not usual nesting habitats for these species.

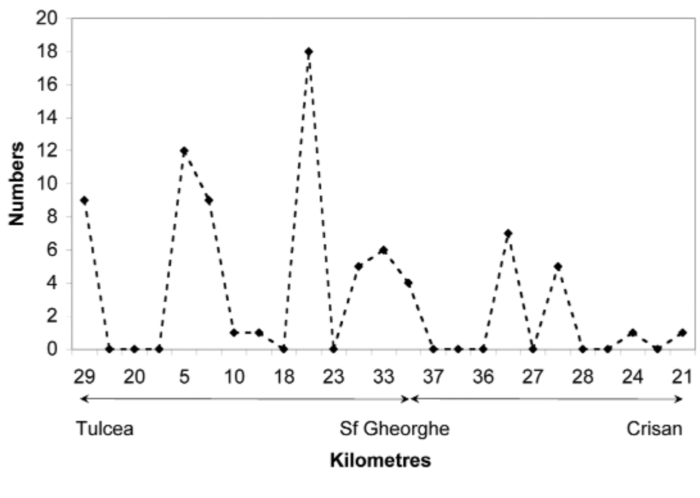


Fig. 3.3.
Numbers of Pontic Gull observed on each section of the transect, expressed in km to Murighiol, the nearest colony (12 June 2002 transect from Tulcea to Sfîntu Gheorghe; 13 June 2002 transect from Sfîntu Gheorghe to Crisan).

A third line transect has been surveyed on 14 June 2002 from Crisan to Tulcea, via Mila 23, Olguta canal, Sontea canal, south Nebunu, Alb lake (Nisipos) and Partizan. Eight Black-headed Gulls and 21 Common Terns were observed on a short distance between Nebunu and Alb lakes. No colony was found there. However, we spent some time on the search for a colony and the presence of a small colony in the area is not unlikely.

3.2.2 Estimates of real numbers on a site

The case of ground survey
Nest count: The most accurate method to estimate breeding numbers of

colonial Charadriiformes is a nest census, the observer(s) crossing the colony by foot and counting the nests. In this process, the shape and materials of the nest and the shape and colour of the eggs identify the species. This method presents the other advantage to check for nest content and to take into account breeders only. Moreover, nest content and clutch size allow to monitor the quality of the reproduction (*e.g.* abnormal small clutch size, see paragraph 3.2.3).

Several precautions must be taken to reduce the impact of the disturbance:
I) nest counts should be done early in the morning or late in the evening to prevent the negative impact of the sun on the eggs
II) because young chicks of these species may flee the nest during disturbance, counts should be done before first hatching, especially where the density is high and vegetation reduced
III) the number of observers should be adapted to the size of the colony to reduce the duration of disturbance (maximum recommended half an hour)
IV) moreover, the intrusion of the observers should not change the habitat in order to not facilitate the intrusion of predators afterwards
V) finally, the observers should be able to recognise the nest of each species with accuracy and should count together in order to prevent double counts or missing parts of the colony.

In 2001 nest counts have been done only on three sites, the islands of lake Sinoe and Bisericuta and the ship wreck on Sachalin peninsula.

Count at distance: The accuracy of the survey of colonial Charadriiformes by counting breeding pairs at distance depends on several factors: the distance between the colony and the observer, the possibility to observe from a high location, the presence-absence of vegetation, the light, the density of nests etc.
These factors varied among the different areas. In Enisala sugar basin, Murighiol and Vadu, the presence of elevated point at the periphery of the site allowed the observation from a high position. However, the presence of vegetation was a problem in the Vadu areas to estimate numbers of Collared Pratincoles *Glareola pratincola* and in the Murighiol lake for the counting of Black-headed Gull *Larus ridibundus* on the islands 12 and 13, and of Pontic Gull *Larus cachinnans* on island 14 (Fig. 3.4).

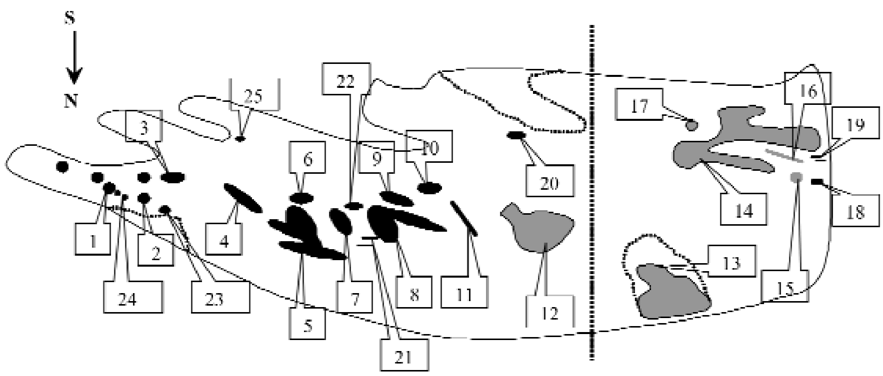


Fig. 3.4.
Representation of the Murighiol Saraturile lake indicating the presence of islands and colonies. The scale of the islands is not related to the scale of the lake and the broken line indicates a disruption in the map.

Consequently, breeding numbers were estimated from the numbers of birds flying off and descending back into the vegetation. Thus, the accuracy of the counts depended on the ratio between the number of birds present and the number of nests (between 1:1 and 2:1) and on the proportion of flying birds relative to the numbers resting on the nest. A double-observer count was realised in Murighiol in 2001 to estimate the errors (Table 3.6).

Table 3.6.
Comparison between Maarten Platteeuw (MP) and Nicolas Sadoul (NS) censuses on Murighiol lake in 2001 (eastern part refers to islands 1 to 12 and western part refers to islands 13 to 17, see Fig. 3.2)

	Eastern part			Western part		Total
Species	**MP**	**NS**	**MP**	**NS**	**MP**	**NS**
Pontic Gull						
Larus cachinnans	0	0	200	160	200	160
Black-headed Gull						
Larus ridibundus	250	284	50	110	300	394
Mediterranean Gull						
Larus melanocephalus	110	104	60	65	170	169
Common Tern						
Sterna hirundo	1100	1529	360	340	1460	1869
Black-winged Stilt						
Himantopus himantopus					20	10

Due to dense vegetation, differences in bird counts varied between 20% for Pontic Gull and 2 and 55% for Black-headed Gull.

Mediterranean Gull *Larus melanocephalus* and Common Tern *Sterna hirundo* bred on bare areas. Therefore, the differences between observers were less important and varied between 5% and 8% for Mediterranean Gull and 6% and 28% for Common Tern. For the latter species, the high density made the census at distance more difficult.

A 20% error for Mediterranean Gull and Common Tern and a 30% one for Black-headed and Pontic Gulls, nesting partly in high vegetation, would seem reasonable (Table 3.6). Because counts at distance generally lead to underestimating real numbers, it seems more realistic to take the higher numbers for each species as minimal estimates.

In Grindul Saele and at the colony of the Collared Pratincole found in a sunflower field near Sinoe town, birds were very dispersed. In such cases, a nest count is not feasible since nest detection is very low and most of the nests will not be discovered. Then a count at distance by the direct observation provides better results (Table 3.6).

The case of aerial survey
The aerial survey was mainly focused on the survey of Pelecaniformes and Ciconiiformes colonies. Firstly, the altitude of the flight was too low in order to verify the reproductive status of bird. All the birds flushed (from the nest?) and were flying when the plane passed over at about 400 m height. Consequently, errors in the count are unknown (Table 3.7) and Charadriiformes detected during the flight are indicative.

However, as for the Pelecaniformes and Ciconiiformes, an aerial survey seems necessary for the detection of Charadriiformes colonies, especially in areas where the access is difficult (see 3.2.1.).

Table 3.7.
Reliability of the bird count, function to the site characteristics and the method used, realised on the colonies of the Romanian Danube Delta Biosphere Reserve in 2001 and 2002.

Sites	Census methods	Year	Count errors%
Lagoon area			
Grindul Saele	At distance	2001-2002	20%
Murighiol lake	At distance	2001-2002	20% (Lm, Sh) 30%(Lc, Lr, Hh)
Plopu lake	At distance	2001-2002	5%
Sinoe lake	Nest count	2001-2002	5%
Vadu North and South	At distance	2001-2002	20% (Gp), 10% (others)
Insula Bisericuta	Nest count	2001-2002	5%
East Sinoe Town	At distance	2002	10%
Babadag NW	At distance	2002	20%
Enisala sugar basin	At distance	2002	10%
Fluvial and coastal area			
Sachalin wreck	Nest count	2001-2002	5%
Sf Gheorghe Tataru	At distance	2001	20%
Sachalin peninsula	At distance	2001	10%
Hrecisca	At distance	2001	20%
Bondar	Aerial	2001	?
Parches	Aerial	2002	?
Tataru lake	At distance	2002	20%

3.2.3 Phenology and schedule

Colonial Charadriiformes do not all breed at the same time and the phenology of their reproduction should be taken into account in order to survey the colonies at the period of maximum bird presence. Numbers will be underestimated if the count is carried out either too early or too late in the season.

Based on chick age, the Pontic Gull is the first breeding species of colonial Charadriiformes in the Danube delta. We observed an important difference of phenology between years and colonies (Table 3.8).

Table 3.8.
Number of nests in function of clutch size and nest contents (empty and with chicks), total breeding numbers and age of older chicks of Pontic Gull in Sinoe lagoon (nest count), Insula Bisericuta (nest count), Vostotchnoye (Ukraine, nest count) and Murighiol island 14 (count at distance).

Sinoe Date	NW-1 20/04/02	NW-2 20/04/02	NW-1 08/06/02	SE 08/06/02	NW-1 09/06/01	NW-2 09/06/01
Empty	?	2	4	2	35	6
One egg	16	3	6	1	25	0
Two eggs	50	4	2	1	30	0
Three eggs	148	10	1	0	0	0
With chicks	0	0	23	1	10	0
TOTAL	**214**	**19**	**36**	**6**	**100**	**6**
Older chicks	-	-	3 weeks	1 week	1 week	-

Other sites Date	Insula Bisericuta 10/05/02	Vostotchnoye 01/05/02	Murighiol 14 07/06/01	Murighiol 14 29/04/02	Murighiol 14 06/06/02
Empty	6	45			
One egg	2	18			
Two eggs	9	45			
Three eggs	15*	236**			
With chicks	3	41			
TOTAL	**35**	**385**	**200**	**>126**	**170**
Older chicks	1 week	?	3-4 weeks	-	4-5 weeks

* one clutch of 5 eggs;
** 6 clutches of 4 eggs and 5 clutches of 5 eggs

Based on the age of the chicks in Murighiol or direct observation of hatching in Insula Bisericuta and Vostotchnoye, the period of first hatching of Pontic Gull is in the first week of May in the DDBR. With an incubation length of about 25 days (Del Hoyo *et al.* 1996), the first laying should have occurred the first half of April. It is a little bit earlier than described by Papadopol (1980), who rarely observed the first laying at the end of April but similar to Lintia (1955). This schedule of reproduction is delayed in comparison to the closely related species Yellow-legged Gull *Larus michahellis* in the Mediterranean, in which the first laying occurs one month earlier (pers. obs. Nicolas Sadoul). This difference may be due to milder climatic circumstances in the Mediterranean. The greatest variation observed comes from the colonies in lake Sinoe, where a delay of at least 3 weeks was noted in 2001. Indeed, the majority of uncompleted clutches (one and two eggs) and the presence of one-week-old chicks (Table 3.8) seem to indicate the occurrence of second clutches after perturbation. It is thus probable that high water level due to a storm in spring had submerged the first clutches explaining this delay. According to J.B. Kiss (pers. obs.), Dalmatian Pelicans similarly failed to establish successfully after their nests had flushed away on the other island of Sinoe. In 2002, the small numbers of nests counted in June compared to the April census again indicated a similar problem in these colonies.

The difference between the counts at the end of April and in June 2002 in Sinoe and Murighiol also resulted from the census method. In Sinoe, at the end of April, nest counts certainly took place slightly before the peak of reproduction and no chicks were present yet. In June, the presence of

Table 3.9.
Numbers of pairs and of individuals (between brackets) and age of chicks of Black-headed Gull (*Larus ridibundus*), Mediterranean Gull (*Larus melanocephalus*), Common Tern (*Sterna hirundo*), Little Tern (*Sterna albifrons*), Black-winged Stilt (*Himantopus himantopus*), Pied Avocet (*Recurvirostra avosetta*) and Collared Pratincole (*Glareola pratincola*) breeding in Murighiol and Vadu in 2001 and 2002.

Date	Murighiol 07/06/01	Murighiol 29/04/02	Murighiol 06/06/02	Vadu 20/05/01	Vadu 11/06/01	Vadu 21/04/02	Vadu 07/06/02
Black-headed Gull N°	394	200 (650)	1335	0	2	0	0
Larus ridibundus chicks	2 weeks		2 weeks		No		
Mediterranean Gull N°	170	150 (30)	219	0	0	0	0
Larus melanocephalus chicks	1 week		0				
Common Tern N°	1869	15-20 (500)	3263	262	250	1 (75)	590
Sterna hirundo chicks	No		?		1-2 weeks		1-2 weeks
Little Tern N°	0	0	0	20	50	(5)	39
Sterna albifrons chicks					No		?
Black-winged Stilt N°	20	(55)	67	40	65	(37)	12
Himantopus himantopus chicks			2 weeks		1-2 weeks		?
Pied Avocet N°	0	1	5	13-15	4	(43)	7
Recurvirostra avosetta chicks			No	No	2 weeks		2 weeks
Collared Pratincole N°	0	0	0	20	340	(36)	245
Glareola pratincola chicks					No		2 weeks

vagrant chicks hidden in the vegetation outside the nest made the count more difficult. On the contrary, in Murighiol, the count was realised at distance. In April, most of the birds incubating in high vegetation were probably not detected. In June, the presence of chicks outside their nesting territory at the limit of the vegetation made the count easier.

The other species of colonial Charadriiformes breed later in the season (Table 3.9). The duration of incubation varies between 18 and 21 days (Del Hoyo *et al.* 1996) amongst the species. Consequently, the Black-headed Gull, the Pied Avocet *Recurvirostra avosetta*, the Collared Pratincole and the Black-winged Stilt *Himantopus himantopus* start to lay the first week of May. The Mediterranean Gull and the Common Tern lay one week latter. These periods are very similar to those observed in the northern Mediterranean region (pers. obs. Nicolas Sadoul). Due to the absence of chicks, it was not possible to estimate the date of hatching for the Little Tern *Sterna albifrons*.

The very strong increase of Collared Pratincole between 20 May and 11 June 2001 and the absence of chicks seem to indicate that the reproduction was clearly delayed in time. A road construction nearby the Historical City of Istria (Museum complex) during the reproduction destroyed one part of the nesting area and disturbed the numerous pratincoles present at this moment (J.B. Kiss, pers. obs.). Most of the birds recorded in the Vadu area in June should be the result of the displacement of the former colony in Grindul Saele.

We observed also an intra-specific variation in the schedule of the reproduction of the Common Tern colonies in Murighiol and Vadu in both 2001 and 2002. Despite their larger numbers in Murighiol, the colonies seem belated there. We have no clear explanation for that.

3.2.4 Final estimated numbers

The Romanian Danube Delta Biosphere Reserve

With regard to the results and the discussion developed above, it can be assumed that numbers estimated during the present surveys were quite well representative of total numbers of breeding colonial Charadriiformes in the Romanian Danube delta. The lagoon area was globally covered and the source of errors should come essentially from undetected but small colonies. In the fluvial and coastal ecosystem, the coverage was largely partial. However, line transects confirmed the very likely absence of colonies along the southern part of the Sulina branch and the possible presence of a small undetected colony in the north-western part.

Differences in numbers between 2001 and 2002 have been observed (Table 3.10). Such differences are partly due to bias in the survey. It is the case of the Pontic Gull for which numbers were larger in 2002 than in 2001. The difference came principally from the Sinoe colony that was censused in May 2002, just before hatching. The nest detection was largely higher than in June 2001 (see paragraph 3.2.2). The phenology of the reproduction may have influenced also the count of the Little Tern. Although the date of the census was similar between the two years, the reproduction may have been delayed in time in 2002 and explained the difference.

Table 3.10.
Numbers of Pontic Gull, Black-headed Gull, Mediterranean Gull, Common Tern, Little Tern, Black-winged Stilt, Avocet and Collared Pratincole breeding in 2001 and 2002 in the Romanian Danube Delta Biosphere Reserve.

2001

Site	Pontic Gull	Black-headed Gull	Mediterranean Gull	Common Tern	Little Tern	Pied Avocet	Black-winged Stilt	Collared Pratincole
Vadu North		2		250	50	13-15	15	340
Vadu South				1		2	50	
Lake Sinoe	106							
Grindul Saele					3	5		10
Murighiol Saraturile	200	396	169	1869			10	
Plopu lake						10-15	10	
Total lagoon ecosystem	**306**	**396**	**170**	**2120**	**53**	**30-37**	**95**	**350**
Crasnicol & Bondar (aerial)		50 ?		? ?				
Sfîntu Gheorghe/Tataru				20			6	
Buhaiova-Hrecisca				2				
Total fluvial ecosystem	**0**	**50 ?**	**0**	**22**	**0**	**0**	**0**	**0**
Sacalin wreck	20							
Sacalin Peninsula				1				
Total coastal ecosystem	**20**	**0**	**0**	**1+**	**0**	**0**	**6**	**0**
TOTAL Romanian DDBR	**326**	**446**	**170**	**2143**	**53**	**30-37**	**101**	**350**

2002

Site	Pontic Gull	Black-headed Gull	Mediterranean Gull	Common Tern	Little Tern	Pied Avocet	Black-winged Stilt	Collared Pratincole
Vadu North				590	39	6	10	245
Vadu South						1	2	
Lake Sinoe	245							
Grindul Saele						3	1	11
Murighiol Saraturile	170	1335	219	3263		5	67	
Plopu lake						35		
Babadag NW							2	
East Sinoe Town								22
Enisala						1	2	
Insula Bisericuta	35							
Total lagoon ecosystem	**450**	**1335**	**219**	**3853**	**39**	**51**	**84**	**278**
Parches Lake (aerial)		300						
Tataru lake				6				
Total fluvial ecosystem	**0**	**300**	**0**	**6**	**0**	**0**	**0**	**0**
Sacalin wreck	0							
Total coastal ecosystem	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL Romanian DDBR	**450**	**1635**	**219**	**3859**	**39**	**51**	**84**	**278**

Numbers of Black-headed Gull, Mediterranean Gull, Common Tern and Pied Avocet were higher in 2002 than in 2001 (Table 3.10). If biases in the survey occurred for these species, they should be globally equal in the two years. Thus, the increase in numbers for these species is explained by a real increase in Murighiol for the first three species and in Plopu for the latter. In these two lakes, water level in 2002 was lower than in 2001. One breeding island, below water in 2001, appeared in Plopu in 2002, whereas large beaches were discovered around existing islands in Murighiol. This was very obvious for the island n° 13 (*cf.* Fig. 3.4), where 60 pairs of Black-headed Gull and no Common Terns bred in 2001 against 1228 pairs and 309 pairs respectively in 2002 (Table 3.11). On island n° 16, 40 pairs of Common Tern and no Mediterranean Gulls bred in 2001 against 245 pairs and 105 pairs in 2002. However, environmental changes alone do not explain the increase of Common Tern. In Vadu where no habitat change was detected, numbers were two times higher in 2002. Hence, the presence of larger number of birds in the delta is also an explaining factor.

Table 3.11.
Numbers of breeding pairs of colonial Charadriiformes in the Murighiol Saraturile lake. Island numbers correspond to Fig. 3.4.

Islands	Pontic Gull		Black-headed Gull		Mediterranean Gull		Common Tern		Black-winged Stilt	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
1			15	0			7	149		
2			6	8			0	25	0	2
3			3	0			0	6	0	1
4							160	92	3	0
5			130	22	54	3	688	1051	0	1
7							50	12		
8			40	1	10	0	370	339	2	0
9							65	62		
10			15	13			0	11		
11			5	2	5	5	124	260		
12			70	54	35	92	65	327	0	2
13			60	1228	0	4	0	309	5	48
14	200	170	50	0	65	10	200	192	0	2
15							40	24	0	4
16			0	4	0	105	40	245	0	1
17	0	1					60	65	0	2
18	0	1					0	14	0	1
19							0	19		
20							0	7		
21							0	8		
22			0	1			0	20		
23			0	1			0	19	0	1
24							0	7	0	2
25			0	1						
TOTAL	**200**	**172**	**394**	**1335**	**169**	**219**	**1869**	**3263**	**10**	**67**

Numbers of Black-winged Stilt and Collared Pratincole decreased slightly. Both species suffered a decrease in Vadu, whereas the former increased proportionally in Murighiol. Human disturbance may be at the origin of the decline in Vadu (see next chapter) and birds probably left. This movement may explain the increase of the Black-winged Stilt in Murighiol and the appearance of a new colony of Collared Pratincole near Sinoe. However, it is not excluded that these two species, which are able to breed in loose or small colonies, dispersed in other areas not discovered.

The Ukrainian part of Danube delta
The Ukrainian part of the Danube delta was surveyed from 30 April to 9 May 2002 by three of us (MP, JBK, MZ). The area was covered both by boat and by plane. Because it was too early in the season, the present

numbers may well be representative for Pontic Gull only (Table 3.12). For Black-headed Gull, it was just a little bit too early, even though birds had started to lay on the colonies. Additional counts were realised later by MZ for Sandwich Tern. No information on colony detection probability is available.

Table 3.12.
Numbers of Pontic Gull, Black-headed Gull and Sandwich Tern breeding in the Ukrainian part of the Danube delta in 2002. Counts of the latter were realised later in June (M.Ye. Zhmud).

Colony site	Methods	Date	Pontic Gull	Black-headed Gull	Sandwich Tern
Limba	Aerial	08/05/03		30	
Chitai SE	Aerial	08/05/03		120	
Chitai mid-W	Aerial	08/05/03		180	
Kartal	Aerial	08/05/03	60	115	
Kugurluy SE 1	Aerial	08/05/03		250	
Kugurluy SE 3	Aerial	08/05/03		150	
Kugurluy SW 3	Aerial	08/05/03		40	
Kugurluy SW 4	Aerial	08/05/03		200	
Kugurluy SW 5	Aerial	08/05/03		60	
Vostotchnoye sandbank	Ground	01/05/03	385		1800
Stentsovsko Z. Plavni 2	Ground	03/05/03		250	
Novaya Zemlya	Ground	04/05/03	800		1900
TOTAL			**1195**	**1395**	**3700**

3.2.5 The case of the Whiskered Tern

The reliability of the estimates differs between ground nesting species which breed principally in the lagoon area and Whiskered Tern *Chlidonias hybridus* which breeds on floating vegetation in the fluvial area. Above we discussed the difficulties encountered in the fluvial area to census the colonies. Moreover, Whiskered Tern reproduction is delayed in time compared to the other species. If the first birds laid at the beginning of June, such as was observed in several colonies, most of them did not start the reproduction before mid-June, being dependent upon the development of floating aquatic vegetation to construct their nests on. In such a case, it was not possible to give accurate counts for this species. Therefore, numbers in Table 3.13 are just presented here for information without any idea of exhaustiveness.

Whiskered Terns do not forage over more than 10 km away from the colony site (Del Hoyo *et al.* 1996). During our line transect, we saw only 4 birds from Tulcea to Sfîntu Gheorghe on 12 June 2002, all of which were on the Mahmudia section, few kilometres away from the Mahmudia colony. From Sfîntu Gheorghe to Crisan on 13 June, 14 birds were observed on Imputite and Crisan canal. Again, it was at a short distance of the Crisan colony. On 14 June, birds were again dispersed around known colony sites, two were detected near the Olguta canal colony, seven on the section near Olguta-Ligheanca but the largest numbers were observed on Garla Sontea between Martinca-Nebunu area and Alb lake.

As concluded for Common Tern and Black-headed Gull, line transects should be the best method to detect Whiskered Tern colonies in the fluvial area of the Danube Delta Biosphere Reserve. An accurate selection of the route for the line transect may allow a good coverage of the delta as a whole.

Table 3.13.
Numbers of Whiskered Tern pairs surveyed in Romanian DDBR in 2001 and 2002. All colony site names with their co-ordinates are given in Appendix 1.

Colony site	Date	Methods	Numbers
Cuzmintiu Mare	17/05/01	Ground	50
Sulimanca Canal	22/05/01	Ground	20
Sf. Gheorghe Sud, beach	30/05/01	Ground	25
Obretinu Mic-2	08/06/01	Aerial	500-800
Chiril lagul	10/06/01	Ground	50
Uzlina	10/06/01	Ground	60
Parches	08/06/01	Aerial	200-400
Alb lake	14/06/02	Ground	1000-2000
Babadag NW	11/06/02	Ground	20
Babadag SE	11/06/02	Ground	18
Babintii mari	06/06/02	Aerial	80
Crisan canal	13/06/02	Ground	70
Mahmudia SE	10/06/02	Ground	35
Martinca	06/06/02	Aerial	180
Nebunu	06/06/02	Aerial	250
Nebunu	14/06/02	Ground	200
Obretinu Mic-2	13/05/02	Aerial	70
Olguta canal	14/06/02	Ground	5
Olguta-Ligheanca	13/05/02	Aerial	150
Parches	06/06/02	Aerial	130
Potcoava Lagul	04/06/02	Ground	100
Purcelu	03/06/02	Ground	100
Purcelu	06/06/02	Aerial	90

It is recommended that the census of Whiskered Tern be realised at the earliest during the second half of June, or at the end of June preferentially. Line transects by boat should be used to detect colonies and aerial surveys in inaccessible areas. Because nests are built on floating vegetation, a census should be done at distance, from a high position (in a tree) when possible.

The colony in Alb Lake was particularly huge and probably one of the largest in Europe. This site should need a particular protection status. More generally, the Danube Delta Biosphere Reserve appears to be one of the most important area for the reproduction of the Whiskered Tern in Europe and particular attention should be oriented to this species.

Table 3.14.
Numbers of pairs of solitary nesting waders observed in Romanian DDBR in 2001 and 2002.

Colony site	Date	*Tringa totanus*	*Charadrius alexandrinus*	*Vanellus vanellus*	*Vanellus leucurus*
Vadu South	20/05/01	?	?	?	6
Vadu South	11/06/01	?	?	?	0
Grindul Saele	07/06/02	0	13	8	0
Vadu North	07/06/02	2	11	4	0
Vadu South	07/06/02	0	2	1	0

3.2.6 The case of the solitary nesting waders

We devoted only little attention to solitary nesting waders. We focused in 2001 on the White-tailed Lapwing *Vanellus leucurus*, which bred for the first time in the Danube Delta Biosphere Reserve in 2000. At least 8 individuals and 6 nests were observed in May (Table 3.14). But the colony seems to have suffered perturbation as concluded from the absence of tern and lapwing chicks in June. According to non-verified information, people came to collect White-tailed Lapwing eggs. In 2002, only one single individual was observed without any indication of breeding. We observed three other wader species breeding in 2002, the Redshank *Tringa totanus*, the Kentish Plover *Charadrius alexandrinus* and the Northern Lapwing *Vanellus vanellus*. Numbers in Table 3.14 are just presented here for information without any idea of exhaustiveness.

Alarming White-tailed Lapwing, May 2001.

3.3 Recommendations

Colony detection in the Danube Delta Biosphere Reserve is an important task because of the large surface area to cover. The western part of the lagoon area may be covered principally by car. Elevated point of observations should be used in order to detect bird movements. A boat, such as in Sinoe, should be used in Zmeica and Golovita lakes (see Fig. 2.1) in order to accede to places too far from the west side. Plane survey seems necessary in areas where access by boat or by car is impossible or difficult. In determining the flying route, stratified sampling of the most suitable breeding habitats (e.g. pioneer situations on islands etc.), as identified from the vegetation map (Fig. 2.2), should be the key factor, apart from expert knowledge on the whereabouts of the colonies. In most part of the fluvial area of the Danube Delta Biosphere Reserve, line transects should be used preferentially to plane in order to locate high density areas of birds and then to facilitate the finding of unknown colonies. An accurate selection of the route for the line transect, again based on stratified sampling according to the vegetation map, may allow a better coverage of the delta as a whole.

Bird counts in colonies may be realised by plane. For most of the Pelecaniformes and Ciconiiformes, these counts yielded rather satisfactory results.

In the case of the Charadriiformes, however, due to the small size of most of the species, pictures should be taken in order to count birds at nests from the picture. In that case, species identification may be difficult and should be realised during the flight, using binoculars. Moreover, the size of the plane used in this study seems to be too large and caused a lot of disturbance in the colonies. A smaller sized plane should be used if possible.

Direct nest counts from the ground are generally recommended when numbers are important or visibility is bad. However, the disturbance should be limited to a maximum of 30 minutes. If field constraints do not allow to respect this duration for counting, a count at distance is recommended. On the contrary, in absence of vegetation or with very good visibility, a count at distance may give similar estimates of bird numbers without disturbing the colony and then is preferable.

Intra and inter-specific variations of the reproductive schedule reduced the accuracy of the census with only one period of counts. With regard to the phenology of each species, at least two periods seem necessary. For Great Cormorant and Grey Heron, the last week of April or the first week of May seem appropriate for the survey, but for the other Pelecaniformes and Ciconiiformes, among which particularly the migratory species like Little Egret, Squacco Heron, Black-crowned Night-heron and Glossy Ibis, a second survey in early June would be necessary.
Among the Charadriiformes, as we have seen, the last week of April or the first week of May is appropriate for the survey of Pontic Gulls. This period corresponds to the first hatching and thus to the peak of presence of the species. However, as we saw for the Murighiol colony, the count at distance may lead to an under-estimate of the numbers in the presence of high vegetation. In such colonies, the best period would be the first week of June when chicks are still present before fledging, although the vegetation is higher by this time. However, in case of breeding failure, as observed in Sinoe, such a belated period presents a higher risk of underestimation.
For the other species of colonial Charadriiformes, two periods may be recommended. The second half or the last week of May seems reasonable for all the species except Little Tern. It is the period of first hatching for most of them and then the peak of presence, even if species as Black-winged Stilt or Pied Avocet are less synchronised than the others. For the Little Tern, the most belated species, the second and third week of June seem reasonable.

If two or several counts are not possible due to logistic problems, the beginning of June appears to be the best compromise. For this reason, the present census could be considered as well representative.

Mixed-species colony with Pygmy Cormorants, Black-crowned Night-herons and Little Egrets.

4 Distribution and species-habitat relationships

The relation of a plant or an animal with its habitat has been conceptualised as the multidimensional space resulting from the trade-off between the organism's needs and local abiotic and biotic constraints. Pattern studies of habitat selection aim then at identifying the environmental parameters that explain the niche breadth of a species. We adopted the view that habitat selection involves a hierarchy of choices (Burger 1985). For nesting birds, this hierarchical framework goes from general habitat selection to home range selection, and from colony site or territory selection to nest site selection. Colonial birds form a particularly suitable group for studying selection of reproductive habitat as colony sites are discrete patches, which are easy to describe and represent the only resource searched for by individuals at the colony scale. If food availability is indeed a major cue for home range selection, feeding site features are also critical elements of selection as they determine the maintenance of the colony integrity during the time necessary for reproduction and, therefore, allow reproductive success at the individual level (Lack 1968, Wittenberger & Hunt 1985).

This chapter deals with the relationships between the distribution of the colonies, as found during the 2001 and 2002 surveys of the Danube delta, and the environmental characteristics deemed important for their survival. Most attention was paid to Pelecaniformes and Ciconiiformes (section 4.1), as the survey was considered more complete for this group, but some observations are also made for the group of colonial Charadriiformes (section 4.2).

4.1 Pelecaniformes and Ciconiiformes

4.1.1 Introduction

The main aim of this chapter is to present the distribution of the colonies of pelicans, cormorants, herons, spoonbills and ibises over the entire territory of the Danube delta during the breeding seasons of 2001 and 2002 and to try to explain it in relationship to spatial environmental factors. For many colonial waterbird species, strong evidence has been gathered in several field studies that a combination of safe and quiet breeding sites and the close proximity of favourable feeding grounds is crucial for the establishment of healthy colonies (Custer *et al.* 1978, Fasola 1986, Gibbs 1991, Custer & Bunck 1992, Kelly *et al.* 1993, Platteeuw & Van Eerden 1995, Farinha & Leitão 1996, Fasola & Ruix 1996, Fasola *et al.* 1996, Grüll & Ranner 1998, Wong *et al.* 1999, Tourenq *et al.* 2000, Richardson *et al.* 2001, Bancroft *et al.* 2002). In all these studies, the birds involved lived in largely man-influenced landscapes, either by extensive (agricultural) land use (*e.g.* ricefields or ditched pastures) or even directly man-made (*e.g.* artificial reservoirs or islands). Since the Danube delta can be considered as one of the largest and most untouched wetlands within a European context, it is of high interest to find out which are the most crucial environmental factors governing the spatial distribution and the sizes of the colonies under more or less natural conditions

'Decisions' by colonial birds as to whether or not establish a colony somewhere and to settle in higher or lower numbers are likely to be made on different levels of abstraction. Probably the first consideration will be concerned with the expectations of the average 'carrying capacity' of the potential area: will there be enough food within the range of daily attainable feeding habitats for the birds and their offspring for a prolonged period of at least two to three months (period of reproductive cycle). Productivity of aquatic, amphibian and semi-terrestrial habitats within the delta as well as their attainability within each species' daily radius of action are important factors in determining this first question.

Secondly, the birds will have to find breeding sites, which are suitable for nest construction as well as safe against predators and other forms of disturbance such as flooding. Suitability for nest construction would mean availability of trees that support the construction of relatively big nests and can be approached easily by relatively large birds (*e.g.* relatively isolated and small stands of trees) for cormorants and most wading birds, of bare ground with no or only very sparse and low vegetation cover for Great Cormorant, Eurasian Spoonbill or Dalmatian Pelican or of firm floating vegetation for Great White Pelican (*e.g.* Voisin 1991, Voslamber 1994, Grieco 1999, Catsadorakis & Crivelli 2001, Van Rijn & Van Eerden 2001). Moreover, most wading birds are also occasionally found nesting in dense and well-inundated Reed beds, which for some species (*e.g.* Great Egret and particularly Purple Heron) even constitute the main breeding habitat (*e.g.* Tomlinson 1974, Kayser *et al.* 1994, Grüll & Ranner 1998).

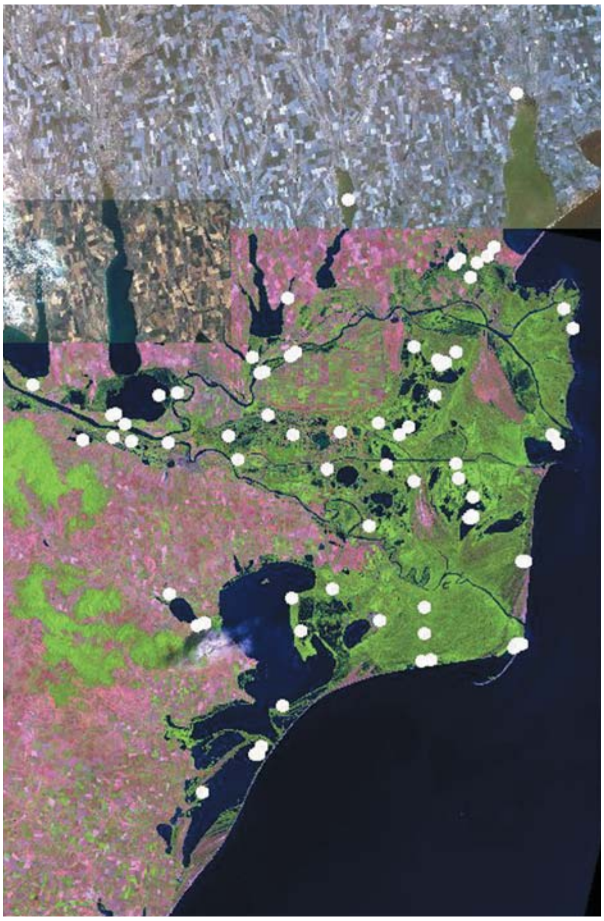
Safety against predators is particularly important for colonial birds, since because of their size and their concentration they are very conspicuous to terrestrial predators (*e.g.* Red Fox *Vulpes vulpes*, Raccoon Dog *Nyctereutes procyonoides* or even Wild Boar *Sus scrofa* or man) (Tomlinson 1974, Frederick & Collopy 1989, Kelly *et al.* 1993, Grüll & Ranner 1998, Carney & Sydeman 1999). To ensure this safety several options may exist. Since most of the potential predators are primarily terrestrial living mammals, colonies tend to become established in situations where the actual nests are completely surrounded by water. Thus, small islands and islets are potentially favoured for colony site selection. Tree-nesting is another option. Hereby, the birds remain out of reach of non-arboreal predator species like foxes and, by the way, maintain the option of having the nests surrounded by water during spring when seasonal flooding by the river occurs. The third and last option lies in choosing colony sites in relatively open terrain, which enables the breeding birds to keep a good watch for approaching predators. Here too are good opportunities to combine this prerequisite with the factor of physical isolation: islands, particularly in coastal and lagoon systems, tend to be quite open.

4.1.2 Distribution of colonies

In both survey years all 13 target species of colonial Pelecaniformes and Ciconiiformes were found breeding in the Danube delta. In 2001, when only the Romanian side was surveyed, a total of 38,960 breeding pairs spread over 30 colonies was found. In 2002 no less than 72 colonies were localised, holding an estimated total of 48,075 breeding pairs.

The spatial distribution of the colonies found in either of the two survey years clearly shows that the vast majority is situated in direct proximity to patches of open water (Fig. 4.1). In the vast patches of dense and high Reed beds between Sfîntu Gheorghe and the sand ridge of Caraorman in the southeast, between the Letea forest and the Chilia branch in the northeast and in the Ukrainian secondary delta, no colonies were found.

Fig. 4.1.
Distribution of colony sites for pelicans and cormorants (Pelecaniformes) and wading birds (Ciconiiformes) in the Danube Delta in 2001 and 2002. Note that almost all sites are situated in immediate proximity to larger water bodies.



4.1.3 The importance of feeding grounds

Clearly, one of the most crucial factors allowing the occurrence of large breeding colonies of waterbirds in a certain area is the availability of suitable and profitable feeding grounds throughout the period of nesting, incubating and chick raising. In order to get an impression on how much food is needed to support the population sizes of pelicans, cormorants, herons, spoonbills and ibises actually found during the surveys, some rough calculations have been made.

Daily food intake by the different species was estimated on the basis of mean body masses (derived from data in Cramp & Simmons 1977 and Del Hoyo *et al.* 1992) and the allometric relationship between body mass and Basal Metabolic Rate (BMR) presented by Aschoff & Pohl (1971):

$$BMR\ (kJ.\ day^{-1}) = 307.6\ M^{0.734}, \text{ in which } M = \text{body mass in kg}$$

Assuming, furthermore, a mean daily energy expenditure of 3*BMR (Drent & Daan 1980), a mean caloric value of the main food items (fish) of 4.6 $kJ.g^{-1}$ (Platteeuw 1985) and an assimilation efficiency by the birds of 0.8 (Castro *et al.* 1988), the daily food intake (DFI) of each individual bird can be estimated for each of the 13 species (Table 4.1). Multiplying these figures for DFI with the estimated numbers of breeding adults of each species and with a period of 120 days (March till June), estimates of total food requirements were obtained for both seasons. Thus, it was estimated that in 2001 and 2002 for the mainly piscivorous species (excluding

Glossy Ibis) 3894 and 6141 tonnes of (fish) food, respectively, were needed to support the present breeding adults during the three months of their reproductive period. Assuming furthermore a mean reproductive output for each of the species involved as represented in Table 4.2 (based on estimates by J.B. Kiss) and a nestling period of 40 days, these figures rise to 5668 and 8403 tonnes, respectively (Fig. 4.2). Assuming similar caloric values and assimilation efficiencies for the food items consumed by Glossy Ibis and their offspring, a further 147 and 273 tonnes of food, respectively, would be needed.

Table 4.1.
Daily individual food needs of the 13 species of colonial Pelecaniformes and Ciconiiformes breeding in the Danube delta, as calculated on the basis of body mass and allometric relationships between body mass and Basal Metabolic Rate (Aschoff & Pohl 1971).

Species	**Estimated daily food consumption (g fresh mass per bird)**
Great White Pelican *Pelecanus onocrotalus*	1400
Dalmatian Pelican *Pelecanus crispus*	1500
Great Cormorant *Phalacrocorax carbo*	470
Pygmy Cormorant *Phalacrocorax pygmeus*	200
Grey Heron *Ardea cinerea*	355
Purple Heron *Ardea purpurea*	233
Great Egret *Casmerodius albus*	259
Little Egret *Egretta garzetta*	140
Squacco Heron *Ardeola ralloides*	104
Cattle Egret *Bubulcus ibis*	118
Black-crowned Night-heron *Nycticorax nycticorax*	178
Eurasian Spoonbill *Platalea leucorodia*	331
Glossy Ibis *Plegadis falcinellus*	170

Table 4.2.
Estimated reproductive output per pair for each of the 13 colonial waterbird species breeding in the Danube delta (estimates by J.B. Kiss).

Species	**Number of chicks per nest**
Great White Pelican *Pelecanus onocrotalus*	1
Dalmatian Pelican *Pelecanus crispus*	1
Great Cormorant *Phalacrocorax carbo*	3.5
Pygmy Cormorant *Microcarbo pygmeus*	4
Great Egret *Casmerodius albus*	3
Grey Heron *Ardea cinerea*	3
Purple Heron *Ardea purpurea*	3
Little Egret *Egretta garzetta*	4.5
Squacco Heron *Ardeola ralloides*	4.5
Cattle Egret *Bubulcus ibis*	4.5
Black-crowned Night-heron *Nycticorax nycticorax*	4.5
Eurasian Spoonbill *Platalea leucorodia*	3
Glossy Ibis *Plegadis falcinellus*	4.5

In both years, the pelicans and cormorants show by far the highest food requirements. These four species together are good for no less than 92% of the needs for fish preys in both seasons (Fig. 4.2), amounting to 5129 tonnes for 2001 and 7739 tonnes for 2002. Herons and spoonbills

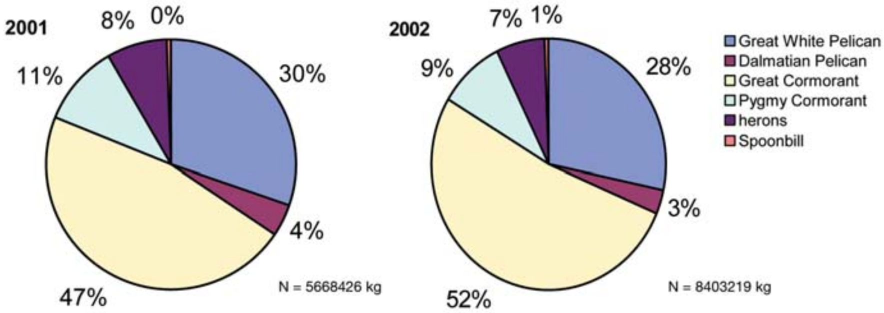
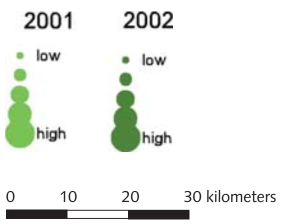
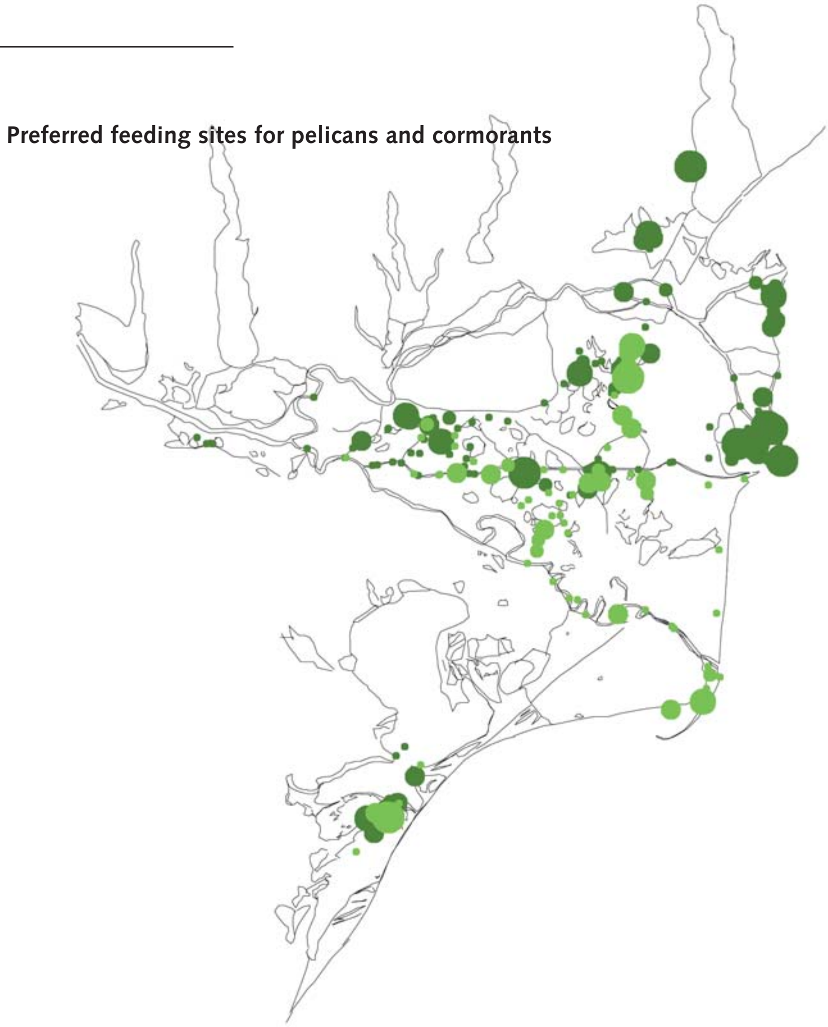


Fig. 4.2.
Estimated proportional food requirements of breeding adults of colonial waterbird species in the Danube delta during the three months of their reproductive period (March - June) in 2001 (upper panel) and 2002 (lower panel).

Fig. 4.3.
Approximate feeding distribution of the four larger piscivores (Pelecaniformes), according to the ground-based transect estimates.





together would have needed 540 and 665 tonnes of fish, respectively. These impressive figures clearly suggest that both size and productivity of available feeding grounds in the Danube delta need to be large in order to hold and support the present populations of colonial waterbirds.

Preferred feeding grounds

Pelecaniformes; feeding by diving and swimming

The four species of colonially breeding Pelecaniformes in the Danube delta, Great and Pygmy Cormorant and Great White and Dalmatian Pelican, are strictly aquatic feeders, feeding primarily on fish. All four species generally prefer the larger water bodies to the narrow canals or the main channels of the river (Fig. 4.3), but there are still some major interspecific differences. The Pygmy Cormorant is the most inland feeder and almost completely avoids the brackish coastal waters, while also shunning the largest lakes. It is primarily found foraging on the smaller inland lakes, where it particularly seems to favour the clearer waters with either submerged or floating aquatic vegetation (Table 4.3).

Table 4.3.
Preferred feeding habitats in the four species of Pelecaniformes in the Danube delta.

	Great Cormorant	Pygmy Cormorant	Great White Pelican	Dalmatian Pelican
	Phalacrocorax carbo	*Microcarbo pygmeus*	*Pelecanus onocrotalus*	*Pelecanus crispus*
floating aquatic vegetation	X	XX	X	
submerged aquatic vegetation	XX	XX	XX	X
clear water	XX	X	XX	XX
turbid water (algae or silt)	XX	X	XX	XX
fish polder	X	XX	X	
coastal inshore water (< 20 m)	XX		X	XX

Its larger relative, the Great Cormorant, has a slightly wider range of frequent feeding habitats. While markedly less abundant on lakes with floating aquatic vegetation, it is frequently seen in sometimes large feeding flocks on any other body of open water, either fresh, brackish or even marine. Between the two species of pelican, a similar sort of allocation between inland and more coastal feeding habitats seems to exist, the Great White Pelican being the more inland species and the Dalmatian the coastal one.

Ciconiiformes; feeding by wading and searching
The colonially breeding wading birds can be separated into three somewhat different groups, according to their feeding habits. The first group consists of the larger herons: Purple Heron, Grey Heron and Great Egret. These species feed mostly on fish and larger amphibians, which they catch by standing still or walking slowly along shallow water down to some 30 cm depth (*e.g.* Voisin 1991). Grey Herons are the most versatile feeders within this group, individuals being found foraging in almost any of the vegetation types distinguished except for the driest and the most densely forested ones while almost avoiding the coast (Table 4.4). Purple Herons also forage almost exclusively along freshwater habitats, but tend to remain more confined to higher stands of vegetation, particularly reed beds. Great Egrets are found in the most open vegetation types and seem to be less restricted to freshwater habitats than the two other large herons.

The second group consists of the smaller herons and egrets, mostly feeding on small fish and amphibians as well as on invertebrates by wading and searching in and along extremely shallow water bodies (up to 10 cm depth) or, in the case of the Cattle Egret, even in completely dry terrain.

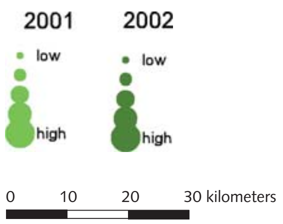
Table 4.4.
Preferred feeding habitats in the three large heron species in the Danube delta.

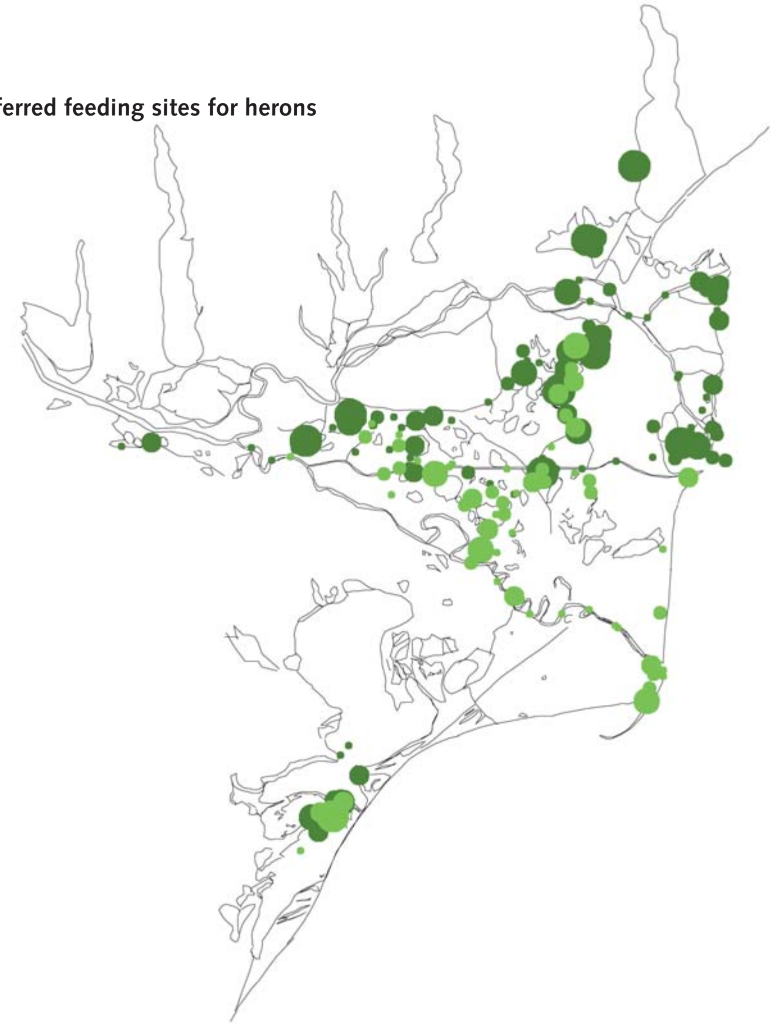
	Grey Heron	Purple Heron	Great Egret
	Ardea cinerea	*Ardea purpurea*	*Casmerodius albus*
seashore vegetation	X		X
saltmarsh vegetation	X		X
grassland on river levee	X	X	X
reedmace vegetation	X	X	
sedge vegetation	X	X	X
reed vegetation	X	X	X
vegetation of reed and trees	X	X	
salinated reed vegetation	X		X
floodplain forest		X	
floating aquatic vegetation	X	X	X
submerged aquatic vegetation	X	X	X
clear water	X	X	X
turbid water (algae or silt)	X	X	X
agricultural polder	X	X	X
fish polder	X	X	X
coastal inshore water (< 20 m)			X

Table 4.5.
Preferred feeding habitats in the four smaller species of herons in the Danube delta.

	Black-crowned Night-heron	Squacco Heron	Little Egret	Cattle Egret
	Nycticorax nycticorax	*Ardeola ralloides*	*Egretta garzetta*	*Bubulcus ibis*
seashore vegetation			X	
saltmarsh vegetation			X	
grassland on river levee	X	X	X	
reedmace vegetation	X	X	X	
sedge vegetation	X	X	X	
reed vegetation	X	X	X	
vegetation of reed and trees	X		X	
salinated reed vegetation	X			
floodplain forest	X	X	X	
floodplain bushes	X	X		
floating aquatic vegetation	X	X	X	
submerged aquatic vegetation	X	X	X	
clear water	X	X	X	
turbid water (algae or silt)	X		X	
agricultural polder	X		X	X
fish polder	X	X	X	X
coastal inshore water (< 20 m)			X	

Fig. 4.4.
Approximate feeding distribution of the colonial heron species (Ardeidae), according to the ground-based transect estimates.

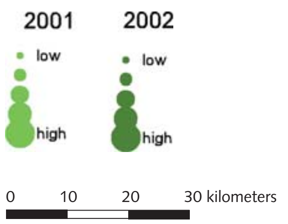


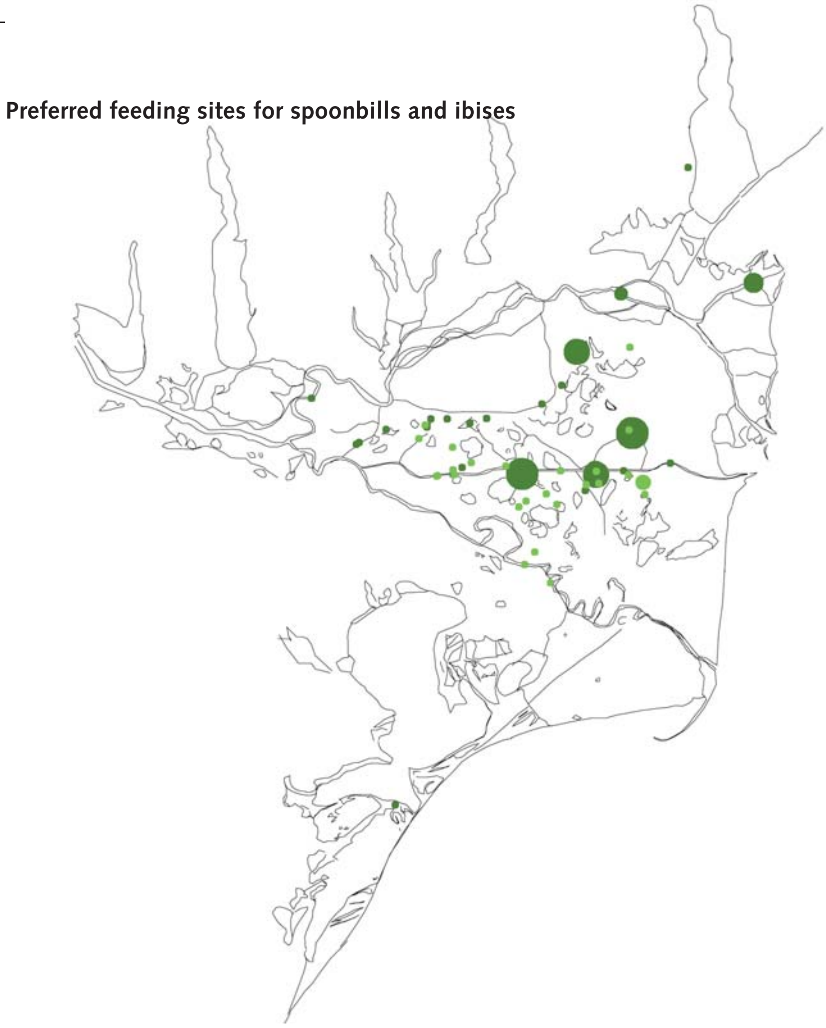


The Little Egret is the most versatile species within this group and can be found foraging in quite open terrain as well as in more densely vegetated areas, both along fresh and brackish water and even along the coast (Table 4.5). The Black-crowned Night-heron also frequents most vegetation types for feeding, but tends to avoid the opener habitats as well as the close proximity of the coast, while the Squacco Heron is even more confined to rather densely vegetated areas in the freshwater zone (Table 4.5). A very typical feeding habitat for the latter is right on top of the leaves of floating aquatic vegetation, particularly of Nymphaeids. The Cattle Egret, a very scarce breeding bird in the Danube delta, has never been seen feeding during the fieldwork for this project. Nonetheless, it is known to be by far the most terrestrial feeding species of heron in Europe, mainly found foraging on dry pastures (*e.g.* Fasola 1986) where it feeds on large invertebrates, often scared off by grazing cattle or horses.
The feeding distribution of all seven heron species together, as observed during the ground-survey transects, is shown in Fig. 4.4. Here it becomes apparent that the highest densities of feeding herons occur in the lake-rich areas of the central and northern parts of the delta, near the mouths of the three main river branches and along the shoreline of the former lagoons of Razim and Sinoe in the south.

The third and last group distinguished consists of the Eurasian Spoonbill and the Glossy Ibis. Although these two species belong to the same family (Threskiornithidae), their feeding habits are very different. Eurasian Spoonbills are strictly aquatic foragers, feeding mostly on small fish and aquatic crustaceans, and are therefore found feeding in and along shallow

Fig. 4.5.
Approximate feeding ranges of Eurasian Spoonbill and Glossy Ibis (Threskiornithidae), according to the ground-based transect estimates.





water bodies of both fresh and brackish water (Table 4.6), while Glossy Ibises tend to be more terrestrial, feeding mostly on aquatic and semi-aquatic insects and their larvae. The latter species is therefore mainly found foraging in wet and moist grassland habitats, but may also be found in open patches in the reed beds or even among the trees of flood-plain forests. The Glossy Ibis clearly avoids the larger water bodies and the more coastal habitats (Table 4.6).

In the field, Eurasian Spoonbills were seldom seen foraging, which was probably due to their relative scarcity and their high mobility. The Glossy Ibis, on the other hand, was found highly concentrated in the central and northern parts of the delta, where it fed almost exclusively in non-coastal habitats (Fig. 4.5).

Table 4.6.
Preferred feeding habitats in Eurasian Spoonbill and Glossy Ibis in the Danube delta.

	Eurasian Spoonbill	Glossy Ibis
	Platalea leucorodia	*Plegadis falcinellus*
grassland on river levee	X	X
reedmace vegetation		X
sedge vegetation		X
reed vegetation	X	X
vegetation of reed and trees		X
floodplain forest		X
floodplain bushes		X
floating aquatic vegetation		X
submerged aquatic vegetation		X
clear water	X	X
turbid water (algae or silt)	X	X
agricultural polder		X
fish polder	X	X
coastal inshore water (< 20 m)	X	

Availability of suitable feeding grounds
On the basis of the vegetation map published by Hanganu *et al.* (2002), as presented in Fig. 2.2, the availability of each of the vegetation types distinguished is calculated. Out of a total surface area of 509,750 ha, the largest proportions consisted of turbid water (19%), Reed and trees on plaur (16%) and Reed vegetation (13%) (Fig. 4.6). The freshwater aquatic environments, subdivided into submerged aquatic vegetation, floating aquatic vegetation, clear water and turbid water, made up a total of 135,468 ha (26.6%), the marshland habitats (Reed vegetation, Reed and trees on plaur, vegetation of Reed and trees, reedmace vegetation and sedge vegetation) were good for 197,211 ha (38.7%) and grassland and floodplain bushes and forests together amounted to 40,174 ha (7.9%). The coastal vegetation types used as feeding habitats (salinated Reed, saltmarsh and seashore vegetation) covered a total surface area of 43,765 ha (8.6%).

Composition of vegetation types in Danube delta

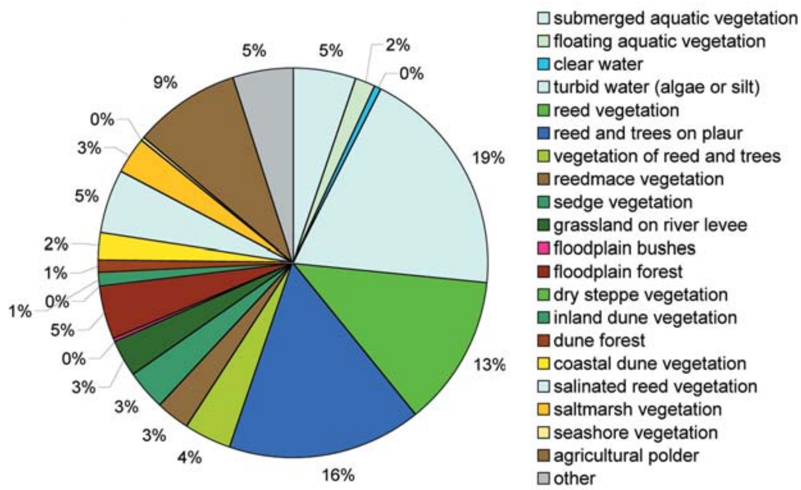


Fig. 4.6.
The composition of vegetation types in the Romanian and Ukrainian ranges of the Danube Delta Biosphere Reserve, as distinguished by Hanganu *et al.* (2002) and shown in Fig. 2.2.

Combining the data on vegetation (or habitat) type availability, preferred feeding habitats and the gross calculations of food requirements by the birds, estimates can be made of the minimum food productivity needed per habitat type. If pelicans and cormorants feed exclusively on freshwater lakes and ponds, they would have to extract between 37 and 59 kg.ha^{-1} from these habitats to cover the needs of themselves and their offspring. Herons and spoonbills would have to extract between 1.9 and 2.4 kg.ha^{-1} from the combined feeding areas of marshland, floodplain and coastal habitats.

Rough estimates of maximum flying distances that the different species of pelicans, cormorants and wading birds may range from their colony sites for feeding and the corresponding feeding ranges have been estimated for each species, based on direct observations in the field as well as on literature data (Custer & Osborn 1978, Fasola 1986, Fasola & Bogliani 1990, Gibbs 1991, Alieri & Fasola 1992, Hafner & Fasola 1992, Platteeuw & Van Eerden 1995, Van Eerden & Voslamber 1995; Table 4.7). By superimposing these feeding ranges over the respective colony sites as mapped against the vegetation map it was possible to calculate for all species the amount of potentially suitable feeding grounds within reach of each of the colonies. Thus, for each species the mean percentage of potentially suitable feeding grounds within reach of a colony site could be estimated as well (Table 4.7). For pelicans and cormorants, as exclusively aquatic foragers, the proportion of suitable feeding grounds within reach of the colony sites is relatively small, fluctuating between 6- 7% for the Great White Pelican to 15-18% for the Pygmy Cormorant. Here it has to be taken into account that only freshwater habitats have been considered. Particularly for Dalmatian Pelican and Great Cormorant this has led to a significant underestimation, since these two species frequently forage in the coastal Black Sea waters. The wading bird colonies have considerably higher percentages of potentially good feeding grounds within reach of the colony sites, generally from about 40% in Purple Heron to 80% in Grey Heron. An exceptional position among the wading birds is shown by Eurasian Spoonbill, which only found slightly over 20% suitable feeding grounds within its daily reach (Table 4.7).

Table 4.7.
Estimated flying distances (field observations and literature indications), corresponding feeding ranges and the average percentage of potentially suitable feeding grounds within reach of the colony sites for each of the 13 species of breeding colonial waterbirds in the Danube delta.

			mean %-age of potentially suitable feeding grounds		
	flying distance (km)	feeding range (km^2)	2001	2002	mean
Great White Pelican	60	11310	6	7	7
Dalmatian Pelican	60	11310	8	8	8
Great Cormorant	40	5027	12	12	12
Pygmy Cormorant	10	314	18	15	17
Great Egret	20	1257	51	61	56
Grey Heron	20	1257	70	90	80
Purple Heron	15	707	43	37	40
Little Egret	10	314	69	60	65
Squacco Heron	10	314	58	38	48
Cattle Egret	10	314	33	33	33
Black-crowned Night-heron	10	314	100	67	83
Eurasian Spoonbill	40	5027	23	22	23
Glossy Ibis	10	314	77	57	67

It would seem logical to assume that the observed interspecific differences with respect to flying distance (and consequently feeding range) and proportion of potentially suitable feeding habitats within reach are governed by different specific energetic needs. The higher the needs of a colony, the more one would expect its members to be adapted to cover greater distances to find enough food or to settle in colony sites with higher proportions of potentially suitable feeding grounds nearby. Indeed, it is found that the surface area of the feeding range (as a consequence of an adaptation to longer daily feeding flights) increases significantly with body mass (an indication of food requirements) (Fig. 4.7).

On the other hand, a tendency is observed among the actual colony sites that the average proportion of suitable feeding grounds within the theoretical feeding range decreases with increasing individual specific body mass

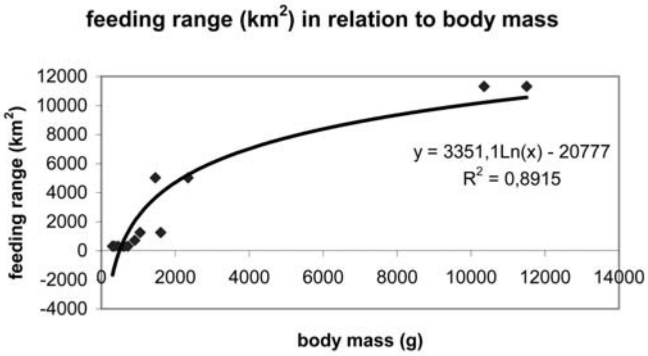


Fig. 4.7.
Relationship between average individual body mass (g) of a species and the surface area of the estimated maximum feeding range it may cover according to the estimated maximum daily flying distances as presented in Table 4.7. Clearly, heavier birds fly farther and can therefore cover a larger area. Since heavier birds also need more food, this ability may be interpreted as an adaptation to their greater size.

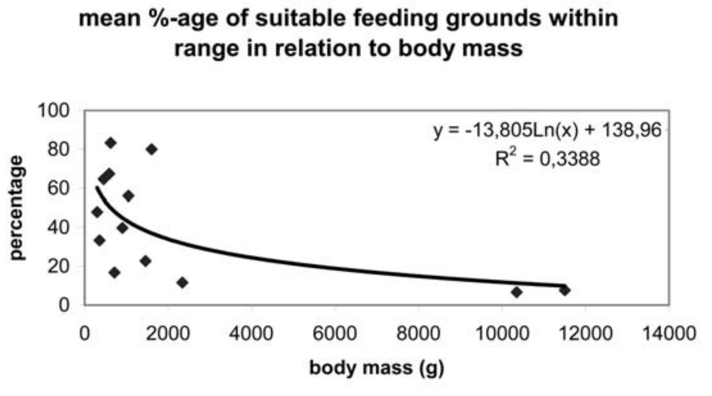


Fig. 4.8.
Relationship between average individual body mass (g) of a species and the percentage of potentially suitable feeding habitats it finds within its maximum flying distance (from Table 4.7) from its colony sites. Heavier birds tend to find a lower proportion of suitable feeding grounds, despite their higher food requirements.

(Fig. 4.8). In combination, these two findings indicate that larger and heavier birds, which have markedly higher food needs, tend to find themselves facing a lower proportion of suitable feeding habitat within reach of their colony, but may overcome part of this inconvenience by being able to cover far wider areas. In contrast, smaller and lighter birds, with lower daily food needs, find a higher proportion of potential feeding habitats nearby their colony sites, which they probably need despite their lower food needs because they cannot cover very large areas.

In fact, in the plot of the absolute figures for surface area of potentially suitable feeding sites within the daily feeding range of birds against their specific body mass, it is shown that heavier birds, thanks to their ability for longer-distance flights, do find higher absolute surface areas of suitable feeding grounds within their daily flying range (Fig. 4.9).

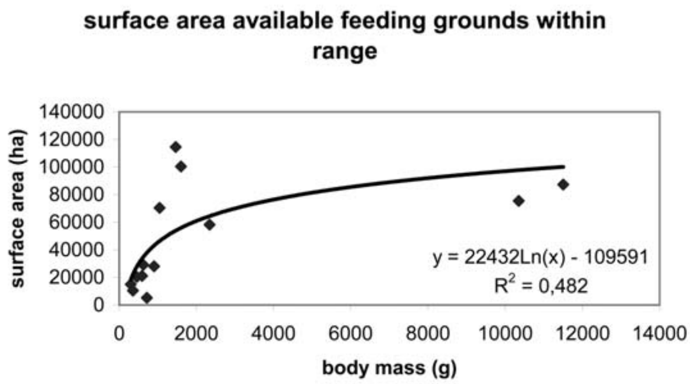


Fig. 4.9.
Relationship between average individual body mass (g) of a species and the absolute amount of feeding grounds (in ha) within the daily range from the colony site. Heavier species, in spite of finding a lower percentage of suitable feeding grounds within their range, do find larger absolute amounts of it, thanks to their wider range (*cf.* Figs 4.7 and 4.8).

The next question would be whether the availability of suitable feeding grounds around the colony sites, apart from determining their positioning, would also influence the (potential) size of the colony. Larger colonies, of course, have higher energetic needs and it would thus be logical to assume a positive relationship between the absolute surface area of potentially suitable feeding grounds within reach of a site and the number of birds that actually breed and grow up there. Rather surprisingly, however, for most of the colonial species found in the Danube delta during this survey, this relationship was not found in the field (Table 4.8). Only in Dalmatian Pelican (R^2 = 0.7209), and to a lesser extent in Little Egret and Squacco Heron (R^2 = 0.335 and 0.2388, respectively), a clear positive relationship was found between the food needs of the colony and the amount of suitable feeding grounds within the daily reach.

Table 4.8.
Relation between total food needs for breeding adults (March-June) and their offspring (during 40 days, as estimated from Table 4.1) at a colony (y) and surface area of suitable feeding grounds (x) for 12 of the 13 species of colonial waterbirds in the Danube delta. The significant positive relationships are marked in bold, the one significant negative relation is marked in italics.

Species	Maximum flying distance	R^2	Linear regression equation
Great White Pelican	60	0.1916	y = -17.832x + 2.10^6
Dalmatian Pelican	**60**	**0.7209**	**y = 3.6494x - 248552**
Great Cormorant	40	0.00004	y = 0.0571x + 226096
Pygmy Cormorant	10	0.0512	y = 4.9198x + 47738
Great Egret	20	0.0658	y = -0.0196x +5186.7
Grey Heron	20	0.0242	y = -0.0159x + 6084.6
Purple Heron	15	0.0197	y = -0.109x + 10066
Little Egret	**10**	**0.335**	**y = 0.6097x – 3773.3**
Squacco Heron	**10**	**0.2388**	**y = 0.3913x + 1416.9**
Black-crowned Night-heron	10	0.008	y = -0.0459x + 17436
Eurasian Spoonbill	*40*	*0.6625*	*y = -0.0887x + 15714*
Glossy Ibis	10	0.081	y = 0.5219x +14813

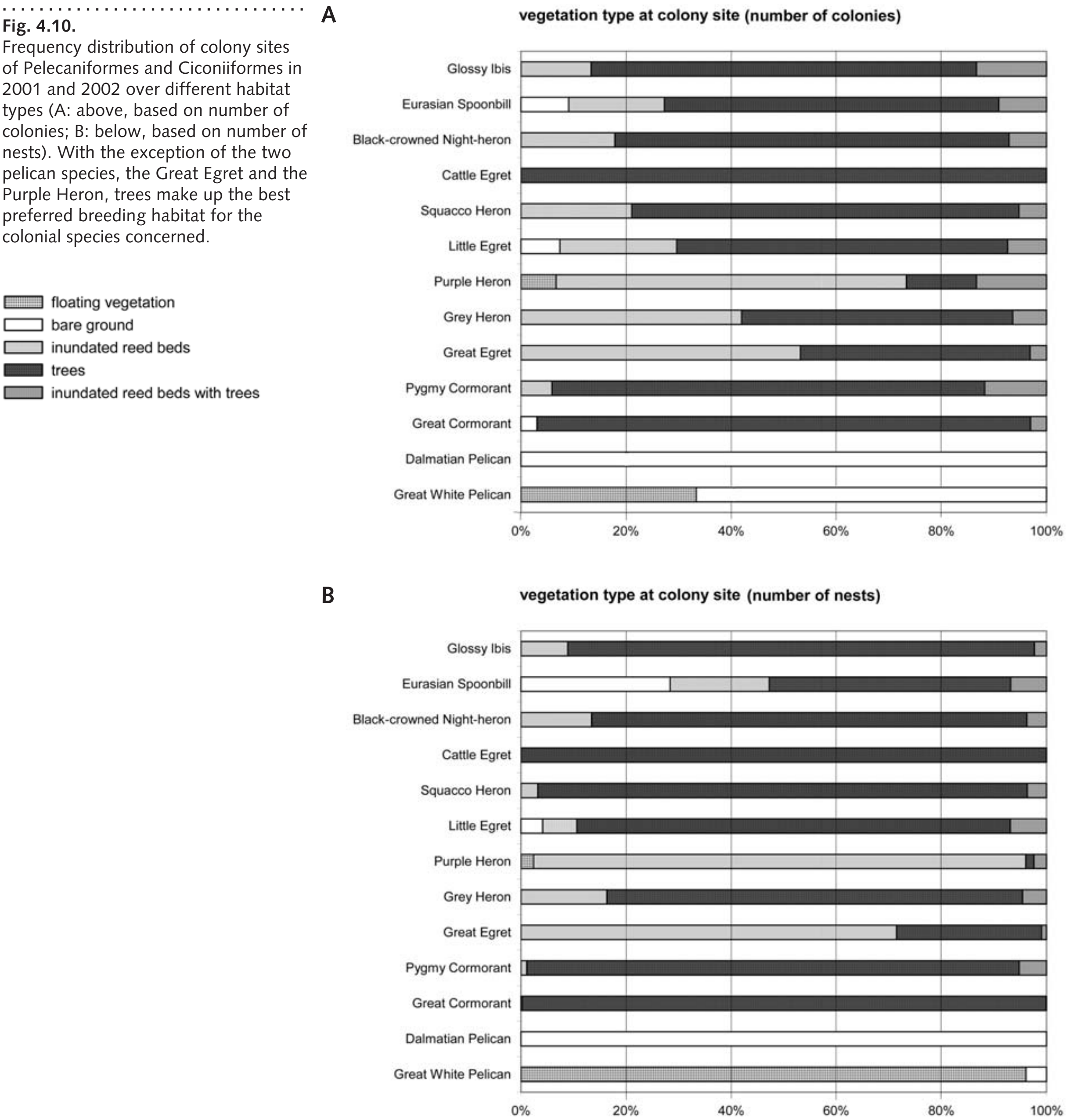
4.1.4 Colony site characteristics

Apart from factors related to proximity and/or profitability of neighbouring feeding grounds, colony sites may also be selected because of specific characteristics of the sites themselves. Generally, these characteristics will in some way or other have to do with the safety a site may offer against predators. Moreover, also man may contribute to disturbing or even actively destroying colonies, particularly when large fish-eating birds (*e.g.* pelicans or cormorants) are involved, which are perceived as serious threats to local fisheries. Therefore, colony sites are generally found in isolated places, surrounded by water (on small islands or islets) or by extensive and dense vegetations or both, and often in trees or inundated Reed beds. Apart from safety and isolation, other local factors that might influence a site's suitability for the settlement of a colony and its (potential) size could be the availability of actual nesting sites (and the competition for them between individuals of the same species or even among different species; *e.g.* Grieco 1999) and possibly also the presence or absence of other colonial species on the same site.

For all colony sites of Pelecaniformes and Ciconiiformes located in 2001 and 2002 it has been registered in what kind of habitat they were established. Roughly, five habitat types used as breeding places were noted: floating vegetation, bare (or sparsely vegetated) ground, inundated Reed beds, trees or inundated Reed beds with trees. For most of the species involved the colony sites were mainly situated in trees, the only exceptions being the Purple Heron (almost entirely restricted to Reed beds) and the two species of pelican (too heavy to breed in trees) (Fig. 4.10A). On the basis of nest numbers, the preference for tree stands as colony sites became more apparent in Glossy Ibis, Black-crowned Night-heron, Squacco Heron, Little Egret, Grey Heron and in the two cormorant species, while in Euasian Spoonbill and Great Egret relatively more nests were found in the Reed bed colonies (Fig. 4.10B).

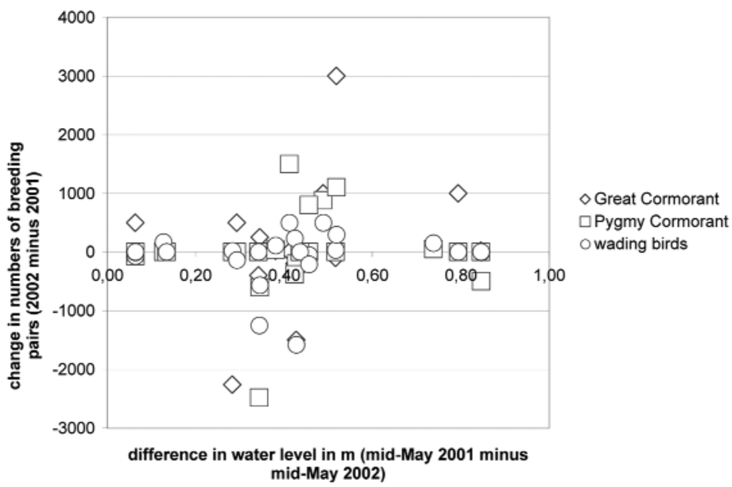
The amount of isolation and protection that a colony site achieves is likely to depend, among other factors, upon the amount of inundation during the actual breeding season. Of course, for ground-nesting birds (e.g. Dalmatian Pelican and in some instances Great White Pelican and Great Cormorant) inundations caused by exceptionally high water levels may cause losses of eggs or chicks. Therefore, it seems logical that these birds mainly breed in the downstream part of the delta, where water level

Fig. 4.10.
Frequency distribution of colony sites of Pelecaniformes and Ciconiiformes in 2001 and 2002 over different habitat types (A: above, based on number of colonies; B: below, based on number of nests). With the exception of the two pelican species, the Great Egret and the Purple Heron, trees make up the best preferred breeding habitat for the colonial species concerned.



fluctuation are the lowest. For floating nests (e.g. floating vegetation or floating nests in Reed beds) and for tree nests, however, it may be expected that the higher the water level at a colony site, the better the level of protection against predators may be. In order to test this hypothesis, a comparison was made for the colony sites that were surveyed in both seasons and for which water level data could be calculated for mid-May (at the peak of reproductive activity). In 2002, due to a lower discharge by the Danube, water levels were markedly lower than in 2001 (up to 1 m) by mid-May at almost all colony sites. Simultaneously, it was noted that the bird numbers did not show a clear-cut response to this difference (Fig. 4.11). Neither the two species of cormorant nor the wading birds (herons, egrets, spoonbills and ibises) showed any distinct tendency of decrease as a function of the decrease in water level at the actual colony site. Apparently, colony site choice has become adapted over the years to

Fig. 4.11.
Relationship between the difference in water table in mid-May 2002 (lower) and in mid-May 2001 (higher) at 24 colony sites monitored in both years and the change in number of occupied nests of Great Cormorant, Pygmy Cormorant and wading birds (*e.g.* herons, spoonbills and ibises). Neither the cormorant species nor the wading birds showed any clear response to changes in water level at the colony sites.



a sort of long-term average of the expected water level and (minor) fluctuations herein between subsequent years do not really influence colony occupation.

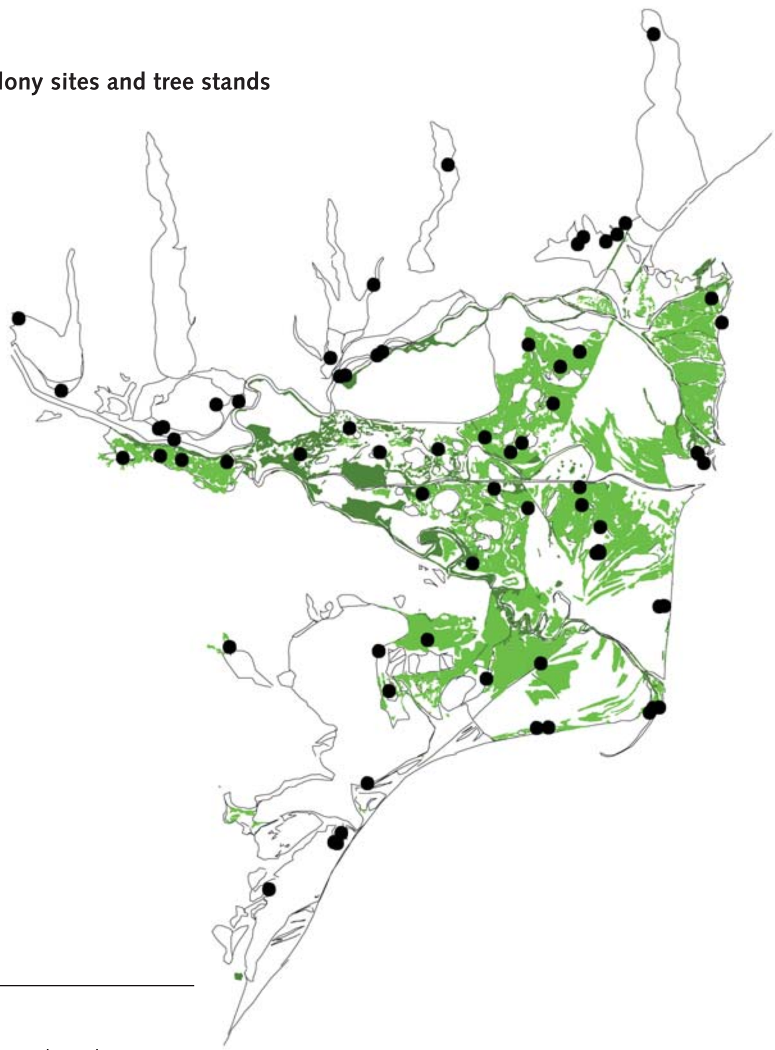
For most species the highest numbers of breeding colonies as well as of actual breeding pairs are found in (inundated) stands of trees (Fig. 4.10). These stands may be found in the following vegetation types (*cf.* Fig. 4.6): vegetation of Reed and trees, Reed and trees on plaur, floodplain forest and floodplain bushes. In dune forests no colonial birds are expected to settle. Fig. 4.12 shows the availability of the suitable vegetation types for tree-nesting colonial birds, together with the actual distribution of the

Fig. 4.12.
Availability of vegetation types where (inundated) stands of trees, suitable for settlement of tree-nesting colonial birds, in comparison with the actual distribution of colonial Pelecaniformes and Ciconiiformes in the Danube delta. While on the scale of the entire area, scarcity of breeding habitat does not seem to occur, on the smaller scale of the central part such an effect might be taking place.

colony sites of tree-dwelling species
vegetation of reed and trees (including plaur)
floodplain forest and bushes

0 10 20 30 kilometers

Colony sites and tree stands



colony sites. This map suggests that, while it seems unlikely that scarcity of suitable tree stands will pose a limitation to the amount of possible colonies on the scale of the entire Danube delta, that locally (and particularly in the central fluvial area) such a limitation might actually occur.

With respect to other local features of colony sites that might in any way affect either safety or direct availability of nests, no direct measurements were made. Some indirect indications may be obtained from the data on size and on species composition per colony site, but these allow at best some speculative conclusions that are better treated in the discussion.

4.1.5 Discussion

Two years of merely localising and (superficially) censusing the Danube delta's colonies of pelicans, cormorants and wading birds, together with the ecological data on freshwater lake ecology and distribution of vegetation (habitat) types (Oosterberg *et al.* 2000, Hanganu *et al.* 2002), provide of course insufficient scientific evidence to come to any definite conclusions about the fundamental factors underlying the birds' distribution patterns and population levels. Nevertheless, the data as presented in the previous sector and the general impressions from the field do allow a more speculative discussion on several aspects of species-habitat relationships and their possible influences on distribution and population. Thus, the following subjects will be briefly addressed:

- suitability of nesting sites over time; here the influence is discussed of the interactions among hydrodynamics, vegetation succession and the impact of the birds themselves (*e.g.* faeces and eutrophication);
- spacing out of colonies; in which some inter-specific differences in the spatial distribution of the colonies are highlighted in relation to habitat use;
- mixed-species colonies; in which the incidence of the occurrence of mixed-species colonies is discussed in relation to its possible significance.

Finally, an attempt is made to come to a final synthesis, in which a conceptual model is being proposed for trying to understand the way large colonial waterbirds come to settle or not in certain wetland areas, on which criteria they choose their actual breeding sites and which factors may determine the level of their population size.

Suitability of nesting sites over time

A potential threat to the sustainability of colonial bird populations in the Danube delta is posed by the interactions between water level fluctuations (within as well as between seasons), vegetation succession and the possible impact of the birds themselves. None of the habitat types identified as preferential for the settlement of pelecaniform or ciconiiform bird colonies can be considered sustainable over longer time periods. Tree-based colonies may last longer than open island situations, which suffer from bank erosion by wave action and vegetation succession from the land side, but even they do not last forever. Due to the prolonged use by the mostly piscivorous birds, the trees suffer year after year from direct destruction (the breaking off of branches and twigs for nest construction) and from hypertrophication by the birds' excrements. After a series of 15 - 40 years of intensive use as nesting site by colonial birds, the trees (mostly different species of willow *Salix* spp.) die and little by little decay, thus becoming increasingly vulnerable to storms and less secure for holding nests (*cf.* Fig. 4.13). Tree colonies, therefore, tend to 'move' along over the years through the forested parts of a wetland area. In an ideal world, the rate of

Fig. 4.13.
Some examples of tree-based colonies, clearly showing the decay and dying off of the trees due to the hypertrophication by the birds' excrements.

regeneration of new stands of trees, suitable as colony sites, as the result of vegetation succession would balance the rate of dying off and decay of formerly used colony sites. Little is known so far about the rates of these processes, so for long-term sustainable management of the habitats and birds of wetlands like the Danube delta future research into this matter would seem necessary.

Hypertrophication, or at least, eutrophication, may also be a complicating factor for the sustainability of colony sites on floating vegetation. Particularly if these floating vegetations have to support the immense nests of the Great White Pelican, as is the case in the only large Danube delta colony of Hrecisca (Fig. 4.14), an advanced degree of eutrophication of the lake by the birds' excrements may lead to a decrease in the viability of the floating aquatic vegetation, in case of the pelicans consisting of *plaur* (floating Reed beds) or even to the disappearance of it. Would the pelicans be able to colonise another area with strong enough floating vegetation and sufficiently well protected against man and other predators? Eutrophication has been named, in The Netherlands as well as in Germany, as the main cause for the disappearance of the floating vegetation of *Stratiotes aloides* from many of the lakes formerly covered by it (Smolders 1995), thus causing a significant decline in nesting habitat for Black Terns *Chlidonias niger* (Schröder & Zöckler 1992, Van der Winden *et al.* in press). Other floating-leaf species like Nymphaeids may suffer the same fate, but data on the vulnerability of *plaur* for eutrophication are lacking. Nothing much is known about possible cyclicity in processes like these: do floating-leaf plants re-colonise when trophic rates go down again and, if they do, would the birds be able to return?

Fig. 4.14.
Great White *Pelicans Pelecanus* onocrotalus breeding on rests of floating vegetation *(plaur)* at the Hrecisca colony site in the Romanian Danube delta.

In coastal and/or lagoon systems, the island-situated colony sites are potentially subject to occasional flooding during high winds or, in the long run, they may even disappear due to prolonged wind and wave erosion. On the other hand, in truly dynamic outer delta situations, new sedimentation processes will also continuously lead to the development of new islands. Within the present-day Danube delta, this latter process is nowadays only at work at the Chilia branch on the Ukrainian side of the Biosphere Reserve. This is the only branch still transporting a sufficiently high load of sediment to allow for this new land development. Another threat to the sustainability of island-based waterbird colonies in the coastal and lagoon region may be the proceeding vegetation succession.

In the recent past, the large (former) lagoon systems of Razim and Sinoe in the south have been cut off from the Black Sea and were connected to inflow of Danube water. Therefore, they have been modified from brackish systems to freshwater systems, which allow the development of a much wider array of upgoing vegetation types. Vegetation succession will now tend to lead to the development of Reed beds, followed by scrubs, bushes and eventually even forests. The mainly open systems with bare grounds or only sparse halophytic vegetation, providing suitable colony sites for Dalmatian Pelican and for charadriiform birds (gulls, terns and some gregarious wader species), as well as to a lesser extent, for ground-nesting Great Cormorant, Eurasian Spoonbill and Little Egret (Fig. 4.15), tend to disappear.

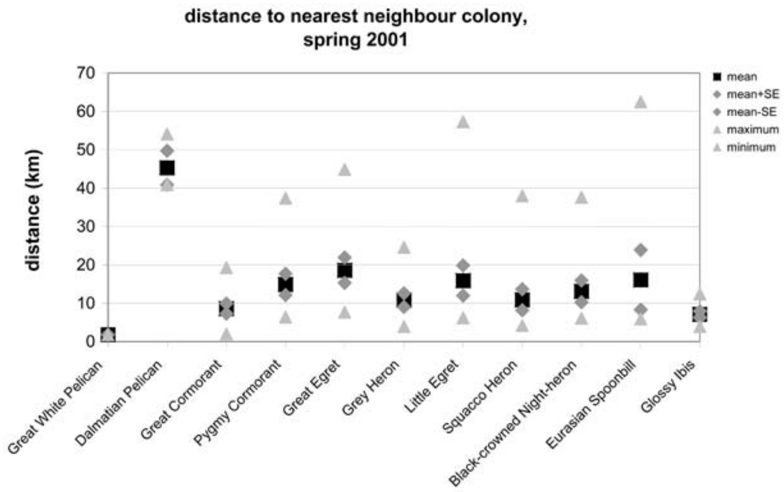
Spacing out of colonies
The spatial distribution of waterbird colonies could also, at least partly, be

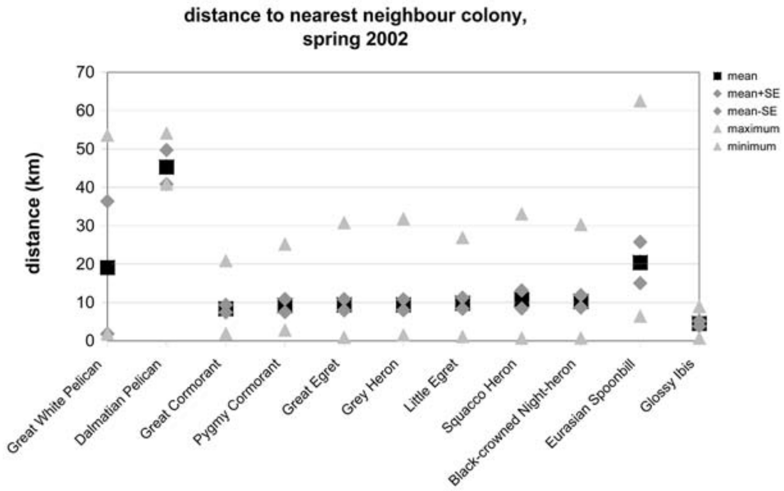
Fig. 4.15.
Examples of ground nests in island situations in lake Sinoe (Romanian Danube delta); above Great Cormorants *Phalacrocorax carbo* on bare ground, lower left nestling Eurasian Spoonbill *Platalea leucorodia* in inundated Reed on islet and lower right eggs and very recently hatched chick of Little Egret *Egretta garzetta* in similar habitat.

influenced by specific patterns of colonisation of the birds themselves. The probability of the settling of a new colony of a certain species in a potentially suitable nesting habitat, surrounded by a sufficient amount of good feeding grounds, may depend upon the proximity of an older, 'source' colony. This potential relationship may work in two ways. On the one hand, the distance between the 'mother' and the 'daughter' colonies is not likely to be too high, because surplus birds from the source are much more likely to 'discover' a suitable site close to where they were born, but on the other hand the distance will not be too close in order to avoid possible competition for the best feeding grounds with the 'ancestral' colony's feeding range.

For all breeding colonies of pelicans, cormorants and wading birds localised in both seasons, the distance to the nearest neighbouring colony has been calculated. Some remarkably consistent inter-specific differences in both the average nearest neighbour distance and the range in nearest neighbour distances were found (Fig. 4.16). The widest range of nearest neighbour distances was found among the two species of pelican (the colonies occurring up to over 50 km apart), cormorants and herons were spaced out in a very similar pattern (at mutual distances of on average 10-20 km apart, exceptionally up to 30 or even over 40 km). Eurasian Spoonbills, on average, did not space out much more than the herons, but their maximum nearest neighbour distance was registered at over 60 km in both years. At the other extreme of the scale, the Glossy Ibis colonies were on average always less than 10 km apart from each other, with an extremely small range between minimum and maximum registered values (Fig. 4.16).

Fig. 4.16.
Species-specific differences in nearest neighbour distances between colonies of Danube delta breeding waterbird species in 2001 (upper) and 2002 (lower). Note the remarkable differences between pelicans and cormorants, the remarkable similarities between cormorants and herons and the differences between herons and Eurasian Spoonbill on the one hand and Glossy Ibis on the other.





The general impression conveyed by Fig. 4.16 is that the spacing out of the colonies of the different species rather closely follows each species' own maximum daily feeding range. While both pelicans are estimated to be capable of the daily coverage of one-way flights of up to 60 km, we also observe that they tend not to breed too close together. The only exception is a small satellite-colony of Great White Pelican in Buhaiova (20 pairs), next to the huge main colony of Hrecisca (over 3500 pairs). Glossy Ibises, on the other hand, which are estimated not to fly much further than a one-way flight 10 km from the colony site, are all breeding very closely together. The only exception to this general rule seems to be found in the Great Cormorant, which despite its foraging range of at least a 40 km is found in colonies not much further apart than on average 10 km (Fig. 4.16). These findings evidently suggests, that in most colonial bird species the majority of individuals from any one colony are unlikely to overlap on their feeding grounds with conspecifics from neighbouring colony sites, with the clear exception of the Great Cormorant, in which considerable overlaps are bound to occur.

Mixed-species colonies
A phenomenon often mentioned in descriptions of colonially breeding cormorants and wading birds is the occurrence of so-called 'mixed-species' colonies (*e.g.* Munteanu *et al.* 1994, Hagemeijer & Blair 1997), where particularly several of the smaller heron species, Pygmy Cormorant, Glossy

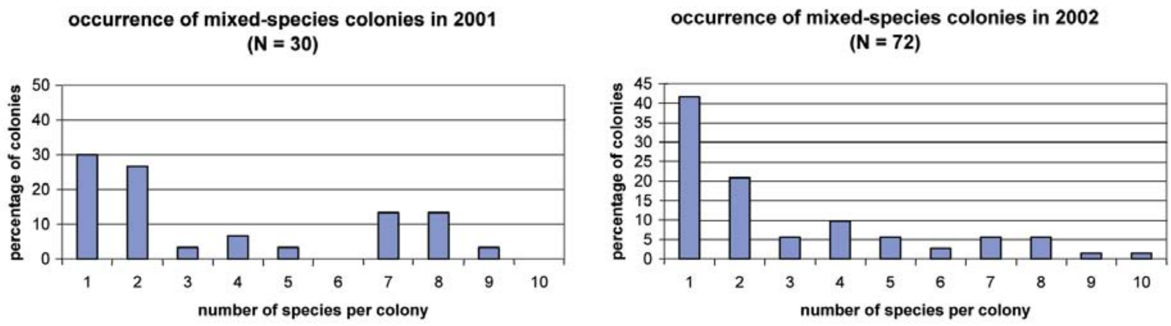


Fig. 4.17.
Incidence of mixed-species colonies in the Danube Delta in 2001 (left) and 2002 (right).

Ibis (and on occasions other species) breed together in close proximity, often even sharing the same nesting trees or bushes. In calling these colonies thus, it is implicitly suggested that somehow the member species inhabiting them may have something more in common than just sharing the same breeding site. During the present surveys, many species of cormorants and wading birds were frequently found breeding together in the same colonies. It was particularly common in inundated stands of trees, in which the different species nest at different heights. Nonetheless, mixed-species colonies have also been found in inundated Reed beds. In 2001 and 2002, 70 and 58%, respectively, of all colonies found held more than one species. A maximum of 10 species was found breeding together on the same site, but colonies consisting of one, two, seven or eight species were most frequently found (Fig. 4.17). Remarkably, in 2002 a smaller proportion of the colonies was found to consist of more than a single species.

The fact that the different species of cormorants and wading birds so often occur in mixed-species colonies also seems to stress the importance of safety at colony sites. Just to avoid inter-specific competition for the best nesting places, it would seem to be beneficial to nest as much as possible in mono-specific colonies, although it cannot be discarded that different species may also take advantage of each other's presence, for example by an enhanced alertness for predators, the utilisation of food remains of one species by the other or even the sharing of information on interesting common feeding grounds. Thus, it is possible that some species may profit from the presence of others for reasons of safety or even of sharing information on the most profitable nearby feeding sites in much the same way as has been proposed and tested in the field for individual members of mono-specific bird colonies (Ward & Zahavi 1973, Krebs 1974). In fact, for Sandwich Terns *Sterna sandvicensis* in The Netherlands, Veen (1977) has shown evidence that colonies could only aspire at reasonable reproductive success rates when situated in close proximity to Black-headed Gull *Larus ridibundus* colonies. The latter species tends to be much more alert and aggressive towards avian predators such as Herring Gulls *Larus argentatus* and thus offer protection to the eggs and chicks of the terns. On the other hand, the Black-headed Gulls take benefit from the Sandwich Terns by robbing adults of the fish they bring in for their chicks (Stienen *et al.* 2001).

Nonetheless, the proportion in which colonial breeders occur seems to be above all a measure of the relative scarcity of safe nesting sites within an area of a sufficient amount of potentially suitable feeding grounds. During the past century slight shifts seem to have occurred in the incidence of mixed-species colonies. In the period 1959-1961 65-85% of the colonies

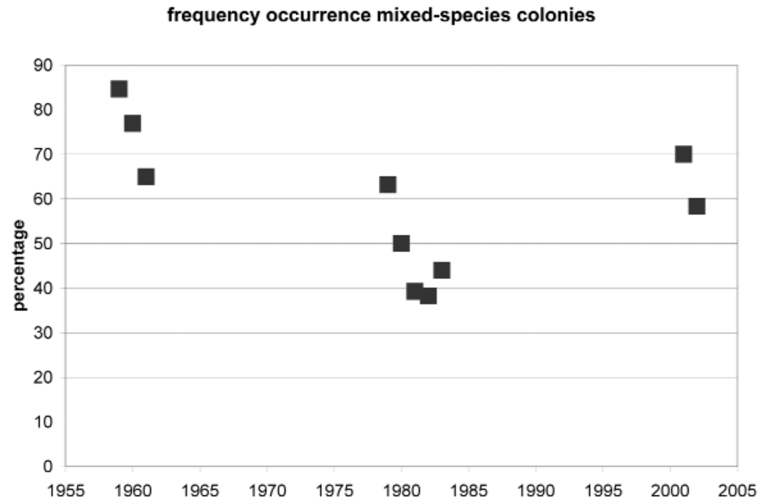


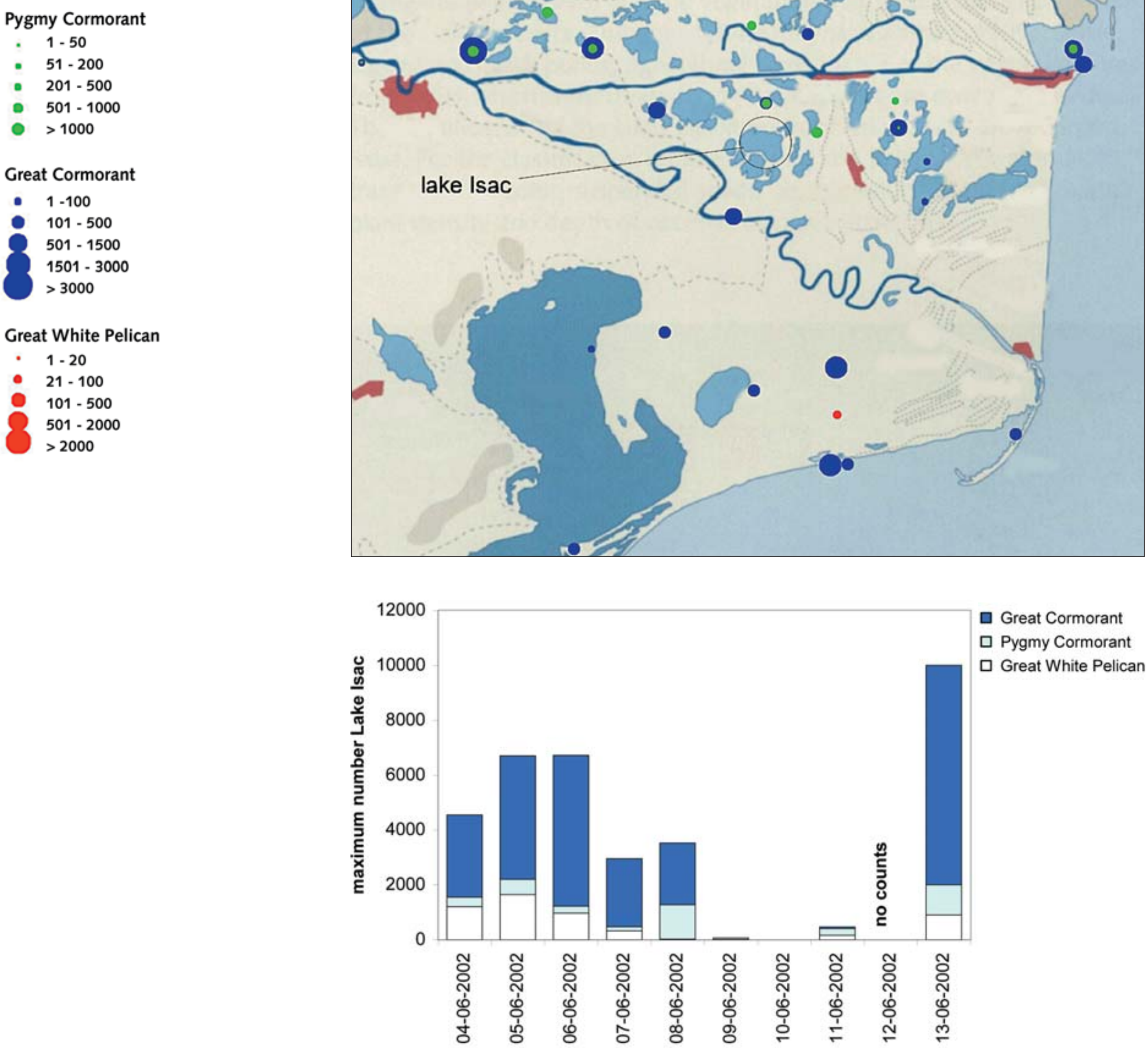
Fig. 4.18.
Proportion of mixed-species colonies in the Danube Delta over the years. Historical data based on Paspaleva *et al.* (1985).

consisted of more than one species, while in 1979-1983 mixed-species colonies made up a mere 38-63% (Fig. 4.18; Paspaleva *et al.* 1985). If these historical data are indeed representative of all colonies during the same periods, the impression is obtained that in the early 1960s less safe breeding sites were available than in the early 1980s. Nowadays, with 58-70% of the colonies holding two or more species, safe breeding sites seem to be slightly scarcer than in the early 1980s, but more abundant than in the early 1960s.

Final synthesis: a conceptual model
In an attempt to integrate all field data and impressions on colony distribution in relation to habitat composition, as presented in this chapter, a conceptual model is suggested for the explanation of site choice and carrying capacity of colonial waterbirds as a function of spatial habitat characteristics. This model may help us understand why a large-scale and more or less untouched delta area like the Danube delta still holds such a wide variety of colonial breeding waterbirds, while similar areas (*e.g.* the delta of Rhine and Meuse) with a more marked influence of human land use almost invariably show either a lower species diversity or lower numbers or both.

First of all it is important to stress that the different species involved have very different energetic needs, particularly in terms of sheer quantities of food. An individual Great White or Dalmatian Pelican, with body masses of 10-12 kg, will have to ingest an amount of about 1.5 kg of fresh fish mass every day in order to maintain its energetic balance, while smaller and lighter birds like Squacco Heron and Black-crowned Night-heron, with body masses of 300 and 625 g respectively, only ingest amounts of 83 and 142 g of fresh food a day (see Table 4.1). This implies that in order to hold a similar number of birds, a suitable area for staging, breeding and raising offspring is likely to be quite a lot larger for larger and heavier birds, than for smaller and lighter birds. As we have seen, the larger species are generally capable of performing longer daily feeding flights, allowing them to cover larger areas in search of profitable feeding grounds.
A series of daily counts of feeding cormorants and pelicans at a single site (lake Isac) between 4 and 13 June 2002 (obs. J.J. De Leeuw) strongly suggests that the exploitation of specific feeding sites occurs in a sort of cyclic way: after some 4-5 days of extensive feeding, the birds cease to visit the

Fig. 4.19.
Exploitation of lake Isac by cormorants and pelicans during ten consecutive days in June 2002 (obs. J.J. De Leeuw). Position of lake Isac with respect to colony sites is represented in map.



lake for another similar length of time, after which they return once again (Fig. 4.19). Such a pattern seems to indicate that a lake of this kind may be successfully exploited by thousands of birds for only a couple of days, after which it needs to be left alone because of either depletion of food resources or an effective avoidance behaviour by the remaining fish. Then, either the site 'fills up' again during the next couple of days thanks to the connectivity of the water bodies in the area, or the fish re-appear out of their 'hiding places', after which the birds can use the lake again. In the meantime other similar sites elsewhere are likely to be exploited in a similar way.

Such a cyclic exploitation of individual lakes requires an abundant supply of several such sites within the daily flying range of the predating birds, in order to sustain the needs of the entire population throughout a breeding season. Therefore, it is suggested that the first important factor which determines whether a colony of waterbirds will settle in a certain wetland or not, is likely to be the availability of sufficient feeding grounds within the daily reach of a potential breeding site. For larger and heavier birds, which require more food, this is likely to imply that a higher amount of feeding grounds will have to be in reach than for smaller and lighter birds. We have seen before that, generally, larger birds also tend to be well adapted to flying longer distances, which potentially allows them to cover a large enough searching area to include a sufficient amount of (cyclically) exploitable feeding grounds. For smaller and lighter birds, which need smaller amounts of food, the total surface area of feeding grounds needed is likely to be generally less. However, since they are unable to cover the same extensive searching areas as larger birds, small herons, egrets and ibises need to find their feeding grounds both closer together and in closer proximity to their colony sites. Fig. 4.20 shows that for smaller birds with

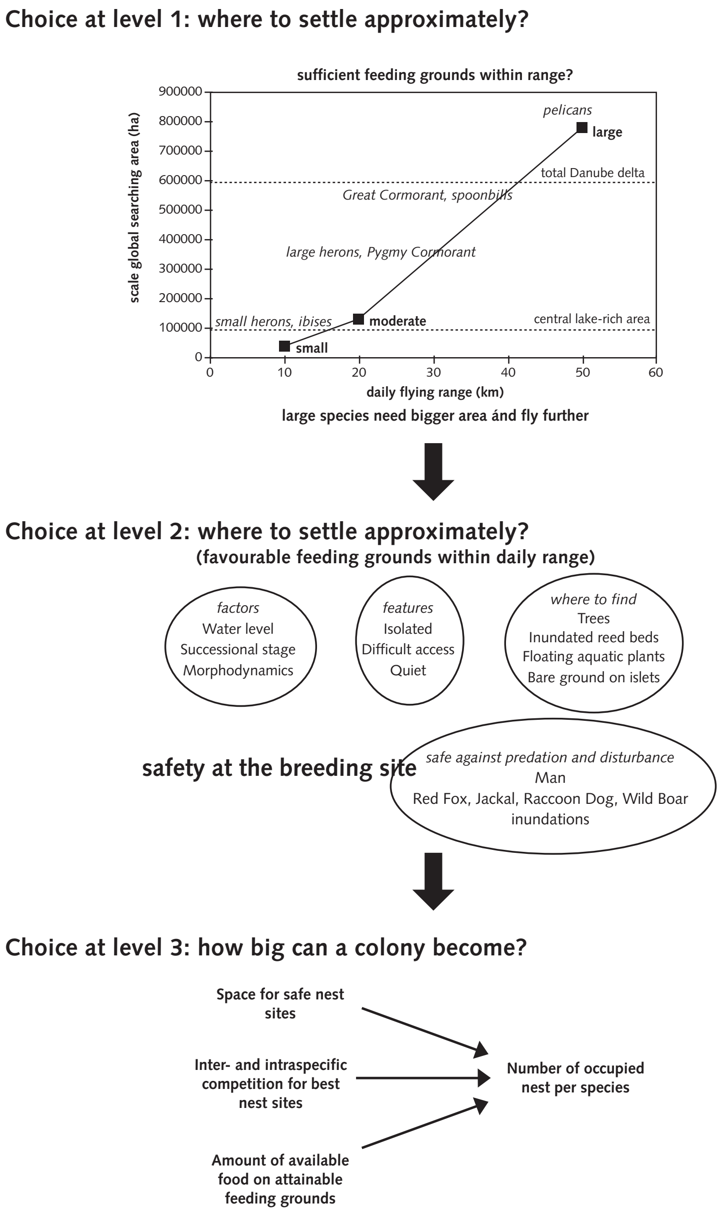


Fig. 4.20.
Schematic representation of the process of choice for site and size of a colony. On level 1 a global choice is made of the general area within which a colony could be established. Here considerations about sufficient feeding area for survival and reproduction within a daily attainable range are crucial. Larger species need more feeding area, but are able to cover larger distances. Smaller species can do with smaller areas, but they will have to be closer together since they cover smaller ranges. On level 2 the exact colony site is being chosen; here safety of the site is the crucial factor. On level 3 it is determined how many birds may breed on the site. Now, availability of space for nests, inter- and intraspecific competition for the nest sites and the availability of food within the coverable distance are determining the actual colony size.

shorter foraging flights, a sufficient amount of feeding grounds will have to be found within a searching area of about 100,000 ha, while the largest and furthest reaching species have to find enough good feeding grounds within an area of almost 600,000 ha. Curiously, these surface areas correspond quite closely to the surface areas of the central and lake-rich part of the Romanian Danube delta and the entire transboundary Danube delta, respectively. Thereby, it is suggested that the smaller birds would have to settle their colonies mainly in the central part, to avoid having too far to fly, while for farther reaching species, like pelicans, Eurasian Spoonbill and Great Cormorant, the exact location of a colony site becomes less important from this point of view.

Once the question as to whether enough food will be available within daily range for a long enough period to last an entire breeding season is answered affirmatively, the choice of the exact location for a colony site comes into the picture. This choice is likely to be mainly determined by safety considerations (Fig 4.20). Potentially, any colony (as a fixed and localised concentration of birds, eggs and chicks) is highly vulnerable to disturbance and/or predation. As we have seen, in the choice of the actual breeding habitats and nest sites the colonial waterbirds tend to use natural processes as hydro- and morphodynamics and vegetation succession to choose precisely those stages in which the desired nesting sites obtain a maximum of isolation and quiet and a minimum of accessibility for terrestrial predators or man. These features may be found in trees, particularly when completely surrounded by water, on islands or inside inundated beds of Reed or other riparian vegetation. Alternatively, floating vegetation or remains of it may also serve this need for protection against intrusion.

Finally, habitat characteristics are not only likely to influence the geographical distribution of the colonies, but also the size of them and, consequently, the size of the entire population of colonial birds that any wetland might hold. Here the amount of available food on the feeding grounds within range of the colony sites is likely to play a major role, the question of carrying capacity. However, another potentially important limiting factor is the actual amount of available nesting space at any individual colony site (*e.g.* Grieco 1999). Almost each nesting habitat type has its own specific limits as to how many nests of birds it may hold. Trees will only hold up to a limited number of nests for each of the potentially tree-nesting colonial species (all but pelicans, which are too heavy for tree-nesting) and so will (remains of) floating vegetation and sites of bare ground on islets.

According to the conceptual model presented above, both the availability of profitable feeding grounds within reach and the attainable safety of potential nesting sites determine the site choice of colonial birds and their population size. In order for all different species to be able to inhabit a certain wetland area, this ideal combination has to be applicable on several different scale levels at the same time, in order to ensure a sufficient proximity of the feeding grounds to the safe nesting sites for the smaller species and a sufficient amount of feeding grounds within the much larger range of the largest species. For the time being, it can be concluded that the scale, the habitat diversity and the relatively low level of human disturbances in the Danube delta still provide these conditions.

4.2 Charadriiformes

4.2.1 Introduction

In this section, we aim at determining broadly the choice of nesting habitat by colonial Charadriiformes at two different scales. At the delta scale, we investigate the choice of the colony site with respect to the surrounding habitats considered here as feeding habitats for breeding birds. Then, colony distribution should depend on the feeding behaviour and food preferences of each species. At the colony scale, we focus on the accessibility of the nesting sites to mammalian predators. Colonies offer a high potential of food to predators and are highly detectable as a result of continuous vocal and social interactions (Lack 1968). Colonial Charadriiformes such as the Black-headed Gull and the Common Tern or the Pied Avocet have developed behavioural adaptations such as group defence that can efficiently deter avian predators (Lemmetyinen 1971, Burger & Gochfeld 1991). However these behaviours are not efficient against terrestrial and nocturnal predators (Southern & Southern 1979). Protection against these aggressions is best achieved by breeding on inaccessible sites to terrestrial predators. Isolation is therefore considered as one of the main criteria of colony site selection (Lack 1968, Buckley & Buckley 1980, Wittenberger & Hunt 1985).

4.2.2 Habitat partitioning and feeding resources.

The colonies counted in 2001 and 2002 were classified in three categories, according to their location: in lagoon, in coastal and in fluvial areas. Then we compared the annual percentage of nesting pairs between each category. Moreover, we have calculated on GIS the percentage covered by several types of habitats (sea, lagoon, freshwater marshes, dry land and others habitats) around each colony as a function of the foraging range of each breeding species (in a radius of 5 km for Collared Pratincole and Little Tern, 15 km for Common Tern, 20 km for Black-headed Gull and 25 km for Pontic Gull and Sandwich Tern).

Habitat selection of most colonial Charadriiformes species in the Romanian Danube Delta Biosphere Reserve is mainly oriented towards the lagoon ecosystem (Table 4.9). This distribution may be explained by the vicinity of their preferred feeding habitats. However, when the Ukrainian part of the delta and the more inland breeding Whiskered Tern are also taken into consideration, the fluvial system (particularly the central part where most lakes and ponds are found) also holds a lot of colony sites (Fig. 4.21).

Table 4.9.
Percentage of Pontic Gull, Black-headed Gull, Mediterranean Gull, Common Tern, Little Tern, Black-winged Stilt, Avocet and Collared Pratincole pairs breeding in coastal, fluvial and lagoon areas of the Romanian Danube Delta Biosphere Reserve in both years of survey.

Area	Year	Pontic Gull	Black-headed Gull	Mediterranean Gull	Common Tern	Little Tern	Pied Avocet	Black-winged Stilt	Collared Pratincole
Coastal	2001	7	0	0	1	0	0	6.3	0
	2002	0	0	0	0	0	0	0	0
Fluvial	2001	0	11.2	0	0.1	0	0	0	0
	2002	0	18.3	0	0.2	0	0	0	0
Lagoon	2001	93	88.8	100	98.9	100	100	93.8	100
	2002	100	81.7	100	99.8	100	100	100	100

Fig. 4.21.
Distribution of colony sites for gulls, terns and waders (Charadriiformes) in the Danube Delta in 2001 and 2002. Note that almost all sites are situated in immediate proximity to larger water bodies.

The Pontic Gull and the Black-headed Gull are feeding generalists (Del Hoyo *et al.* 1996). The diet of the former species has been analysed by Papadopol (1980) for the Dobrodja area. It feeds mostly on fish, terrestrial and aquatic invertebrates, birds and mammals such as rodents, obtained in surrounding steppes and refuse. The Black-headed Gull relies on aquatic and terrestrial insects, earthworms, and marine invertrebrates (Del Hoyo *et al.* 1996). Around the Razim complex both species can find a high variety of usual feeding habitat such as crops, dry and meadow pastures, lagoon, coastal areas, fresh water lakes etc. (Isenmann 1979, Honza & Modry 1994). This corresponds closely to what we observed in the Danube Delta Biosphere Reserve (Table 4.9). The sea was the dominant surrounding habitat for the Pontic Gull, whereas the Black-headed Gull bred preferentially nearby dry land formed by culture, meadows and steppes. Several colonies of Black-headed Gull have been detected in the fluvial ecosystem each year, possibly near Bondar in 2001 and Parches in 2002. In both cases, it was in the margin of this area at a small distance of other habitats. We observed the same pattern in Ukraine in 2002.

Breeding Mediterranean Gull and Collared Pratincole feed principally in terrestrial ecosystems, such as crops and pastures, and freshwater marshes on insects and, for the former, also on rodents and worms (Calvo 1996, Del Hoyo *et al.* 1996). These two habitats were predominant around their colonies in the Danube Delta Biosphere Reserve (Table 4.9). It is not surprising that their colonies were located at the west of the Razim complex. The only Mediterranean Gull colony was present in Murighiol, whereas the Collared Pratincole presented a distribution more in the south (Istria-Sinoe area). This phenomenon may be due to nesting sites characteristics (see below).

Table 4.10.
Mean percentage of habitat coverage around the colonies according to the species and its foraging range. The predominating habitat type for each species is indicated in bold.

Species	Foraging range (km)	Country	Sea	Lagoon	Fresh water	Dry land	Others
Pontic Gull	25	Romania	32.5	12.5	12.5	28.8	13.8
Larus cachinnans		Ukraine	38.3	5.0	21.7	28.3	6.7
TOTAL			**35.0**	9.3	16.4	28.6	10.7
Black-headed Gull	20	Romania	0.0	5.0	12.5	60.0	22.5
Larus ridibundus		Ukraine	6.4	2.4	12.9	47.1	31.1
TOTAL			5.0	3.0	12.8	**50.0**	29.2
Mediterranean Gull *Larus melanocephalus*	*20*	Romania	0.0	10	20	**60**	10
Collared Pratincole *Glareola pratincola*	*5*	Romania	6.7	16.7	21.7	**50.0**	5.0
Little Tern *Sterna albifrons*	5	Romania	10.0	15.0	20.0	**55.0**	0.0
Common Tern *Sterna hirundo*	15	Romania	27.5	10.0	12.5	**38.8**	11.3
Sandwich Tern *Sterna sandvicensis*	25	Ukraine	**57.5**	7.5	30.0	5.0	0.0

The tern species are fish eating birds. The Sandwich Tern feeds on marine fish at a maximum of 25 kilometres from breeding sites at sea (Fasola & Bogliani 1990, Brenninkmeijer & Stienen 1992). Therefore, they usually breed on littoral or coastal lagoons such as in the Ukrainian part of the delta and the sea represented 57.5% of the habitats around their colonies (Table 4.9). Common Tern and Little Tern are specialised on small fish but they forage at a smaller range, about 10-15 km for the former and 5 km for the latter (Fasola & Bogliani 1990). They breed mainly in coastal areas and coastal lagoons, even if they also breed inland along lakes and rivers (Del Hoyo *et al.* 1996). However, in the Danube Delta Biosphere Reserve, the dry habitats were predominant in the vicinity of their colonies (Table 4.10), although they do not use them. Consequently, the location of their colonies does not completely respond to their needs. Their virtual absence in the fluvial habitats of the delta may be related to the low availability of nesting sites there and to the possible competition with other very abundant small fishing birds (*e.g.* Whiskered Terns and grebes).
The Pied Avocet and the Black-winged Stilt are mainly invertebrate feeders (Del Hoyo *et al.* 1996). They tend to feed close to the colony sites. The former prefers brackish and salt-water areas, whereas the latter inhabits brackish as well as freshwater areas, both of them looking for shallow water. Consequently, the Black-winged Stilt was observed mainly in Murighiol and Vadu, shallow water bodies and small freshwater ponds, whereas the Pied Avocet was restricted to the brackish water of Plopu and Vadu.

As expected, foraging ecology of the colonial Charadriiformes explains the distribution of their colonies. The Danube Delta Biosphere Reserve is largely dominated by freshwater marshes and reedbeds and water depth is quite high. Therefore, most of the area is not favourable to these species which are restricted to the lagoon area. The coastal marine ecosystem, however, is poorly used for breeding in comparison with other deltas.
A huge difference is observed between the Romanian and the Ukrainian part where very large colonies were observed on the dynamic coastal area.

More precisely, the Sachalin peninsula in Romania, apparently as favourable as the Novaya Zemlya in Ukraine, presented high numbers of birds without breeding. The dynamics of the peninsula and human perturbation may be the reasons of the absence of breeding birds there (see below and chapter 5.2)

4.2.3 Nesting and man-modified habitat

Colonial waterbirds require nesting sites isolated from mammalian predation and human disturbance. Colonial Charadriiformes usually nest on islands and islets isolated from the mainland. In order to reduce disturbance (see paragraph 3.2.1), most of the colonies were observed at distance. Thus, we were not able to measure nesting habitat features precisely. Therefore, colonies on island were considered as isolated from mammal predators and those settled on the mainland were considered accessible to mammal predators.

Most of the colonies observed in Romanian Danube Delta Biosphere Reserve were isolated from terrestrial predation (Table 4.10). Semi-colonial species such as Pied Avocet and Black-winged Stilt may breed in very small colonies (less than 10 pairs) and even solitarily. In that case, isolation from mammal predation is not an absolute prerequisite and they can evict predation by mimetic nesting. Thus, they can breed quite everywhere if feeding conditions are good in the close surrounding area. This was the case of several pairs of Pied Avocet breeding along the shore of lake Plopu and in Grindul Saele in 2001.

The Collared Praticole also is a species adapted to breeding in accessible sites (Calvo 1994). In 2001, they bred essentially on the island of the North Vadu basin. In 2002, they bred in larger numbers than in 2001 in the salt steppes around Vadu basin, in Grindul Saele and in a sunflower crop near Sinoe town. In such a case, the colonies are quite small and present a quite loose concentration of the nests, thus reducing nest detection by predators.

Perhaps one of the most surprising situations for colonial Charadriiformes in the Romanian Danube Delta Biosphere Reserve is the use of man-modified habitat for nesting, despite the huge surface area of natural areas (Table 4.11). The only colony of Pontic Gull discovered in the coastal marine ecosystem, in 2001, was on a ship wreck. The Vadu's colonies were within highly artificial decantation pans built for factory. They were the first most important nesting areas for the Little Tern and the Collared

Table 4.11.
Percentage of Pontic Gull, Black-headed Gull, Mediterranean Gull, Common Tern, Little Tern, Black-winged Stilt, Pied Avocet and Collared Pratincole pairs breeding in sites accessible or isolated from mammal predators in the Romanian Danube Delta Biosphere Reserve in regards to the year of survey.

Nesting habitat	Year	Pontic Gull	Black-headed Gull	Mediterranean Gull	Common Tern	Little Tern	Pied Avocet	Black-winged Stilt	Collared Pratincole
Accessible	2001	0	0	0	1	5.7	34.3	6.2	8.6
	2002	0	0	0	0	0	7.8	3.6	46
Isolated	2001	100	100	100	99	94.3	65.7	93.8	91.4
	2002	100	100	100	100	100	92.2	96.4	54

Pratincole in 2001 and 2002 and for Black-winged Stilt and Pied Avocet in 2001. Another decantation basin near Enisala hosted few pairs of these two latter species in 2002.

Although lake Murighiol appears more natural, its hydrological functioning depends partly on irrigation input and drainage and it has suffered an important ecological changes in a recent past (Gâstescu *et al.* 1999, Papadopol 1981). It hosted the largest colonies of the two small gull species and Common Tern in 2001 and 2002, and of Black-winged Stilt in 2002.

Table 4.12.
Percentage of Pontic Gull, Black-headed Gull, Mediterranean Gull, Common Tern, Little Tern, Black-winged Stilt, Pied Avocet and Collared Pratincole pairs according to the degree of habitat artificiality in the Romanian Danube Delta Biosphere Reserve in 2001 and 2002.

Nesting habitat	Year	Pontic Gull	Black-headed Gull	Mediterranean Gull	Common Tern	Little Tern	Pied Avocet	Black-winged Stilt	Collared Pratincole
Man made	2001	7	0.4	0	11.7	94.3	47.8	67.7	97.1
nesting site	2002	0	0	0	15.3	100	9.8	16.7	96
Functioning	2001	56	88.3	100	87.2	0	0	15.6	0
induced by man	2002	37.8	81.6	100	84.6	0	15.7	79.8	0
Natural	2001	37	11.3	0	1.1	5.7	52.2	16.7	2.9
	2002	62.2	18.4	0	0.1	0	74.5	3.5	4

Very different areas are found in the natural habitat category. Lake Plopu is located just near the village of Plopu and is highly frequented by humans and grazing animals. However, it can be considered as natural from a functional point of view. It is the most important breeding area for the Pied Avocet in the Romanian Danube Delta Biosphere Reserve. Sinoe lagoon is also an important natural nesting area for Pontic Gull. However, water level variations and flooding in spring may be detrimental to the settlement of the colonies, as observed in 2001 and 2002 (see paragraph 3.2.2). Finally, one Black-headed Gull colony was detected both in 2001 and 2002 in the fluvial ecosystem on an island composed by emerged land and reeds. This seems quite rare in the Romanian part of the Danube delta. The important water level variation in spring due to the connection of the marshes with the Danube River may be the explaining factor. Early in spring, high water level may cover islands during the colony settlement period, making them unavailable for nesting, whereas later in the season, it may flood the nests. Because of the risk of flooding, emerged islands above maximum water level seem necessary and may be a rare resource in the fluvial ecosystem.

The use of man-modified habitat by colonial Charadriiformes may be the sign of a general lack of optimal islands for breeding. The scarcity of colonies in the fluvial ecosystem of the Romanian Danube Delta Biosphere Reserve is not very surprising, even if Black-headed Gull and Common Tern colonies should be expected more frequently. On the other hand, the lagoon complex of Razim and Sinoe, and the coastal area should be largely used. Despite the large size of the area, breeding numbers are comparatively small and this may be explained by the scarcity of islands.

The Sachalin peninsula forms a specific habitat for breeding colonial Charadriiformes fishing at sea such as terns or Pontic Gull. However, the peninsula is now connected to the mainland and tracks of several predators, such as Otters *Lutra lutra* and Jackals *Canis aureus* were observed. Moreover, human presence is also largely predominant. Several cow herds and fishermen camps were noted on Sachalin. This situation contrasts with the coastal area of the Ukrainian part of the delta, which is still dynamic. Sedimentation processes are in progress and bare sand dunes and coastal lagoons are still in formation. Human disturbance and predation should be low in these places. Therefore, it comes as no surprise that we found the largest colonies of Pontic Gull and Sandwich Tern in Novaya Zemlya and Vostotchnoye sandbank areas.

Another indication of the lack of nesting sites is the effect of the low water level observed in Murighiol and lake Plopu in 2002. In the former, larger bare beaches were exposed around islands forming a larger nesting place. Thus, in 2002, total numbers of breeding pairs doubled accordingly. This was particularly spectacular on islands 13 and 16 where the number of pairs was multiplied by 24 and 88 respectively and new breeding species appeared. This clearly illustrates the well-known versatility of Charadriiform birds in colonising new breeding habitat (pioneer situations) as soon as it becomes available. In Plopu, it was a bare "new" island that was exposed above water that attracted higher numbers of breeding birds. Numbers of Pied Avocet doubled too and they were all nesting on this new island.

The case of the Whiskered Tern

The Whiskered Tern principally occupies the fluvial system of the delta, as well as some vegetated areas of small and big lakes such as lake Babadag. There they find floating vegetation, their preferred nesting habitat (water lilies *Nymphaea* spp. and *Trappa natans*) and feeding habitat. They are not limited by shallow water because they feed flying over fresh and open water on small fish and invertebrates (Del Hoyo *et al.* 1996).

It seems that their distribution in the Romanian Danube Delta Biosphere Reserve is not uniform (*cf.* section 8.3.10). Most of them breed on the canals and lakes at the north of the Sulina branch and at south in the Gorgova-Isac-Uzlina area. Particularly, the Alb colony (Nisipos) was huge and probably one of the larger colonies known in Europe.

The Danube Delta is a very important area for Whiskered Tern. Moreover, the research on this species is very poor elsewhere in Europe. Because recent ecological changes in water composition and vegetation composition may have affected the species, it should be essential to investigate their nesting habitat selection and reproduction in the DDBR.

4.2.4 Conclusion

Patterns and processes of habitat selection are often perceived through a narrow window of time that fails to adequately grasp the larger picture (Wiens 1989). A "species' habitat" is therefore described as a relation between the presence or abundance of an organism and attributes of its physical and biological environment. In this context, relations between animals and habitats are considered stable systems, in which individuals are not limited in their choice. This is rarely the case and spatial and temporal variations in resource abundance or availability over the long term have to be considered to avoid erroneous conclusions on processes of habitat selection. Moreover in the case of species of high conservation profile such knowledge is critical for taking biologically sound management decisions. In the Romanian Danube Delta Biosphere Reserve, several pieces of evidence point to the suggestion that colonial Charadriiformes are at least limited by nesting sites. A specific study on nesting habitat selection should be necessary in order to verify if optimal islands for breeding are a limiting resource for colonial Charadriiformes and may explain the relatively low numbers found.

Feeding Eurasian Spoonbills in man-made canal in lagoon area.

5 Numerical developments in relation to human activities

5.1 Pelecaniformes and Ciconiiformes

It is typical for wetland habitats that they show a quite considerable amount of dynamics in space and time. This does not only influence the suitability of feeding sites, as has been indicated above, but will also affect the suitability of colony sites. Changes in spatial patterns of habitats that may affect colony site suitability will take place in all parts of the Danube delta, but are particularly well noticeable in the coastal and lagoon systems, where the time scale of the changes is shorter than in the freshwater fluvial systems.

Without more specific data, Dragomir & Staras (1992) estimated an overall presence of waterbirds (including all piscivorous species) of no less than 7 million individuals by the end of the Second World War in 1945, while by 1989 these numbers had gone down to no more than 0.3 million (Fig. 5.1). Although, this decline would seem to be unbelievably strong, there is good documentation of the fact that, at times, quite impressive numbers of fish-eating birds, have been killed (*e.g.* in 1956 and 1957 totals of 106,340 and 70,000 respectively; Paspaleva *et al.* 1985).

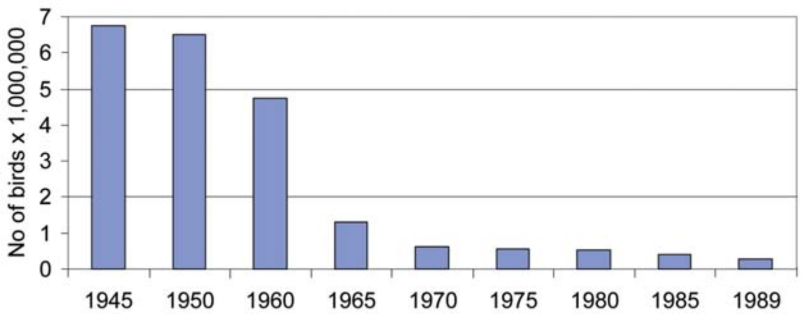


Fig. 5.1.
Estimated numerical development of waterbird numbers in the Danube Delta between 1945 and 1989, according to Dragomir & Staras (1997).

5.1.1 Fisheries

Many of the colonial waterbirds live primarily on fish, which also represents the main source of income for the local human population of the Danube delta. Considering the huge numbers of particularly pelicans and cormorants breeding within the confines of the Biosphere Reserve and the vast amounts of fish they need for themselves and their offspring, it is logical that questions are being asked as to whether the delta's carrying capacity for fish production is or will prove to be sufficient to support both the birds and the local human population. This real, or at least potential, conflict will be (briefly) addressed here, taking into account a probable/possible increase in human fisheries intensity in the future.

It has already been mentioned that rough calculations of the total gross fish consumption during the entire breeding season by cormorants and pelicans, by far the most important fish consumers among the colonial waterbirds, amounted to over 5,100 and over 7,700 tonnes of fresh fish for the years 2001 and 2002, respectively. In order to obtain a better idea of what this may mean on the level of one particular feeding site, the daily counts of feeding piscivorous birds on lake Isac in the period of 4 till 6 June

2002 by J.J. De Leeuw have been used to get estimates of the maximum amount of fish caught by these fishing flocks, assuming the birds obtained all their food on those days from this particular lake (Fig. 5.2). The results suggest that a maximum 'harvesting' level of between 3000 and 5000 kg of fresh fish could be caught in a single day, but that then after three to four days the lake would become 'depleted', or at least 'unharvestable'. Taking into account that lake Isac has a surface area of about 1000 ha, this would mean that five days of 'heavy' exploitation by cormorants and pelicans at a rate of 3000-4000 $kg.day^{-1}$ would involve a harvest of 5*3000/1000 = 15 $kg.ha^{-1}$ to 5*4000/1000 = 20 $kg.ha^{-1}$ of fish biomass during a period of five days. After such a period, it may take three to four days before a similarly high predation rate can be reached again, probably as a result of 'refilling' of the lake by fish from elsewhere. Assuming that such a rhythm of predation, i.e. in about 55-60% of the days harvesting some 3-4 $kg.ha^{-1}$ of fish per day, could be maintained throughout the three month breeding season, lake Isac may yield between 200 and 280 $kg.ha^{-1}$ of fish for bird consumption during the breeding season.

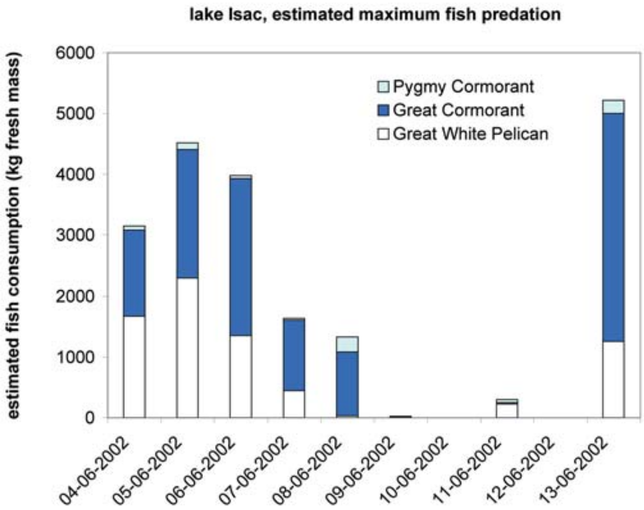


Fig. 5.2.
Estimated maximum fish predation by pelicans and cormorants during ten consecutive days in June 2002 at lake Isac, based on counts by J.J. De Leeuw and assumptions on daily food consumption.

Within the confines of the entire Danube Delta Biosphere Reserve, a total of about 10,000 ha of the habitat type 'turbid fresh water', to which lake Isac belongs (Oosterberg *et al.* 2000, Hanganu *et al.* 2002) is available. Larger freshwater bodies with turbid water, like the Ukrainian lakes and the lakes in the Razim/Sinoe complex, are not included in this figure, since it is considered to be virtually impossible that pelicans and cormorants could have even a temporary impact on fish attainability there. Thus, the rough calculations above imply that cormorants and pelicans, which can reach the entire area from their breeding colonies, may take a total amount of 2000-2800 tonnes of fish from the smaller turbid freshwater lakes in the area. Thus, lakes of the type of lake Isac could provide at least for 32-55% of the total food needs for cormorants and pelicans in the Danube delta. However, although Great Cormorants as well as both species of pelican also frequently feed in large numbers at sea and in the Ukrainian lake Sasyk, outside the confines of the Biosphere Reserve, it seems likely that in fact the central lakes of the Danube delta are exploited by these birds in more than the estimated 55-60% of the days. Thus, it can be tentatively concluded, although data are scarce, that cormorants and pelicans together might take up to 70% (= 3,600-5,400 tonnes) of their food requirements from these lakes.

In 2001 the lakes, which were closest to the main river branches, were shown to hold larger fish biomasses than the more isolated lake types. In 2002 the importance of connectivity for high fish biomass was confirmed by the finding that the blocking in May 2002 of the canal connecting the lakes Isac and Uzlina with the Sfintu Gheorghe river branch had led to a reversed trend in fish biomass in relation to distance to the river. Thus, it would seem that the best-connected freshwater lakes in the Danube delta are able to maintain high standing stocks of fish biomass due to their connectivity. The system of these lakes even proved to be capable of producing an increase of fish biomass between June and September in both 2001 and 2002, in spite of the seemingly high predation pressure by the piscivorous birds (Navodaru *et al.* 2003a). They showed an overall increase in fish biomass of 5.992 to 7.657 kg/100 m gillnet in 2001 and of 3.198 to 7.853 kg/100 m gillnet in 2002.

Data on amounts of fish landed by human fisheries have not been analysed, but the combined data on fish abundance throughout the summer season and the estimates on bird predation suggest that at least for the moment the productivity of the delta's freshwater lake system is sufficient to support both a healthy fish population and the existing large populations of colonial fish-eating birds. The fact that most of these lakes are firmly inter-connected among themselves and with the main river branches greatly contributes to this resilience of the system. It is even likely that human fisheries, as they tend to focus more on the larger predatory fish species, may contribute to the availability of large amounts of smaller fish that are generally the best prey items for fish-eating birds. Such relationships are likely to occur in other heavily fished wetland systems like the lakes IJsselmeer and Markermeer in the Netherlands (Van Rijn & Van Eerden 2001). However, more detailed research into exact fish production and more precise data on both bird and human predation rates are needed in order to predict up to which point a future increase in human fisheries would prove to be possible without disturbing this apparent balance.

5.1.2 Land-use and water management

Up to the present day, agricultural land-use has had a very limited impact on the ecological functioning of the Danube delta. Nonetheless, significant parts have been reclaimed for agricultural use and have thus reduced the surface area of natural wetlands. The largest polder reclaimed is the Pardina polder in the northwestern part of the Romanian Danube Delta Biosphere Reserve. Without doubt, the reclamation of this area has led to a decrease in both potential feeding habitats and suitable breeding sites for most of the colonial waterbird species. The only exception is likely to be the Cattle Egret, which is by far the most terrestrial feeding species and probably even became established as a breeding bird due to this reclamation.

Another type of land-use, which has been practised in the past, consists of the construction of artificial fishponds. This artificial habitat, however, is likely to have become included in the feeding areas of most colonial bird species. Moreover, these practises have proved to be uneconomical, because of the difficulty of regularly draining and refilling the ponds. By and large, nowadays all former fishponds have been abandoned and are, once again, completely incorporated into the delta's natural ecosystem. An exception is the fishpond area at Rusca Balteni, where a large Purple Heron colony was still established in 2001 (pers. comm. Paul Cîrpaveche), but was reclaimed for agricultural purposes in autumn of the same year. This inevitably resulted in the disappearance of this colony.

The main human impact on the Danube delta has undoubtedly been the design, construction and maintenance of waterways for navigation infrastructure, facilitating activities such as fishing and Reed harvesting. This has led in the past to a vast network of canals, connecting the lakes among themselves and with the main river branches. As has been shown above, this system of canals and its enhancement of the connectivity of many of the larger lakes have probably led to higher standing stocks of fish in the lakes. Both man and piscivorous birds may have taken benefit from these changes. On the other hand, water quality gradients are likely to have changed in favour of the more eutrophic situations, reducing the amount of more isolated and more mesotrophic freshwater lakes that are likely to have characterised the more pristine situation (*e.g.* Oosterberg *et al.* 2000). Thus, although the larger piscivores like cormorants and pelicans may have profited from these man-induced changes, the smaller species of heron, the Pygmy Cormorant and the Glossy Ibis, feeding mainly on small (semi-)aquatic invertebrates, are likely to have suffered decreases.

5.2 Charadriiformes

5.2.1 Introduction

The relationships between bird numbers and habitat are generally not obvious (Järvinen & Väisänen 1979, Wiens & Rotenberry 1981). Food availability, predators, competition, disease, mortality, natality, immigration, emigration and weather all influence how bird numbers relate to habitat. Furthermore, the size of migratory populations may be limited by conditions prevailing on their wintering grounds. These interactions exhibit some degree of scale dependency and influence population sizes either locally, regionally or even over larger areas (Virkkala 1991). Furthermore, the importance of each of these may change with time. Knowledge of the history of one population or community is prerequisite to the understanding of these relationships. Since it is rarely possible to manipulate these systems, a comparative approach at different spatial levels seems to be an effective way to study their functioning.

Väisänen *et al.* (1986) proposed two general hypotheses to explain the relationships between population and community dynamics at the local and regional scales. The first one is that bird population changes depend mainly on local habitat changes and the regional pattern appears to be a sum of the local patterns. The second is that local population changes are influenced by changes on the regional scale and cannot be understood without reference to the latter.

5.2.2 Material and methods

Over the last century, major habitat changes have occurred in the Romanian Danube delta. Important management measures have been taken to control water regime for agriculture, to improve access to the larger lakes and to the sea and to develop fish ponds and agricultural polders within the delta. In order to obtain a better understanding of the present situation in bird numbers, distribution and habitat preferences, it seems indispensable to take a closer look at the historical data on birds and habitat changes.

Despite the existence of papers on birds in general, and Charadriiformes in particular, breeding in the Danube delta, very few quantitative data are available. For this reason, it is quite difficult to determine the real impact of these changes on waterbird community. Papadopol (1981) said that

"… and particularly in the Danube delta, the Dranov island and the Razelm-Sinoe lagoon complex were known as the land of huge colonies of herons, cormorants, ibises, crowded of gulls, terns…" and afterwards "… from the second half of the XIX^e century and the first half of the XX^e, under the intensification and diversification of human management, the avifauna has suffered contrasting modifications and has been more and more touched by these anthropogenic factors and their home range and numbers have been reduced ….".

We have distinguished three different periods from the literature. The first one from the end of the 19th century to the first half of the 20th century is characterised by major habitat changes. The construction of two big canals, Dunavât in 1905 and Dranov in 1912, connecting the Sfîntu Gheorghe branch to the Razim lagoon led to a progressive decrease of salinity in the lagoon system. The construction of two outlets during the second period, between 1950 and 1970, aimed at controlling the exchange with the sea. By consequence, the salinity of the Razim lagoon decreased from 27‰ to 6‰ and most of the surrounding lakes changed from salt or brackish water lakes to freshwater lakes due to the water input from the irrigation - drainage network (Murighiol and Nuntasi for example). During the third period, from 1970 to present, several lakes around the Razim lagoon were affected by eutrophication (Gâstescu *et al.* 1999), whereas most of the lakes surrounding the Razim lagoon were transformed into fish farms. Nowadays, lake Plopu and part of lake Sinoe are still brackish. It is not excluded that with salinity, both water regime and water level variation have changed over the last decades. Are changes in bird numbers and distribution related to these habitat managements?

5.2.3 History of birds and human impact

1) The end of the XIX^e century and first half of the XX^e century (from Dombrowski (1912) and Lintia (1955) in Papadopol (1966a, 1980))

By the end of the 20th century, very large numbers of breeding gulls and terns were present in the Romanian Danube delta (Table 5.1). Moreover, six species absent in the 2001-2002 censuses were still noted as breeders:

Table 5.1
Estimated numbers and location of breeding gulls and terns in the Romanian Danube delta between the end of the 19th century and the end of the first half of the 20th century.

Species	End of the 19th century	Beginning of the 20th century	Main sites
Pontic Gull	Thousands	Largely smaller numbers	Razim and Sinoe lagoon
Lesser Black-backed Gull	Small numbers until 1922-1923		Snakes island
Slender-billed Gull	Thousands	Hundreds	Sinoe lagoon
		Some colonies (1930)	Grindul Chituc
		3 nests	Near Istria
Mediterranean Gull	Thousands	800-1000 pairs	Razim and Sinoe lagoon
Black-headed Gull	Large numbers		all lakes of the Danube delta
Little Gull	Small numbers	Unknown	Dobrodja area
Gull-billed Tern	Thousands	Unknown	Razim area
Sandwich Tern	Thousands	One small colony	Sinoe lagoon
Caspian Tern	Thousands	Largely smaller numbers	Razim and Sinoe lagoon
Common Tern	Thousands		Razim and freshwater of the delta
Little Tern	Breeding	Breeding	Razim and Sinoe lagoon

Lesser Black-backed Gull *Larus fuscus*, Slender-billed Gull *Larus genei*, Little Gull *Larus minutus*, Gull-billed Tern *Gelochelidon nilotica*, Sandwich Tern *Sterna sandvicensis* and Caspian Tern *Sterna caspia*. Some observations may be considered suspicious, such as the breeding of the Lesser Black-backed Gull in regard to their present-day distribution area in Central Europe. Moreover, the presence of the Little Gull was not precisely located (i.e. in the Dobrodja area) and the species may not have bred within the delta area.

As observed today, the Razim lagoon complex was the main nesting area of most the species. However, an important decline was observed during the first half of the 20th century for at least Pontic, Slender-billed and Mediterranean Gull and Gull-billed, Sandwich and Caspian Tern.

In addition to the habitat changes expressed above, this period is also characterised by the canal construction on Sulina branch (1874-1902) with the help of numerous manual workers. Moreover, at the beginning of the 20th century, the railroad arrived in Tulcea and numbers of people living in the delta may have increased accordingly. Thus, this period may also be seen as one of an increase of human presence and disturbance in the delta.

2) The 1950' and 1960' period (publications of Catuneanu *et al.* 1978; Munteanu 1960; Papadopol 1966a and b, 1968; Talpeanu 1963)
The breeding area of the Black-winged Stilt was restricted to the salt marshes and lagoons of the Romanian Danube delta. In the salt marshes of Murighiol, the presence of 30 - 60 nesting pairs justified the designation of this area as special refuge for the species in 1960-65. However, numbers were highly variable and only a single pair bred in 1966 due to high water level, whereas three more pairs bred along lake Plopu. The impact of water level variation on these species in Murighiol and Plopu was also noted in 2001-2002. Several pairs bred in the Razim complex and in the mid-southeast of the Danube delta where they nested on small plaurs and old *Juncus* spp. ramets.

Small colonies of Pied Avocet were present in the Razim complex and in several salt marshes along the Sfîntu Gheorghe branch in the north of the complex. Annual fluctuations in numbers were observed, such as the variation between 1-2 pairs to 4-10 pairs in the Murighiol- Plopu - Sarinasuf area. Numbers appeared more constant in the area between Istria and Tuzla. Needs for important conservative measures were expressed.

The Collared Pratincole bred mainly in the salt steppes of the lagoon zone around Plopu and Istria-Tuzla. The size of most of the colonies did not exceed 8-10 pairs.

The Black-headed Gull was localised in the Razim complex and was the most abundant of the *Larus* species, but numbers including the other larids did not exceed 100 pairs (largely underestimated ?). Pontic Gulls bred in a colony on the border of the Razim-Sinoe complex. Mediterranean, Slender-billed and Little Gull were rare and mainly localised in the Istria–Tuzla area. The former was the most frequent.

The Common Tern was abundant in the Danube delta and the Razim complex, whereas the Little Tern, less abundant, was restricted to Sinoe, Istria-Tuzla and Lunca. Sandwich and Gull-billed Tern were rare and confi-

ned to the Razim-Sinoe complex. No quantitative data are available.
The continuation of the decline initiated in the preceding period characterised this second period. The species absent today became rare and, except for the Mediterranean Gull, the numbers of the other species seemed to be similar to the present-day situation. It can be noted that at least the three gull species were absent in lake Murighiol. The distribution of the colonial waders was the same as observed in 2001-2002. However, the Pied Avocet was present in Sarinasuf and the Collared Praticole in Plopu.

3) The 1970′-1990′ period (Gâstescu *et al.* 1999; Kiss 1971, 1973, 1976a and b, 1998, 2001; Meita & Ceico 1993; Papadopol 1980, 1981; Stanescu 1973, 1980; Stanescu & Zsivanovits 1973; Szombath & Kelemen 1972; Van Impe 1977; Weber 2000)
The main change observed since 1968 is the first breeding of colonial Charadriiformes on Sachalin peninsula (Table 5.2). There, 10-12 pairs of Collared Pratincole were counted and one dead chick of Gull-billed Tern was found. The most abundant species was the Common Tern nesting along 2.5-3 km along the beach. About 15,000 pairs were estimated to be present. Between 100 and 200 pairs of Little Tern were counted and Sandwich Terns were present. Between 1969 and 1971, numbers were more or less similar and five pairs of Pied Avocet bred. Between 1972 and 1974, the Black-headed Gull was controlled for the first time (1972) and numbers of Sandwich Tern increased (31 nests in 1972, over 300 in 1973 and 2500 pairs in 1974). Numbers of Common Tern and Little Tern were stable.

Table 5.2
Development of breeding pair numbers of colonial Charadriiformes on the Sacalin peninsula during the period 1968-1990.

Species	1968	1969-71	1972-1974	1980	1990
Pontic Gull	0	0	0	0	278+
Black-headed Gull	0	0	20	Several	0
Common Tern	15,000	10,000	15,000	2000	0
Little Tern	100-200	100-200	100-200	100-200	0
Sandwich Tern	Present	Unknown	2500	1000	0
Gull-billed Tern	1+	0	0	0	0
Collared Pratincole	10-12	2-3	0	0	0
Pied Avocet	0	5	0	0	0

In 1980, numbers of Common Tern decreased a lot whereas the other species were still present. In 1990, all these species did not breed anymore and were re-emplaced by the Pontic Gull (278 chicks were ringed).

Data for the other places are fragmented. Two sites in the fluvial ecosystem never mentioned before were occupied at least sporadically: Rosetti where the Black-headed Gull and Common Tern bred in 1987, and Martinca where the Black-headed Gull bred in 1984.

In the lagoon ecosystem, the lake of Murighiol was occupied by Black-headed Gull in 1990 (at least 10 chicks), in 1992 (ca. 40 pairs) and 1995. The Mediterranean Gull bred there for the first time in 1992 (2 pairs) and was present in 1995. The Common Tern bred in 1990 and at least 200 pairs bred in 1992. On the Sinoe lagoon, at least 102 Pontic Gull chicks were ringed in 1996.

More precise data were collected on the Istria lagoons. In 1973, the communication between Sinoe lagoon and Istria lagoon was closed.

Consequently, the salinity of the lagoons decreased from 16-20‰ to freshwater and halophyte vegetation (*Salicornia, Obione* and *Suaeda*) disappeared. Pied Avocet still bred in small numbers whereas Black-winged Stilt became accidental. In 1992 and 1993, 2-4 pairs bred on the eastern bank of lake Tuzla. Collared Pratincole suffered a large regression due to overgrazing and 39 pairs still bred in 1971. No gull species bred anymore and the formerly very abundant Common Tern became rare (183 pairs in 1971). In 1992 and 1993, 1-6 and 5 breeders respectively were counted in the eastern bank of lake Nuntasi. The situation was similar for the Little Tern. While 92 pairs still bred in 1971, they have become rarer and rarer since 1978.

5.2.4 Discussion

Since the 20th century, the distribution of breeding colonial Charadriiformes in the Romanian Danube delta has always been centred on the Razim-Sinoe complex of lagoons. However, we can moderate this affirmation in two points. First, the problems of access and detection in the fluvial ecosystem may have been even more accute at the end of the 20th century than those encountered in 2001 and 2002. As a consequence, the past occupation of the freshwater area may have been severely underestimated. Second, old papers suggested that Black-headed Gulls and Common Terns were abundant in all lakes of the delta. If these also concerned the fluvial ecosystem, we have no precise data on the location of these colonies and on their relative sizes.

Decrease in numbers and impoverishment of the colonial Charadriiformes community seem to be the major changes that occurred at the beginning of the 20th century (Table 5.2). However, quantitative data were scarce or without any precision on methodology and it is quite difficult to advocate strongly for such a decline. But even if over-estimated, the numbers mentioned were so high in comparison to the present numbers that a significant decline is very likely. In the same way, even if Little Gull or Lesser Black-backed Gull have never bred in the Romanian Danube delta, Slender-billed Gull, Gull-billed Tern, Caspian Tern and Sandwich Tern have clearly disappeared today.

This decline occurred during the period of the most massive management of the delta and, more precisely, of the lagoon area. This management has significantly changed the hydrological functioning of the Razim-Sinoe complex at several levels.

First, the presence of large numbers of breeding birds in the past in the Razim-Sinoe complex was only possible because of the presence of safe breeding islands. This is not the case anymore. Human management has modified the water regime of the lagoons and higher water levels in combination with more stability of the water level are perhaps the rule nowadays. Both may have an impact on island availability. Compared to the Black Sea level, only 15% of the area is above 0 m level (Gâstescu *et al*. 1999) and high water level may continuously flood islands that were occupied in the past by colonies. A fine topology of the bottom of the lagoon may still reveal their presence. More importantly, potential breeding islands may have disappeared by erosion without replacement by natural processes. Any catastrophic intrusion of the sea during storm may have been prevented by the re-enforcement of the protection device against the sea (dune, dike etc.) for the control of water input into the lagoon. Thus, formation of new islands and islets by natural landscape disruption and sedimentation would have been prevented too. These habitat modifications must have had a direct impact on all species of colonial Charadriiformes, which need islands for breeding, irrespective of their feeding ecology. This scenario contrasts with the present situation in the Ukrainian part of the Danube delta that is still dynamic and which still presents large colonies. Moreover, the loss of both hydrological dynamics and the salt influence will have caused vegetation succession towards higher and denser stands, less suitable for ground-breeding gulls and terns. Regular rejuvenation of these stands by salt intrusion and or high floods has come to an end.

Second, also the salinity of the water decreased due to the connection with the Danube river and, later, by the control of the exchange with the sea. Consequently, a major disruption of the food chain occurred certainly from salt and brackish fauna and flora to freshwater ones. Slender-billed Gull and Pied Avocet, the two species the most attached to lagoon habitats, would have suffered from this change. However, we have no data on Pied Avocet at this period. The maintenance of the Slender-billed Gull, although rare, during the period 1950-1960 in the Istria zone, which remained brackish until this period, points into that direction. Moreover, the decrease in salinity is often associated with an increase in water turbidity (Grillas, pers. comm.). Fishing efficiency is largely reduced in fish eating birds, such as terns and Pontic Gull, which hunt by eye, by the lack of visibility in the water column. These species may have been affected by this phenomenon.

Thirdly, the increase in human activity in the delta and in human population must have increased human disturbance. These three possible factors are not mutually exclusive and may have occurred together. The quite well documented development of the colonies in the Sachalin peninsula is representative of the combination of these factors and of their resulting effects on the lack of natural breeding sites. The huge colonisation of Sachalin at the beginning of the 1970s resulted from the natural formation of the peninsula and its disconnection from the mainland. It was the most important Charadriiformes area of the Romanian Danube delta and the last site used by Sandwich and Gull-billed Tern, two species which disappeared from the area since the 1990s. Today, the peninsula is directly connected to the mainland and frequently visited by people. Both human disturbance and predation by mammals may explain by themselves the absence of breeding birds in 2001 and 2002.

Since 1950, numbers seem similar as today. Changes in bird distribution were related to local management in surrounding lakes. Most of the peripheral lagoons were transformed into fishfarms largely dominated by Reed beds and birds disappeared from sites such as Sarinasuf. Other areas, such as in the Istria zone, suffered important water regime modifications and eutrophication. Birds moved from one site to the other looking for new breeding sites.
As a result, colonial Charadriiformes have decreased and are now concentrated on a reduced numbers of sites. Moreover, they largely use man-modified habitats that were poorly visited by birds in the past or not used at all. This is the case of the lakes of Murighiol and Plopu and the most surprising decantation pan of Vadu that are the most important nesting sites for these species in the Romanian Danube delta nowadays.

This discussion is principally based on hypotheses. However, they are highly likely. Many other factors such as regional ones may have played a role in the changes of the colonial Charadriiformes community. For example, the recent increase in the Mediterranean Gull numbers is probably related to the large expansion of the species, such as observed in Western Europe, due to the possible decrease observed in the Crimea region, where the bulk of the population is found, and its resulting emigration (Sadoul 1997). In the same way, the occurrence since 2000 of a new breeding species, the White-tailed Lapwing, may have no direct connection with local changes (Kiss *et al.* 2001). But the accordance in time between habitat modifications and decline of the community supports the idea that bird population changes depended mainly on local habitat changes.

Nowadays, the Romanian Romanian Danube Delta Biosphere Reserve does not support large populations of colonial Charadriiformes anymore. They are strongly fragmented and some colonies showed problems in their reproduction. The maintenance of these species in the Romanian Danube Delta Biosphere Reserve is thus jeopardised. Specific conservation measures should be developed in order to protect the last major breeding sites on a long-term basis. Moreover, human disturbance is still imminent in places such as Vadu and Sachalin. Habitat management should be developed in order to reduce human and predator impact. Both the selection and the effective management of strictly protected areas within the Danube Delta Biosphere Reserve could be directed more specifically towards this under-represented group of birds. Pioneer situations on small island or peninsulas should be selected and the entrance to the public strictly forbidden.

6 Conservation of colonial waterbirds in the Danube Delta and elsewhere in Europe

The Danube delta is an example of how a still more or less natural mouth of a large river in a lowland area may look like and may function ecologically. In the actual delta area, mainly situated in Romania, the influence of man on the landscape has so far remained relatively small, with the most impacting (for colonial birds) having occurred in the coastal lagoon area. Here, most of the typical pioneer habitats needed as breeding sites for gulls and terns have disappeared. Nonetheless, for colonial waterbirds of the freshwater habitats, there are still a lot of complete and dynamic gradients between land and water, between nutrient-rich river water and relative oligotrophic 'Reed water' (Oosterberg *et al.* 2000) and also between fresh and salt water. The presence of riverine dynamics as expressed by regular inundations and water level fluctuations sustains these gradients by precluding that water bodies get overgrown by vegetation and Reed beds disappear due to encroachment by shrubs and trees. Up until this very day, these processes of vegetation succession and resetting by hydrodynamics have resulted in the sustained presence of both an impressive biodiversity and biological productivity of *e.g.* fish in these water bodies (Buijse *et al.* 2002). On the Ukrainian side of the Danube river, the landscape has been much more modified by man and nowadays actually quite closely resembles the cultural landscape of the lower stretches of western European river systems (*e.g.* that of the Dutch part of the Rhine and Meuse catchment areas), complete with artificially reduced floodplains, summer embankments, etc. On the other hand, the only remaining part of the area where natural growth of the delta by sedimentation of riverine sediments still takes place, is also found in the Ukraine, in the so-called 'secondary delta' along the northern Chilia branch (Zhmud 1999).

The present survey has shown that the area still holds large breeding populations of 12 species of colonial Pelecaniformes and Ciconiiformes. The sheer size of the populations of at least nine of these (Great White and Dalmatian Pelican, Great and Pygmy Cormorant, Great and Little Egret, Black-crowned Night-heron, Eurasian Spoonbill and Glossy Ibis) is, in itself, of such importance, that the Danube delta harbours over 1% of the respective biogeographical populations (*cf.* Rose & Scott 1997, Table 6.1). For the four species of pelicans and cormorants even over 10% of the flyway populations were found breeding in the area. To further stress the delta's international importance for waterbirds, it suffices to say that two species occur here that are considered 'Vulnerable' on a worldwide scale, the Dalmatian Pelican and the Pygmy Cormorant (BirdLife International 2000). Evidently, Romania as a candidate-memberstate of the European Union, will have to designate their part of the Danube delta as a so-called Special Protected Area (SPA) for the EU Bird Directive. This also implies that knowledge on both numerical developments of the birds that caused the area's qualification and the factors responsible for their occurrence in qualifying numbers will have to be accessible in order to comply with the country's obligation to warrant a sustainable and favourable conservation status for these species.

This study provides the first-ever comprehensive overview of the status of the Danube delta's colonial waterbirds and also offers some very basic

Table 6.1.
Estimated sizes of the populations of thirteen species of colonial breeding pelicans, cormorants and wading birds in the Danube delta in 2001 and 2002, in comparison with recent estimates of the corresponding biogeographical (flyway) populations (Rose & Scott 1997). The species in bold letters are the ones of which the Danube delta population exceeds 1% of the flyway population, also indicated with *; ** indicates the presence of over 10% of the flyway population and *** that of over 50%.

species		number of breeding birds	population estimates	
Great White Pelican	***Pelecanus onocrotalus***	**10000**	**70000**	**
Dalmatian Pelican	***Pelecanus crispus***	**1100**	**3000**	**
Great Cormorant	***Phalacrocorax carbo***	**50000**	**200000**	**
Pygmy Cormorant	***Phalacrocorax pygmeus***	**23000**	**25000**	***
Great Egret	***Casmerodius albus***	**1300**	**17000**	*
Grey Heron	*Ardea cinerea*	1400	500000	
Purple Heron	*Ardea purpurea*	1100	unknown	
Little Egret	***Egretta garzetta***	**5000**	**150000**	*
Squacco Heron	*Ardeola ralloides*	5000	unknown	
Cattle Egret	*Bubulcus ibis*	20	not mentioned	
Black-crowned Night-heron	***Nycticorax nycticorax***	**7000**	**200000**	*
Eurasian Spoonbill	***Platalea leucorodia***	**700**	**15000**	*
Glossy Ibis	***Plegadis falcinellus***	**7000**	**40000**	**

data and speculations on the spatial and ecological relationships between their occurrence and the ecosystem and habitat characteristics. The unravelling of these relationships has provided some clues to how the Danube delta functions ecologically and why the present situation is still 'good' enough to maintain healthy populations of such a wide array of colonial waterbirds. It is the combination of the large scale of the total area with the presence of a wide variety of soft gradients (*e.g.* between water and land, freshwater and brackish water, eutrophic and more mesotrophic conditions) and the ever-changing seasonal and year-to-year dynamics of the river that provides the ideal mixture of safe and quiet breeding sites and profitable feeding grounds within reach of them. Man-induced changes in the natural environment of the Danube delta have occurred in the past (and continue doing so) and may have led to shifts in relative importance of smaller birds like herons and ibises feeding mainly on invertebrates to larger, fish-eating species. When aiming at the conservation of this avian biodiversity for the future, it has to be taken into account that a further increase in the connectivity of the area's freshwater lakes, although apparently favourable for the fish-eating birds, should not be stimulated, because it might very well imply an unacceptable deterioration of the conservation status of the smaller herons and ibises. Similarly, attempts at ecological restoration at specific sites (*e.g.* former fishponds or reclaimed agricultural polders) should aim at the achievement of gradient-rich habitat types rather than at a mere extension of larger scale patterns (*e.g*. lakes or extensive Reed beds).

Meanwhile, the Danube delta evidently lost most of its potentials for colonial gulls, terns and waders, because well-isolated small islands with little or no vegetation cover (pioneer situations) have disappeared and are unlikely to be formed again, due to the loss of the influence of the sea and a strong decrease of the sediment load of the river. Thus, ground-breeding gulls, terns and waders, although still presented with a lot of seemingly favourable feeding grounds, are unable to find enough suitable and safe areas to form large and healthy colonies. Fortunately, most species in this group are rather opportunistic in their choice of breeding habitat, thus allowing specifically designed measures for re-installing and actively managing relatively small patches of suitable and safe breeding places to be potentially successful.

An example of a typical man-dominated riverine landscape is presented by the Dutch delta of Rhine and Meuse. Natural processes here are limited to water level fluctuations and sedimentation of clay, but both these processes nowadays only take place over a severely reduced part of the original floodplain area (less than 10%) (Marteijn *et al.* 1999). Therefore, these processes now only influence a small surface area and, moreover, have too much impact there. Furthermore, the spatial patterns of the landscape are completely dominated by human land use. All these changes have led to an enormous degradation of *e.g.* the biodiversity in fish communities in both the river and the accompanying water bodies (Grift 2001, Buijse *et al.* 2002). Some of the larger colonial water and marshland bird species, often largely dependent on fish resources, do still occur in the area, but already for various centuries neither their diversity nor their densities do even approach anymore those still present in the more intact Danube delta (*cf.* Brouwer 1954, Van Eerden *et al.* 1997). Examples of successful creation and management of suitable breeding habitat (often even artificial) within larger suitable feeding ranges for gulls, terns and colonial waders are found throughout western Europe (*e.g.* Camargue, France; Ebro delta, Spain; Delta area and IJsselmeer area, the Netherlands; Sadoul 1997, Muntaner *et al*. 1983, Meininger *et al*. 2002, Lauwaars & Platteeuw 1999).

The large scale and the spatial coherence of the Danube delta enables it to hold sustainable populations of colonial waterbirds, with the exception of gulls, terns and waders. Thanks to the large scale, the area provides space enough for the largest species that need the entire area to cover their food requirements and thanks to the coherence they are also able to reach their feeding grounds from the safest places within the area. On the scale of smaller parts of the Danube delta, it is the coherence of the landscape that allows also the smaller species to establish colonies at safe sites with sufficient feeding grounds near enough to cover on a daily basis. These are important concepts to keep in mind in the spatial planning of measures for ecological rehabilitation, as they are nowadays increasingly being considered for almost completely man-dominated delta areas like those of Rhine and Meuse. It seems relatively easy to improve local nature conservation values (*e.g.* on the level of riverine fish) by means of simple local measures such as the construction of secondary channels or the local restoration of flooding regimes (Grift 2001). However, when the ambitions for ecological restoration exceed the local scale level, spatial planning should also take into account the needs of organisms that use the landscape on higher scale levels. The needs of colonial breeding waterbirds like cormorants and wading birds are of such a nature. The larger species require a considerable amount of feeding grounds to provide themselves and their offspring with a sufficient amount of food throughout the breeding season and these feeding grounds must be within the daily range from a safe and quiet breeding site. Smaller species may make do with smaller amounts of feeding areas, but for these species the prerequisite that feeding areas have to be within reach of their much smaller daily range from one or more safe breeding sites poses even higher demands on spatial coherence.

Thus, it seems inevitable that, when we also want organisms that need more space to profit from our attempts at the ecological restoration of the river areas in western and northern Europe, we shall have to pay more attention in our plans to the restoration of spatial connections among the strictly riverine nature in the artificially reduced floodplains and the (potentials for) wetland nature in lakes, ponds and marshes in the former backswamp areas which nowadays have become isolated from the mainstream. Theoretically, the concept of Natura 2000 as a European-wide network of protected nature reserves within the framework of the EU Bird and Habitat Directives, would provide for this need for spatial connectivity. However, for an adequate implementation, a good assessment is needed of the demands these colonial birds have for both feeding grounds (in terms of ecological carrying capacity) and breeding sites (in terms of quiet and safety), as well as of the spatial arrangements of these two vital functions with respect to each other. Then, these prerequisites may successfully be applied in the spatial planning by a well-planned allocation of these partial habitats.

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8 Species accounts

In the following species accounts, the maps of all colonial waterbird species are presented per species, both for Pelecaniformes and Ciconiiformes and for Charadriiformes. The species accounts also include the known data on their food choice in the Danube delta. For pelicans, cormorants and wading birds, the species accounts are more comprehensive, for gulls, terns and waders only the information on colony distribution and food choice is included. The results of the censuses of colonial breeding waterbirds in the Danube Delta for 2001 and 2002 are summarised in Table 8.1.

		2001						2002					
species		total of pairs	no. of colonies	mean colony size	std	min	max	total of pairs	no. of colonies	mean colony size	std	min	max
Great White Pelican	*Pelecanus onocrotalus*	3520	2	1760	2461	20	3500	4160	3	1387	2160	100	3880
Dalmatian Pelican	*Pelecanus crispus*	454	3	151	217	4	400	420	4	105	197	1	400
Great Cormorant	*Phalacrocorax carbo*	16161	14	1154	1265	80	4500	22787	30	760	923	10	3500
Pygmy Cormorant	*Phalacrocorax pygmeus*	8740	12	728	704	70	2500	9341	14	667	700	1	2100
Great Egret	*Casmerodius albus*	307	10	31	23	2	70	730	27	27	30	1	100
Grey Heron	*Ardea cinerea*	513	14	37	77	2	300	588	29	20	17	2	85
Purple Heron	*Ardea purpurea*	450	2	225	177	100	350	399	15	27	42	1	147
Little Egret	*Egretta garzetta*	1985	12	165	171	5	500	1725	24	72	73	1	250
Squacco Heron	*Ardeola ralloides*	2405	12	200	194	10	500	1279	16	80	101	4	350
Cattle Egret	*Bubulcus ibis*	12	1	12		12	12	3	1	3		3	3
Black-crowned Night-heron	*Nycticorax nycticorax*	2140	11	195	115	20	300	2964	27	110	138	2	500
Eurasian Spoonbill	*Platalea leucorodia*	218	7	31	30	3	80	339	9	38	33	5	100
Glossy Ibis	*Plegadis falcinellus*	2055	10	206	160	30	500	3340	12	278	236	20	650
Pontic Gull	*Larus cachinnans*	1202	6	200	278	6	750	1685	9	187	262	5	800
Black-headed Gull	*Larus ridibundus*	852	3	284	255	2	500	3030	12	253	352	30	1335
Mediterranean Gull	*Larus melanocephalus*	200	1	200		200	200	219	1	219		219	219
Gull-billed Tern	*Gelochelidon nilotica*	5	1	5		5	5	10	2	5	4	2	8
Sandwich Tern	*Sterna sandvicensis*	2700	3	900	361	500	1200	3700	2	1850	71	1800	1900
Common Tern	*Sterna hirundo*	4687	7	670	861	12	2000	5943	5	1189	1342	10	3263
Little Tern	*Sterna albifrons*	65	3	22	25	3	50	64	2	32	10	25	39
Whiskered Tern	*Chlidonias hybridus*	1405	7	201	302	20	850	3895	18	216	468	5	2000
Black Tern	*Chlidonias niger*	3	2	2	2	0	3	10	1	10		10	10
Collared Pratincole	*Glareola pratincola*	313	3	104	169	3	300	34	2	17	7	12	22
Black-winged Stilt	*Himantopus himantopus*	96	5	19	18	5	50	70	3	23	38	1	67
Pied Avocet	*Recurvirostra avosetta*	63	6	11	8	2	21	241	6	40	70	3	180
White-tailed Lapwing	*Vanellus leucurus*	7	1	7		7	7	1	1	1		1	1

Table 8.1.
Summary of estimated total numbers of breeding colonial waterbirds in the combined Romanian and Ukrainian Danube delta in 2001 and 2002. Moreover, details are provided on number of colonies, mean colony size (including standard deviation) and minimum and maximum colony sizes.

8.1 Pelicans and cormorants Pelecaniformes

8.1.1 Great White Pelican *Pelecanus onocrotalus*

General biogeography

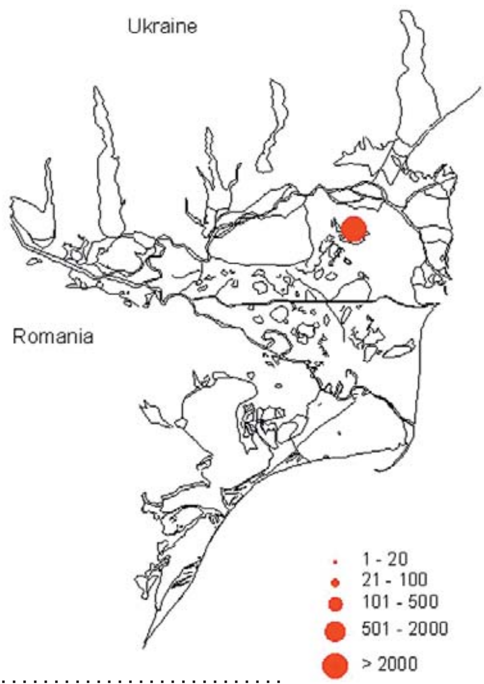
The Great White Pelican *Pelecanus onocrotalus* breeds from Eastern Europe, along the Black and Caspian Sea basins, to western Mongolia. The westernmost populations tend to winter in NE Africa; the more easterly populations spend the winter in the Indian subcontinent. Some smaller breeding populations also exist in sub-Saharan Africa, NW India and Viet Nam (Del Hoyo *et al.* 1992).

On a global level, this species is not considered to be threatened, although particularly the Palearctic population has declined dramatically during the last century (Del Hoyo *et al.* 1992). Half of the Palearctic breeding population is supposedly breeding in Europe (Crivelli 1994), in only four colonies (Danube Delta with 3500 pairs, the Russian lakes Manych and Manych-Gudilo with 200 - 300 pairs and the Greek lake Mikri Prespa with 40 - 100 pairs; Linkov 1994, Crivelli 1994, Hagemeijer & Blair 1997). Hagemeijer & Blair (1997) estimated the European population at 3100 - 3600 pairs, the Russian population at 100 - 350 pairs and the Turkish population at 250 - 400 pairs. Still, however, autumn migration counts in Israel suggest that the western Palearctic population of Great White Pelican amounts to well over 75,000 individuals (Del Hoyo *et al.* 1992, Shmueli *et al.* 2000). The population estimate for the Black and Caspian Sea regions given by Rose & Scott (1997) amounts to 70,000 birds. Within Europe, the breeding population is estimated at 7345 - 10,500 pairs, of which between 3000 and 3500 in the Romanian Danube Delta and 3070 - 4300 pairs in the former Soviet Union (Del Hoyo *et al.* 1992). In Europe, the Great White Pelican is actually considered a threatened breeding bird.

Breeding distribution and numbers in Delta

In the Danube Delta only one relatively small and isolated area is known to be annually occupied by breeding Great White Pelicans. This area concerns two relatively small lakes in the northern part of the Romanian territory of the Biosphere Reserve, only slightly south of the northernmost Chilia branch of the Danube (Fig.8.1). Both these lakes, called Buhaiova and Hrecisca, are surrounded by vast and almost impenetrable Reed *Phragmites australis* beds of heights of up to 6 m. Here the pelicans breed very closely together on floating plant material. Due to their isolation by the extensive and dense Reed beds, both these lakes offer excellent protection to the breeding pelicans and their eggs against any terrestrial predators, including the not easy to be daunted Wild Boar *Sus scrofa*.
In 2001 the vast majority of breeding pairs (3500 apparently occupied nests) was counted at the easternmost of the two lakes, lake Hrecisca, and a mere 20 pairs were found at Buhaiova. In this year a significant distur-

Great White Pelican, 2001



Great White Pelican, 2002

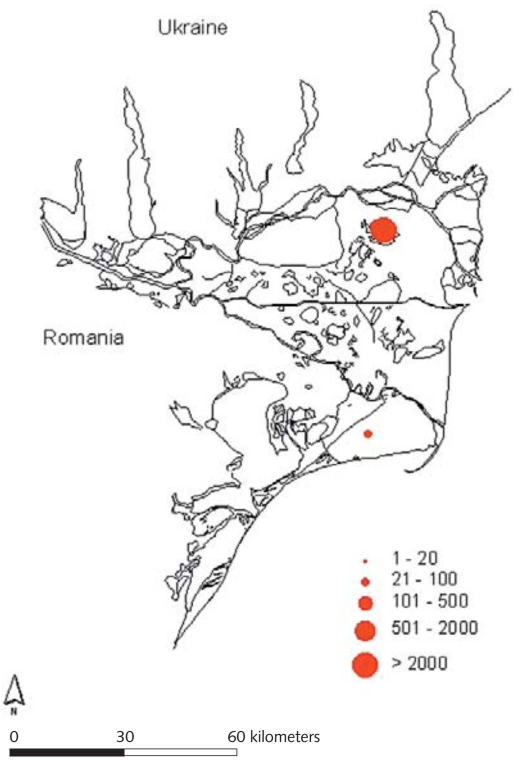


Fig. 8.1.
Breeding distribution of Great White Pelican *Pelecanus onocrotalus* in the Danube Delta in 2001 and 2002.

bance of nests and eggs, involving an estimated 800 nests along the southern edge of the colony, had occurred just before the ground visit. Loose eggs and destroyed nests were everywhere and the adult birds just stood beside their nests without incubating. Indications were found that people had visited the area one or two days earlier and it would seem that probably their visit had been either so prolonged or so intense that the birds abandoned their nests for too long. Thus, the total breeding population of Great White Pelican for 2001 was established at 3520 pairs.

In 2002 a ground visit to Hrecisca proved impossible, due to a much lower water table. During the aerial survey of 13 May 2002, a total of no less than 3400 - 3500 occupied nests were estimated, apart from 150 - 180 pairs at lake Buhaiova. A second aerial survey carried out on 6 June 2002 even suggested the presence of 3880 pairs at Hrecisca. Moreover, during both aerial surveys in 2002, breeding Great White Pelicans were also, for the first time known, located in the southern colony of Lejai, west of the village of Sfîntu Gheorghe (Fig. 8.1). This small lake, equally or perhaps even more isolated by huge and extensive Reed beds, was traditionally only the breeding haunt of Dalmatian Pelican *Pelecanus crispus*, but now the May survey suggested the presence here of 100 nests, while in June at least 40 nests were estimated to be occupied. For 2002 the total Danube Delta breeding population of Great White Pelican can, therefore, be estimated at 3590 - 4160 pairs.

Due to the difficulty of access to the potential and actual colony sites of the pelicans, no systematic annual censuses have been carried out in the past. Munteanu *et al.* (1994) indicated the presence of 2900 - 3000 breeding pairs of Great White Pelican in the early 1990s. More general impressions from historical sources indicate that earlier in the 20th century this bird, as well as many other piscivorous birds, has been much more numerous. Thus, Andone *et al.* (1969) reported that at least five colony sites of pelicans were known in the period 1959 - 1962, though they did not mention any numbers of breeding pairs. Up to which point the massacres of fish-eating birds consisted of pelicans has not been accurately documented. It is not unlikely that actually pelicans remained relatively unharmed, since officially both species enjoyed legal protection from 1933 onwards (Paspaleva *et al.* 1985). It seems safe to assume that up until at least the 1980s, human persecution of large fish-eating birds, perceived as a menace to fisheries, has had noticeable impact on the population development of the Great White Pelican. Maybe, the better protection of the most recent years has enabled the start of a recovery of breeding numbers, as suggested by the comparison of the 2001 and 2002 census results.

Feeding distribution

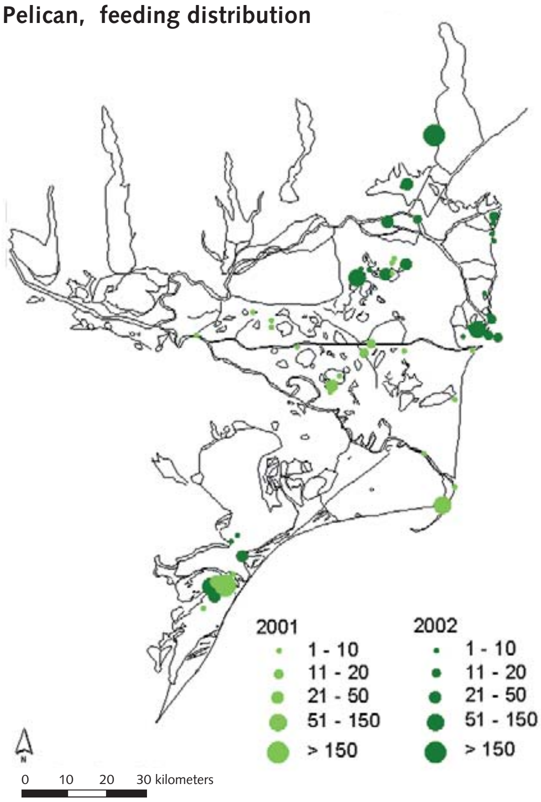
Great White Pelicans are found feeding on virtually all larger extents of water throughout the entire Danube Delta area (Fig. 8.2). Particularly large concentrations of birds frequented the lagoon areas in the south (lakes Razim and Sinoe) and in the north (lake Sasyk in Ukraine). Feeding flocks also occurred on smaller lakes (*e.g.* lakes Isacov, Furtuna and Merhei Mare), but numbers seemed to be smaller here. It is quite unusual to find feeding flocks on the main river branches and canals, but on occasions even there socially feeding birds have been seen driving fish together. Apparently, Great White Pelicans are very well able to cover the entire area from only one or (in 2002) two well-protected colony sites.

Food choice and diet

Like all species in the pelican family, the Great White Pelican feeds exclusi-

Fig. 8.2.
Feeding distribution of Great White Pelican *Pelecanus onocrotalus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

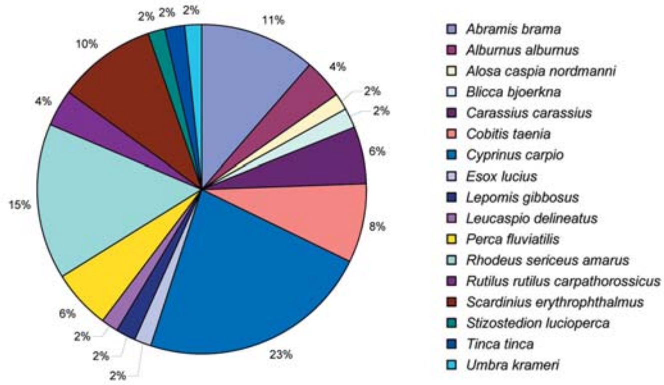
Great White Pelican, feeding distribution



vely on fish. Most prey items caught weigh 300 - 600 g fresh mass and, although the species is able to survive for prolonged periods on smaller fish (if sufficiently numerous), large fish generally comprise about 90% of the total diet (Del Hoyo *et al.* 1992). The most numerous prey species in Europe seems to be Common Carp *Cyprinus carpio* (Del Hoyo *et al.* 1992). For the Danube Delta this also seems to hold true, according to the findings of Andone *et al.* (1969), who registered a frequency of 22.9% of all prey items identified as belonging to this species (Fig. 8.3). The only other fish species represented with over 10% in the diet were *Rhodeus sericeus amarus* (15.2%) and Common Bream *Abramis brama* (11.4%) (Fig. 8.3). During our field work at least one 30 cm long Ide *Leuciscus idus* was recorded as a prey item killed by a flock of 250 Great White Pelicans in a canal near Maliuc on 24 May 2001. This species was not mentioned as prey by Andone *et al.* (1969), nor indeed by Cramp & Simmons (1977) for other West Palearctic areas.

Fig. 8.3.
Prey species composition (frequency of occurrence) of Great White Pelican *Pelecanus onocrotalus* in the Danube Delta, according to Andone *et al.* (1969).

Great White Pelican



According to allometric relationships between bird body size and daily food requirements as shown by Aschoff & Pohl (1971), a caloric value of 4.6 $kJ.g^{-1}$ of fresh fish and an assimilation efficiency of 0.8 (Castro *et al.* 1988), it is estimated that with a mean body mass of 10,350 g (mean value from body masses reported by Cramp & Simmons 1977 and Del Hoyo *et al.* 1992) a Great White Pelican needs a daily amount of 1400 g fresh mass of fish to fulfill its energetic needs. This figure is slightly higher than the estimates of 900 - 1200 $g.day^{-1}$ by Del Hoyo *et al.* (1992) and of 970- 1120 $g.day^{-1}$ by Shmueli *et al.* (2000).

8.1.2 Dalmatian Pelican *Pelecanus crispus*

General biogeography

The Dalmatian Pelican *Pelecanus crispus* is a much scarcer species than its congener. Its breeding distribution is rather similar, ranging from the Balkans eastwards until China, always between 30° and 50° N (Del Hoyo *et al.* 1992). This species is much less migratory than the previous one, most individuals of the westernmost populations wintering rather close to the breeding sites, *e.g.* in the Balkans and the southern fringes of the Black and Caspian Seas. Populations further east generally winter in the Indus and Ganges floodplains of India (Del Hoyo *et al.* 1992).

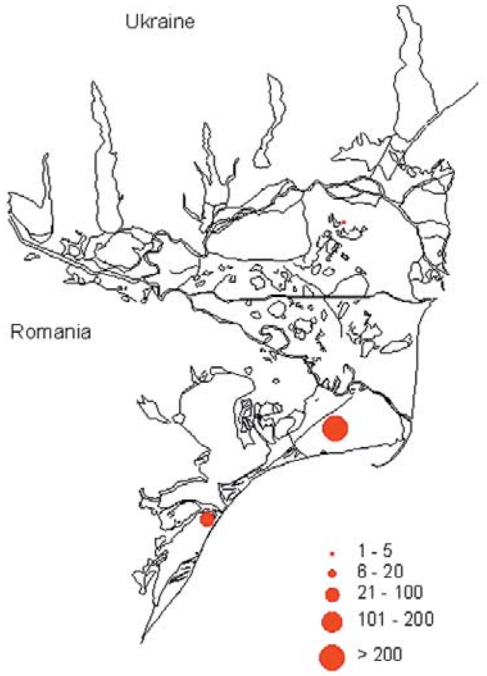
Until recently the Dalmatian Pelican was considered endangered (categorised as 'Vulnerable') on a global scale level. By 1991 the world population was estimated at a mere 1926 - 2710 breeding pairs at no more than 21 - 22 different colonies (Del Hoyo *et al.* 1992). The population of the eastern Mediterranean and the Black and Caspian Sea basins was estimated at 3000 individuals by Rose & Scott (1997). Most of the Palearctic population is thought to be breeding in the former Soviet Union (some 1500 - 2000 pairs, probably overestimated; Del Hoyo *et al.* 1992). Recent increases, however, particularly at the largest known colony (over 500 pairs at lake Mikri Prespa in Greece), have led to population estimates of 15,000 - 20,000 individuals, including 3215 - 4280 breeding pairs (Crivelli *et al.* 1997), of which 2700 - 3500 pairs in the former Soviet Union (Peja *et al.* 1996). Consequently, the status has now been changed to 'Conservation dependent' (BirdLife International 2000). Population estimates given by Hagemeijer & Blair (1997) were: 470-550 pairs for Europe, 400-450 pairs for Russia and 100-150 pairs for Turkey. In Europe, the Dalmatian Pelican breeds in small colonies, generally no more than 10 - 20 pairs, in Greece, former Yugoslavia and, slightly more numerously, in the Danube Delta, where annually several hundreds of pairs are found. Back in the 1980s the Danube Delta population was reported to consist of over a 100 pairs (Hagemeijer & Blair 1997).

Breeding distribution and numbers in Delta

There is only one colony site in the Danube Delta, which is annually used successfully by breeding Dalmatian Pelicans. This is the very well protected and isolated lake Lejai in the south, west of the village of Sfîntu Gheorghe. This site is virtually impossible to visit by foot or by boat, due to the immense and dense Reed beds surrounding the lake (Fig. 8.4). Nonetheless, unlike the Great White Pelican, small numbers of Dalmatian Pelicans try alternative nesting sites elsewhere each year. These are generally small islets in coastal areas, either almost bare or covered by sparse halophytic pioneer vegetation. Theoretically these sites, being surrounded by water, would provide these ground-breeding birds with sufficient protection against terrestrial predators like Red Fox *Vulpes vulpes*, Jackal

Canis aureus, Raccoon Dog *Nyctereutes procyonoides* or Wild Boar *Sus scrofa*. Nevertheless, these scattered settlements, which occur both on the Romanian and the Ukrainian sides of the Danube Delta, generally end up in failure, either due to flooding of the nests during periods of high wind or to deliberate disturbance by fishermen who feel the presence of these large fish-eaters as a menace to their own interests.

Dalmatian Pelican, 2001



Dalmatian Pelican, 2002

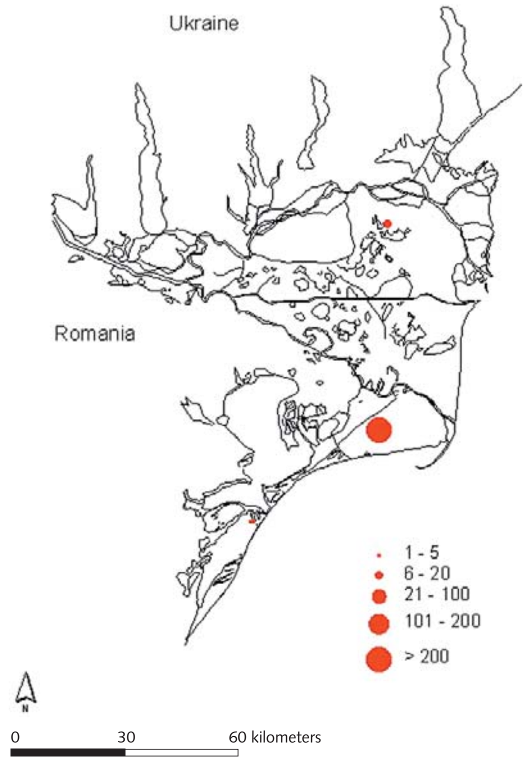


Fig. 8.4.
Breeding distribution of Dalmatian Pelican *Pelecanus crispus* in the Danube Delta in 2001 and 2002.

Both in 2001 and 2002 the breeding colony of Lejai was determined at 400 breeding pairs of Dalmatian Pelican, although in the second year and during the aerial survey of 6 June 2002 no less than 1300 pairs were reported. In view of the results of the 13 May 2002 flight and the fact that such a high number of breeding birds had never been recorded on previous occasions, it was considered likely that a misinterpretation had taken place in June, causing the observer to include non-breeding birds in his count. Settlements outside the main colony were reported in both years. In 2001 4 pairs bred in lake Buhaiova in the north, together with Great White Pelican, and early March 50 pairs settled on an islet in the northern part of lake Sinoe, but were flushed away by high winds later on. This was the third consecutive year that a substantial number of Dalmatian Pelican nests were lost in a similar manner in this area. In 2002, 15 pairs bred in Buhaiova with the Great White Pelicans and 4 pairs tried their luck on the islet in the north of lake Sinoe (again without success). In 2001 the breeding population of Dalmatian Pelican in the Danube Delta was estimated at 454 breeding pairs, in 2002 at 420. This means that this species has probably increased since the 1980s, when the total breeding population was estimated at slightly over a 100 pairs (J.B. Kiss in Hagemeijer & Blair 1997). Probably, however, the population of this as well as other fish-eating species has been considerably higher by the end of the Second World War (Dragomir & Staras 1992).

Feeding distribution

Dalmatian Pelicans are just as mobile as Great White Pelicans and, consequently, may be found feeding almost anywhere in the Danube Delta. It is, however, much more scattered in its appearance than its congener, particularly in the inland freshwater areas (Fig. 8.5). There, it is occasionally seen together with feeding flocks of Great White Pelicans, but also rather frequently single or in pairs. Larger concentrations of feeding Dalmatian Pelicans are found in the shallow coastal waters, most frequently near the mouths of any of the three main branches of the Danube and, even more prominently, in the former lagoon area of lakes Razim and Sinoe in the south. Seemingly, the Dalmatian Pelican has some preference for more brackish and marine feeding areas than its sympatric congener.

Food choice and diet

Del Hoyo *et al.* (1992) mention Common Carp *Cyprinus carpio*, Perch *Perca fluviatilis* and Rudd *Scardinius erythrophthalmus* as main prey species for Dalmatian Pelican, alongside other freshwater species such as Pike *Esox lucius* and Eel *Anguilla anguilla*. No data on the food choice of this species in the Danube Delta are provided by Andone *et al.* (1969), but

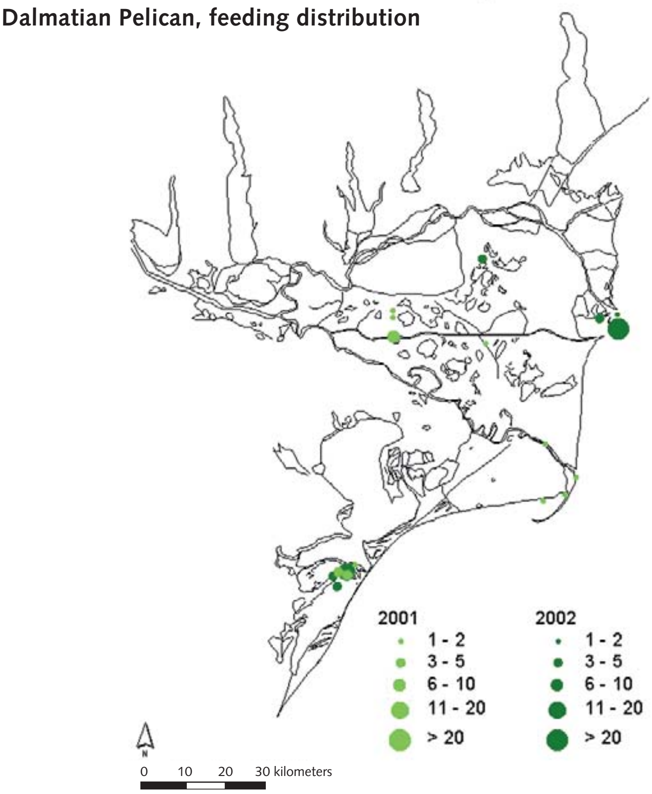


Fig. 8.5.
Feeding distribution of Dalmatian Pelican *Pelecanus crispus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

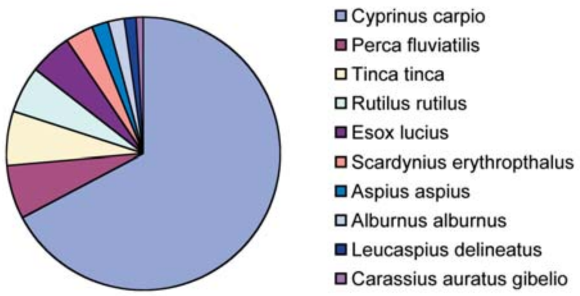


Fig. 8.6.
Prey species composition (frequency of occurrence) of Dalmatian Pelican *Pelecanus crispus* in the Danube Delta, according to Korodi (1963).

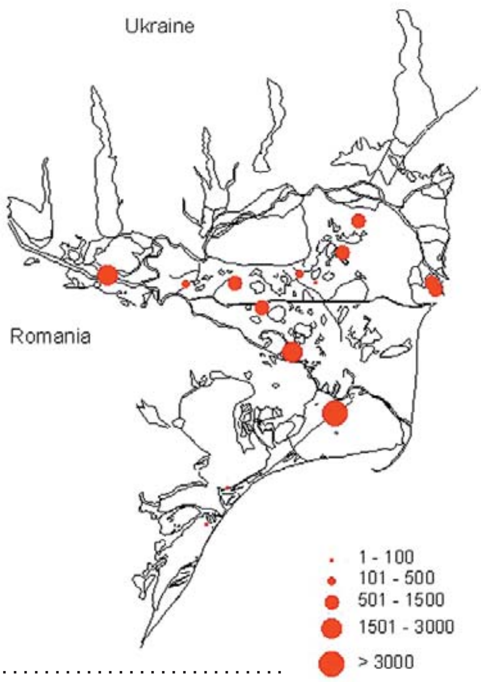
Cramp & Simmons (1977) mention Common Carp (8), Perch *Perca fluviatilis* (6), Asp *Aspius aspius* (4), Roach *Rutilus rutilus* (4), Pike *Esox lucius* (4), Tench *Tinca tinca* (2) and four single individuals of four other species. Data from the Danube Delta confirm this prey choice (Fig. 8.6; Korodi 1963). For the Danube Delta, where the species is frequently seen feeding along the coastline, it is likely that more marine species are rather more frequently eaten than suggested by this list of prey items.

With a mean body mass of 11.5 kg (Cramp & Simmons 1977, Del Hoyo *et al.* 1992), the allometric relationships between body size and energy requirements (Aschoff & Pohl 1970) and data on caloric value and assimilation efficiency of fish (Castro *et al.* 1988), it can estimated that the average daily food intake of an individual Dalmatian Pelican would amount to about 1500 g of fresh fish. This is slightly more than the figure of c. 1200 g indicated by Del Hoyo *et al.* (1992).

8.1.3 Great Cormorant *Phalacrocorax carbo*

General biogeography
The Great Cormorant *Phalacrocorax carbo* has a cosmopolitan breeding distribution, ranging over North America, Europe, Asia, Africa and Australasia. In Europe, two rather distinct races occur, the coastal Atlantic *carbo* and the continental form *sinensis* (Cramp & Simmons 1977, Del Hoyo *et al.* 1992). All populations of *sinensis* are at least partly migratory, the westernmost birds wintering in the western Mediterranean, the central European birds in the central Mediterranean and the eastern European birds in the eastern Mediterranean (Reymond & Zuchuat 1995, Van Eerden & Munsterman 1995).

Great Cormorant, 2001



Great Cormorant 2002

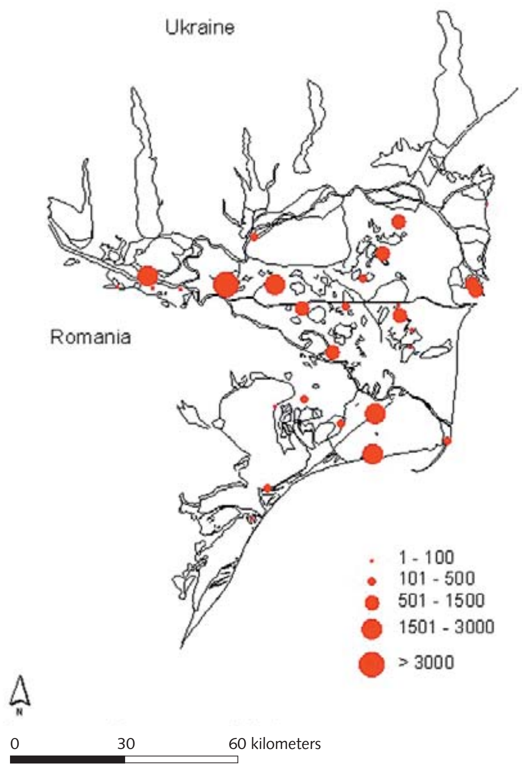


Fig. 8.7.
Breeding distribution of Great Cormorant *Phalacrocorax carbo* in the Danube Delta in 2001 and 2002.

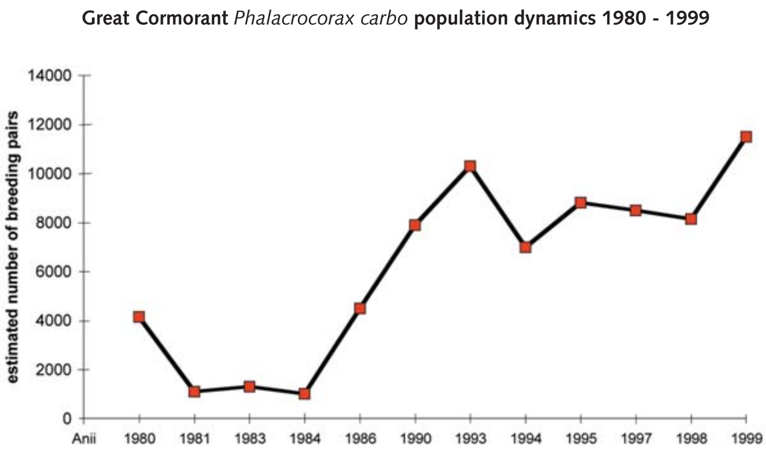
Both races have known a spectacular increase in numbers since the 1970s, when due to better protection measures the severe persecution of the Great Cormorant by fishermen was almost completely stopped. Moreover, indications exist that eutrophication of the water bodies has played an important role in improving food availability by increasing fish production. Both in western Europe (Van Eerden & Gregersen 1995) and in central Europe (Lindell *et al.* 1995), population size has increased dramatically until reaching peak numbers of about 208,000 breeding pairs by 1992 (including 43,000 pairs of *carbo*) (Hagemeijer & Blair 1997). In eastern Europe, similar trends have occurred, although these are less well documented. Rose & Scott (1997) have estimated the population size of Great Cormorant in the Black and Caspian Sea region at 200,000 individuals.

Breeding distribution and numbers in Delta

Great Cormorant colonies were found quite evenly distributed all over the Romanian and Ukrainian Danube Delta. Almost all colonies were established in stands of relatively high trees (larger and older willows *Salix* spp. and Alder *Alnus glutinosa*), either forming part of inundated woodland (at least during the breeding season) or situated directly on the fringe of smaller or larger waterways. Only one colony consisted of ground-nesting birds and was situated on a small islet in the north of lake Sinoe. This colony was only occupied in 2001 and held 100 nests. Although quite safely protected against terrestrial predators, this breeding site is probably unsafe because of its exposure to waves. Periods of high water levels in combination with strong winds will frequently flood the islet and destroy any present nests.

The Great Cormorant was located in 14 breeding colonies in 2001 and in 30 colonies in 2002 (Fig. 8.7). The estimated numbers of breeding pairs amounted to 16,161 and 22,787, respectively. Both the larger number of colonies and the higher estimates of breeding pairs are at least partly attributable to the better coverage in the second year of survey, when the entire Ukrainian part of the Danube Delta was included. On the other hand, in 2002 several newly established colony sites were located also within the Romanian part, particularly south of the Sfîntu Gheorghe branch in the Holbina Dunavat region (Fig. 8.7). Some of these colonies may have been overlooked in 2001, but it seems unlikely that this would also apply to the largest settlements. Thus, the impression prevails that 2002 was indeed a year with higher numbers of breeding Great Cormorants in the Danube Delta spread out over more colony sites than the year before.

Fig. 8.8.
Numerical development of breeding Great Cormorants *Phalacrocorax carbo* in the Romanian Danube Delta in previous years.



Dragomir & Staras (1992) have indicated that the total numbers of piscivorous birds in the Danube Delta are likely to have diminished tremendously between 1945 and 1989. The Great Cormorant, however, has started to increase again since the mid-1980s, when the estimated number of breeding pairs was down to about a thousand. Then, paralleling the general trends elsewhere in Europe in the race *sinensis* (Van Eerden & Gregersen 1995, Lindell *et al.* 1995), the population started to rise, to reach an estimated 11,000 pairs by 1993 (Fig. 8.8). Then, numbers seemed to level off at slightly over 8000 pairs, until 1999 when almost 12,000 occupied nests were estimated. The recent censuses of 2001 and 2002, with for the Romanian part of the delta almost 13,000 and over 17,000 pairs respectively, suggest a slight further increase. In the Ukrainian part of the delta, the censuses of 2001 and 2002 yielded 3500 and 5255 pairs, respectively. This apparent increase is likely to be entirely due to a more comprehensive coverage of the second census year. For eight Romanian colony sites with breeding Great Cormorants, estimates of the apparently occupied nests present are available for at least some previous years between 1979 and 2000. No clear impression of either increase or decrease is conveyed by these data (Fig. 8.9). For the Ukrainian part of the delta, annual data for the so-called 'secondary delta' show a very slow and gradual increase between 1984 and 2002 from 250 to slightly over 2500 breeding pairs (Fig. 8.10). A remarkable peak was observed in 1993 with suddenly no less than 4000 occupied nests here.

Great Cormorant *Phalacrocorax carbo,* **several colonies**

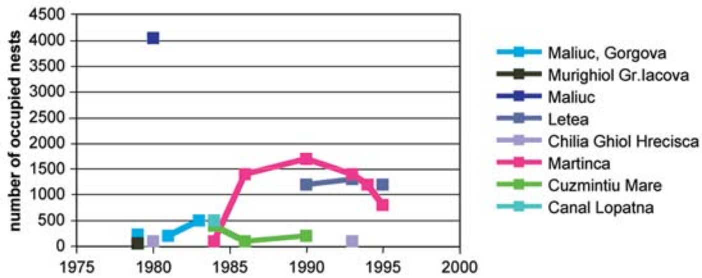


Fig. 8.9.
Numerical developments of some well-known colonies of Great Cormorant *Phalacrocorax carbo* in the Romanian Danube Delta in previous years.

Great Cormorant *Phalacrocorax carbo,* **Ukrainian Danube Delta**

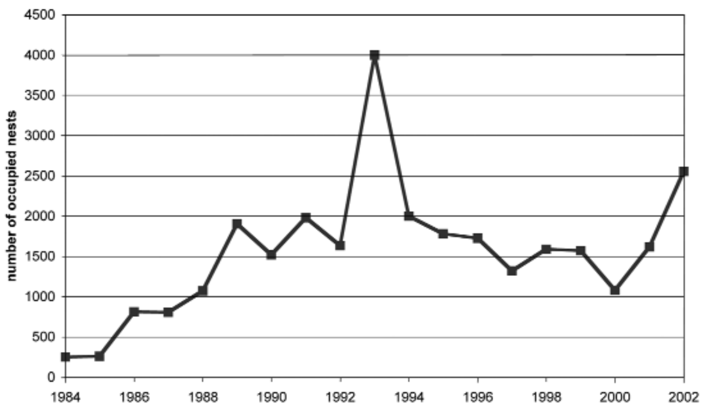


Fig. 8.10.
Numerical development of breeding Great Cormorants *Phalacrocorax carbo* in the Ukrainian Danube Delta in previous years.

Feeding distribution

The largest flocks of feeding Great Cormorants were generally recorded on the larger water bodies of the Danube Delta area, on freshwater lakes as well as in more brackish areas or along the coast (Fig. 8.11). Important concentrations occurred at lake Sasyk, all along the coastline of the Ukrainian 'secondary' delta, at the mouth of the northern Chilia branch, at the Sachalin peninsula and in the Razim-Sinoe area. Concentrations of several hundreds up to a few thousand birds, both roosting and feeding, were regularly seen. More inland, Great Cormorants were mainly observed feeding in smaller flocks on the larger lakes in the central delta area. Feeding also took place along the main river branches, but this mainly involved single individuals or pairs. Feeding Great Cormorants often joined feeding flocks of Great White Pelicans. Apparently, these mixed-species flocks operated jointly to gather together harvestable densities of fish, the cormorants by diving and the pelicans along the water surface.

Great Cormorant feeding distribution

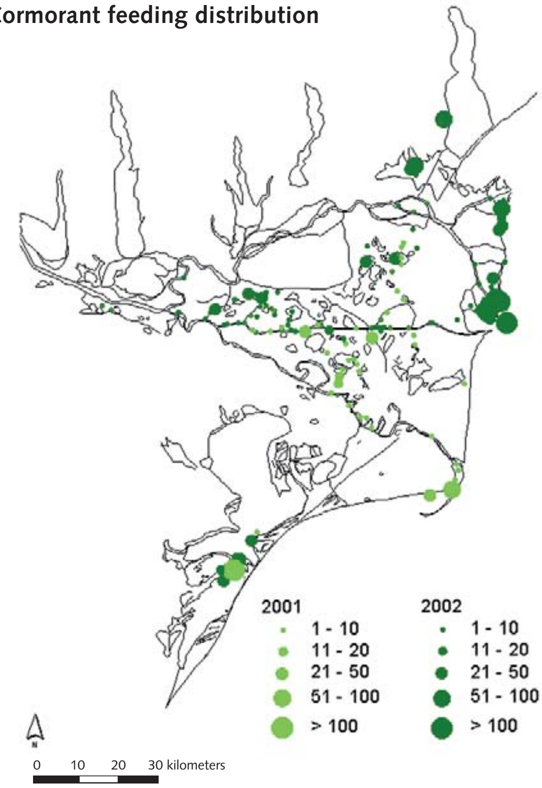


Fig. 8.11.
Feeding distribution of Great Cormorant *Phalacrocorax carbo* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

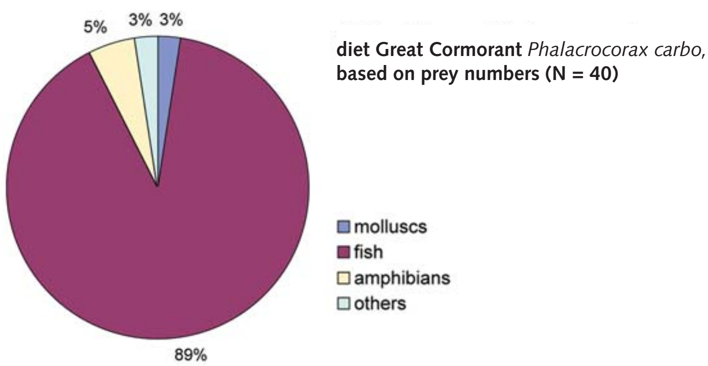


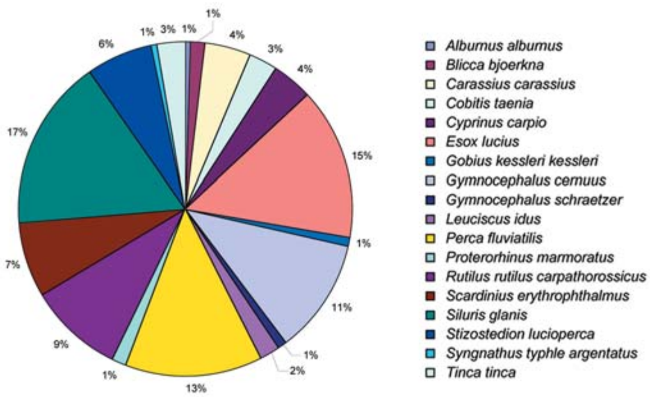
Fig. 8.12.
Diet composition of Great Cormorant *Phalacrocorax carbo* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).

Food choice and diet

Based on 40 prey items in 17 analysed dead specimens of Great Cormorant from the Danube Delta, it can be stated that at least 89% of its diet consists of fish (Fig. 8.12) (Navodaru *et al.* 2003b, J.B. Kiss, unpubl.). The remaining 11%, including amphibians, molluscs and other items, may have been eaten separately but are, particularly in the case of the molluscs, very likely to have been consumed before by the fish. A breakdown by fish species is provided by the data of Andone *et al.* (1969), who found three species in frequencies exceeding 10%: *Siluris glanis* (17%), Pike (15%) and Perch (13%) (Fig. 8.13).

Fig. 8.13.
Prey species composition (frequency of occurrence) of Great Cormorant *Phalacrocorax carbo* in the Danube Delta, according to Andone *et al.* (1969).

Great Cormorant



More detailed studies from later years have revealed clear differences among differently situated colonies. Birds feeding in the lake systems show a very different prey choice from those feeding in the main Danube channels, while birds from coastal colonies frequently feed at sea and catch marine species.

Based on a mean body mass of 2342.5 g (Cramp & Simmons 1977, Del Hoyo *et al.* 1992), the allometric relationships between body size and energy requirements (Aschoff & Pohl 1970) and data on caloric value and assimilation efficiency of fish (Castro *et al.* 1988) predict an average daily food intake of a Great Cormorant to be slightly under 470 g of fresh fish. This is less than half of the daily food intake mentioned for the Great Cormorant by Cramp & Simmons (1977), but coincides well with more recent field studies (*e.g.* Van Eerden *et al.* 1995).

8.1.4 Pygmy Cormorant *Phalacrocorax pygmeus*

General biogeography
The Pygmy Cormorant *Phalacrocorax pygmeus* has a rather limited range, distributed from SE Europe eastwards to the Aral Sea. Its breeding distribution here is rather patchy and discontinuous, typically inhabiting lowland bodies of fresh water, slow-flowing rivers, deltas and other wetland areas (Del Hoyo *et al.* 1992). The most northerly breeding populations are generally migratory, though they do not tend to move very far. The main wintering grounds are found along the southern coasts of the Balkans, where the local breeders are being joined by the migrants from further north (Simeonov & Michev 1991, Hagemeijer & Blair 1997).

The Pygmy Cormorant was still considered a globally threatened species by Del Hoyo *et al.* (1992), categorised as 'Insufficiently known'. More recently, however, following more complete counts throughout its breeding range, the population has been estimated at 22,345 - 27,055 pairs

(Hagemeijer & Blair 1997), considerably more than the 13,000 pairs (25,000 birds) estimated by Rose & Scott (1997). Nowadays, therefore, the Pygmy Cormorant is considered as a 'lower risk/nearly threatened' species (BirdLife International 2000). Within Europe, the species is found breeding in important numbers in Greece (1250 - 1310 pairs), Slovakia and Yugoslavia (1000 - 1200 pairs) and Hungary and Romania (4000 - 7000 pairs), while lower numbers were reported from Bulgaria (20 - 180 pairs), Italy (30 - 50 pairs) and Macedonia, Croatia and Ukraine (20 - 320 pairs) (Hagemeijer & Blair 1997). Hagemeijer & Blair (1997) reported a sharp decline in the 1950s, but a distinct recovery over more recent years. For Romania and Ukraine they estimate 3800 and less than 100 breeding pairs, respectively. By far the largest population, however, is now known to exist in Azerbaijan, where no less than 14,749 pairs were counted in 1986 (Hagemeijer & Blair 1997). These numbers, however, are likely to have decreased in recent years, due to habitat destruction (Crivelli *et al.* in press).

Breeding distribution and numbers in Delta

All Pygmy Cormorant colonies were settled in relatively low willow trees, mostly of the shrub-forming species *Salix cinerea*, inundated during the breeding period. Thus, colony site characteristics were by and large consistent with most of the other European colonies. Only in Azerbaijan, where the vast majority of the world's Pygmy Cormorant population dwells, most colonies are established in Tamarisk *Tamarix* spp. (Crivelli *et al.* in press). All Pygmy Cormorants were breeding in so-called mixed-species colonies, together with other colonial bird species such as Great Cormorant and/or the different species of Ciconiiformes.

The Pygmy Cormorant colonies were in both census years mainly found in the central part of the Danube Delta, along both sides of the central

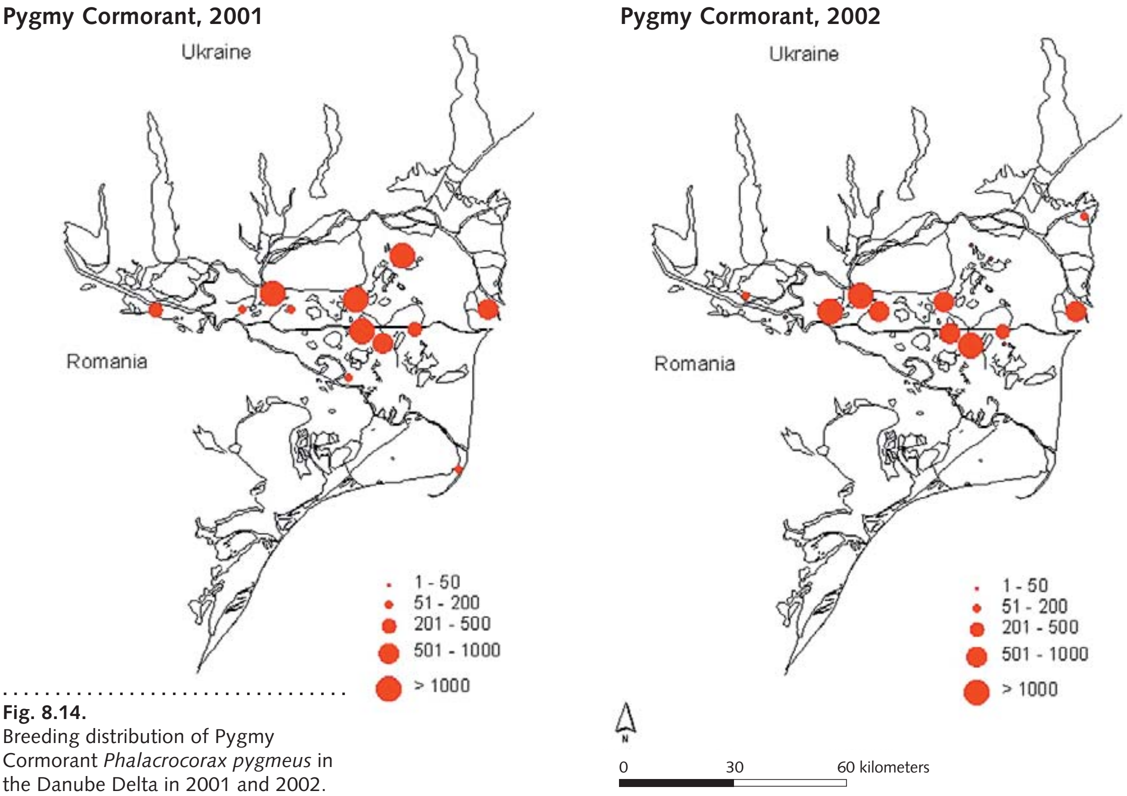


Fig. 8.14.
Breeding distribution of Pygmy Cormorant *Phalacrocorax pygmeus* in the Danube Delta in 2001 and 2002.

Sulina branch of the river. With this distribution, this small cormorant species coincided with the area richest in small-scale freshwater lakes and clearly tended to avoid both the areas with the most extensive Reed beds and the coastal lagoon areas in the north and in the south (Fig. 8.14). In 2001 12 colonies were located with a total number of 8740 breeding pairs, while in 2002 breeding was confirmed at 14 sites (one of which only held one occupied nest) with a total of 9341 pairs. Taking into account that the 2002 survey was more complete, including also the entire Ukrainian part, it seems likely that between these two years little or no change has occurred in the size of the overall breeding population.

For Romania and Ukraine, the most recent estimates of 3700 and less than 100 breeding pairs, respectively (Hagemeijer & Blair 1997), have either clearly underestimated the real population sizes, or are an indication that the population has been on the increase in recent years. Scattered historical data from the best-known Romanian colony sites in the period 1979-1997 do not show a consistent numerical trend (Fig. 8.15). However, data from the Ukrainian 'secondary delta' do suggest that the Pygmy Cormorant, after having reached very low population levels here in the early 1990s, is, indeed, recovering in the most recent years (Fig. 8.16). Some rather abrupt fluctuations in consecutive years occur in this species, which are probably attributable to differences in severity of the previous winter. Colder winters generally cause lower breeding numbers the following spring, because most of the local breeders do winter locally as well (M.Ye. Zhmud, unpubl.).

Pygmy Cormorant *Phalacrocorax pygmeus*, **several colonies**

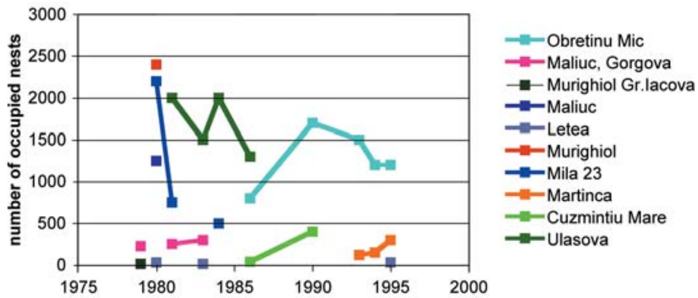


Fig. 8.15.
Numerical developments of some well-known colonies of Pygmy Cormorant *Phalacrocorax pygmeus* in the Romanian Danube Delta in previous years.

Pygmy Cormorant *Phalacrocorax pygmeus*, **Ukrainian Danube Delta**

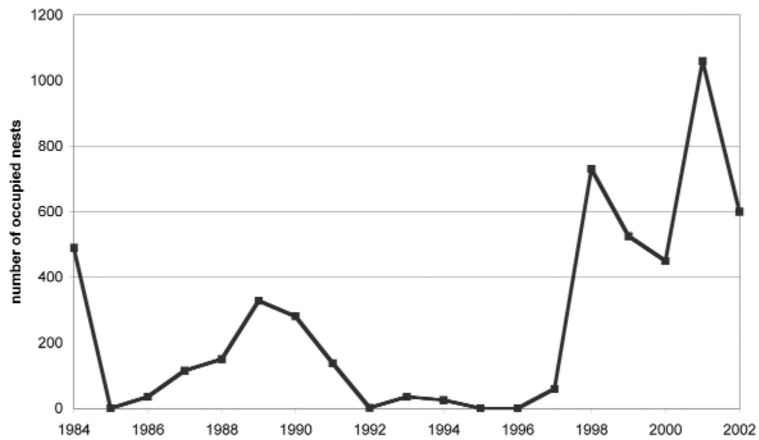
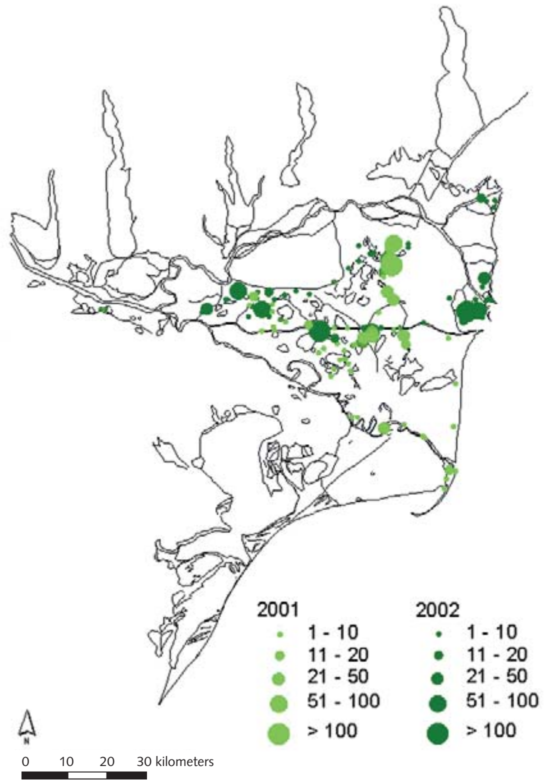


Fig. 8.16.
Numerical development of breeding Pygmy Cormorants *Phalacrocorax pygmeus* in the Ukrainian Danube Delta in previous years.

Fig. 8.17.
Feeding distribution of Pygmy Cormorant *Phalacrocorax pygmeus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

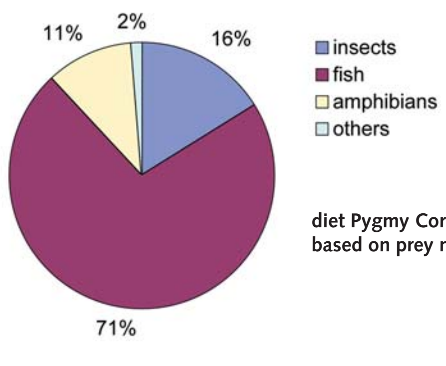
Pygmy Cormorant, feeding distribution



Feeding distribution
The feeding distribution of the Pygmy Cormorant turned out to be remarkably different from that of the Great Cormorant. Virtually all larger concentrations were recorded in the central parts of the Danube Delta, where the highest concentration of smaller lakes is found (Fig. 8.17). Outside the two outer Danube branches of Chilia and Sfîntu Gheorghe, numbers were significantly lower, as well as along the coast. The only significant concentration of Pygmy Cormorants near the coast was found at lake Musura near the Chilia mouth, where the water is extremely shallow and predominantly fresh. In the Razim-Sinoe area in the south, this species was practically absent.

Food choice and diet
In the Danube Delta, the Pygmy Cormorant feeds primarily on fish. The 67 stomachs controlled by Kiss & Rékási (2002) revealed a total of 199 prey items of which over 70% consisted of fish (Fig. 8.18). Significant

Fig. 8.18.
Diet composition of Pygmy Cormorant *Phalacrocorax pygmeus* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



diet Pygmy Cormorant ***Microcarbo pygmeus*****, based on prey numbers (N = 199)**

proportions of insects and amphibians were found as well, but it seems likely that at least some of the insects may have been eaten before by the fish. Andone *et al.* (1969) considered this species for 98% piscivorous and also provides a breakdown by species (Fig. 8.19). The four most abundant prey species in this study were Perch (18%), Rudd *Scardinius erythrophthalmus* (15%), Roach (14%) and *Carassius carassius* (10%). Other fish species mentioned by Cramp & Simmons (1977) include Common Carp, while they also mention occasional other prey items (*e.g.* young water-voles, crustaceans and even leeches). The mean body mass of fish caught was about 15 g (Cramp & Simmons 1977).

Pygmy Cormorant

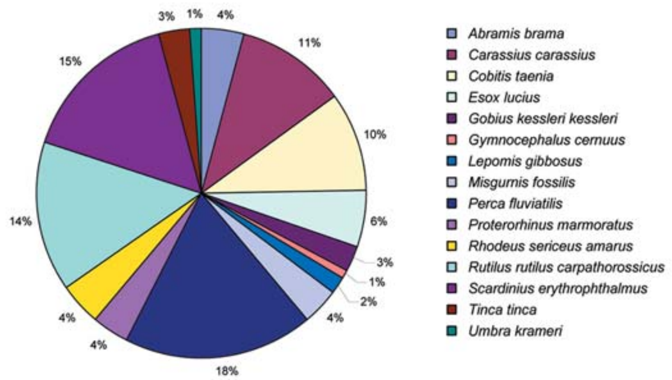


Fig. 8.19.
Prey species composition (frequency of occurrence) of Pygmy Cormorant *Phalacrocorax pygmeus* in the Danube Delta, according to Andone *et al.* (1969).

The mean body mass of the Pygmy Cormorant amounts to 717.5 g (Cramp & Simmons 1977, Del Hoyo *et al.* 1992) and thus the allometric relationships of Aschoff & Pohl (1970) and the data on caloric value and assimilation efficiency of piscivorous birds (Castro *et al.* 1988) allow an estimate of a daily food intake of almost 200 g of fresh fish.

8.2 Wading birds Ciconiiformes

8.2.1 Grey Heron *Ardea cinerea*

General biogeography

The Grey Heron *Ardea cinerea* is a typical Old World species of heron, widely distributed as a breeding bird over the temperate zone of Europe and Asia, from Ireland eastwards to China and Japan and from coastal Norway south to the Indian subcontinent (Del Hoyo *et al.* 1992). Other breeding populations exist in southern Africa. Most of the western and central European Grey Herons are sedentary or, at the most, partially migratory, but the more easterly populations from the former Soviet Union are fully migratory, wintering in ice-free areas along the southern Black and Caspian Sea coasts (Del Hoyo *et al.* 1992).

More than most other herons, the Grey Heron inhabits artificial, man-made wetlands as abundantly as natural wetlands, as it habituates well to the presence and influence of man (Hagemeijer & Blair 1997). Colony sites are usually found in trees, but on isolated islets or rocks the species may nest on the ground as well. Generally, colonies tend to be close to feeding grounds, but sometimes these may be up to 10-30 km away from each other.

The Grey Heron is a common breeding bird all over Europe, with population estimates varying from 50,000 pairs (Del Hoyo *et al.* 1992) to over 122,000 pairs for Europe, over 22,000 pairs for Russia and some 3000 pairs for Turkey (Hagemeijer & Blair 1997), or 500,000 individuals (Rose & Scott 1997). High densities of breeding Grey Herons have been reported for The Netherlands (26.9 pairs.100 km-2), Denmark (15.6 pairs. 100 km-2) and the German region of Schleswig-Holstein (12.8 pairs. 100 km-2) (Bezzel & Geiersberger 1993). Locally, even higher densities have been reached (*e.g.* 92 pairs. 100 km-2 in the Dutch province of Noord-Holland in 1975; Teixeira 1979).

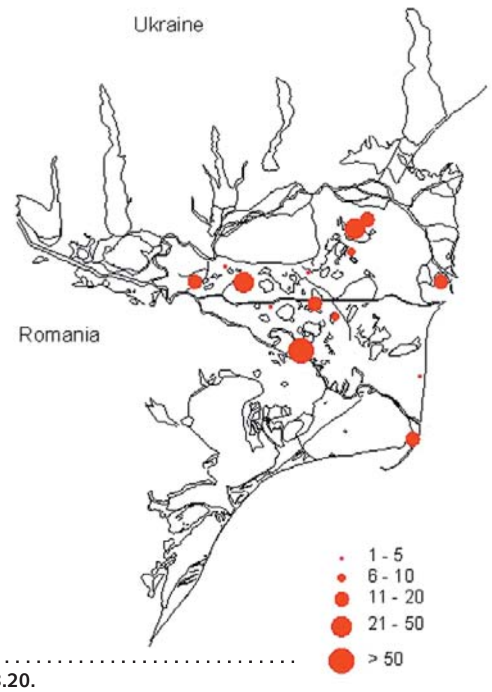
Breeding distribution and numbers in Delta

In the Danube Delta, the Grey Heron was mainly found inhabiting mixed-species colonies, together with cormorants and other herons, situated in inundated stands of willows. Within these stands, the Grey Herons tended to occupy the trees rather than the scrub-forming *Salix* species and nests were generally situated rather low. Ground-nesting colonies were absent.

In 2001 a total of 14 colonies of Grey Heron were located, holding on 2-300 occupied nests (mean 35, SD = 74), resulting in a grand total of 513 breeding pairs. In 2002 the more complete survey yielded 29 colony sites for this species, with 2-85 occupied nests (mean 20, SD = 70) and resulting in 588 breeding pairs. These results indicate that 2002 was probably a less favourable year for the Grey Heron than 2001. Average colony size was smaller, but since the survey was more comprehensive, more colonies were found, which, in turn, resulted in a slightly higher final count.

The vast majority of Grey Heron colonies was located within the 'triangle' formed by the two outermost branches of the Danube river (Fig. 8.20).

Grey Heron, 2001



Grey Heron, 2002

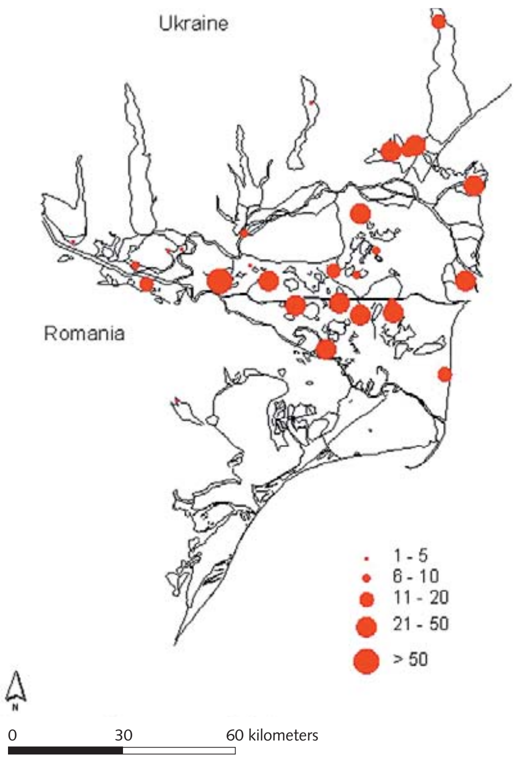


Fig. 8.20.
Breeding distribution of Grey Heron *Ardea cinerea* in the Danube Delta in 2001 and 2002.

On the Romanian side of the Danube delta area, no birds were found breeding in the southern area of former lagoons, while on the Ukrainian side some small colonies occurred in Reed beds of the larger lakes.

The numerical development of breeding Grey Herons in some well-known colony sites in Romania in previous years suggests a slight increase between the early 1980s and halfway the 1990s (Fig. 8.21), but at least some large colonies (of over 250 pairs) did exist as early as 1980. In the Ukrainian part of the Danube delta, Grey Herons were increasing during the 1980s (from about 50 to 140 pairs), but numbers dropped again in the 1990s only to remain more or less stable at about 40 pairs up until now (Fig. 8.22).

Feeding distribution

Feeding Grey Herons were quite unevenly distributed in the Danube Delta, with the highest concentrations invariably rather close to the most important colony sites (compare Figs 8.20 and 8.23). There was a clear preference for freshwater habitats, where most of the birds were observed feeding from the banks of the smaller canals and river channels. Generally, Grey Herons were feeding singly, but occasionally larger flocks were seen. On 23 and 24 May 2001 flocks of 35 and 15 birds, respectively, had gathered together along the banks of canals, which were being fished by large flocks of Great White Pelicans and Great Cormorants. The herons were taking advantage from the banks of the fish driven towards the shoreline by the chasing pelicans and cormorants.

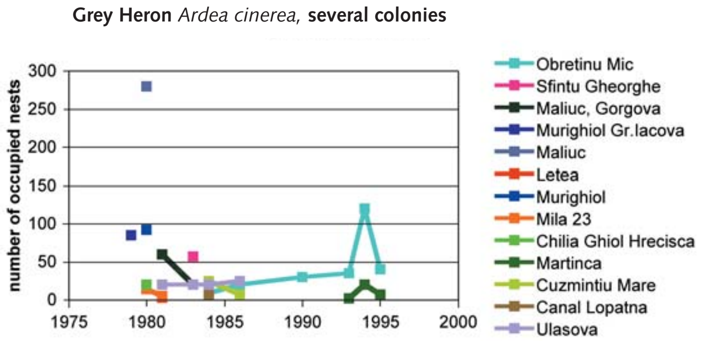


Fig. 8.21.
Numerical developments of some well-known colonies of Grey Heron *Ardea cinerea* in the Romanian Danube Delta in previous years.

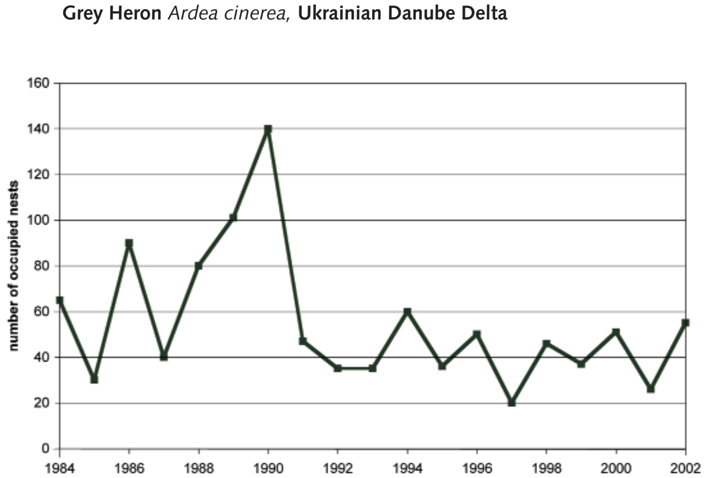


Fig. 8.22.
Numerical development of breeding Grey Herons *Ardea cinerea* in the Ukrainian Danube Delta in previous years.

Fig. 8.23.
Feeding distribution of Grey Heron *Ardea cinerea* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

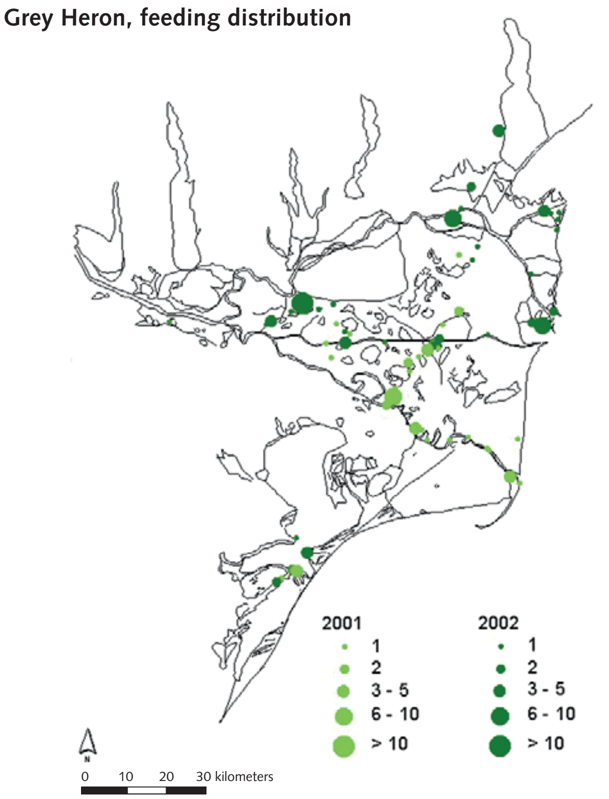
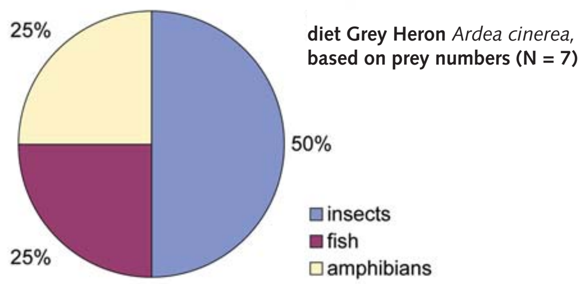


Fig. 8.24.
Diet composition of Grey Heron *Ardea cinerea* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



Food choice and diet
According to the analysis of three stomach contents of Grey Heron analysed by J.B. Kiss (unpubl.), Grey Heron diet in the Danube delta consists for 50% of insects, 25% of fish and another 25% of amphibians (Fig. 8.23). In terms of biomass, this undoubtedly means that fish and amphibians together make up the bulk of the birds' diet.

An estimate of the individual daily food needs of an adult Grey Heron with a body mass of 1.6 kg (Cramp & Simmons 1977, Del Hoyo *et al.* 1992) yields an approximate amount of 355 g of fresh fish or amphibians, according to the allometric relationships provided by Aschoff & Pohl (1970).

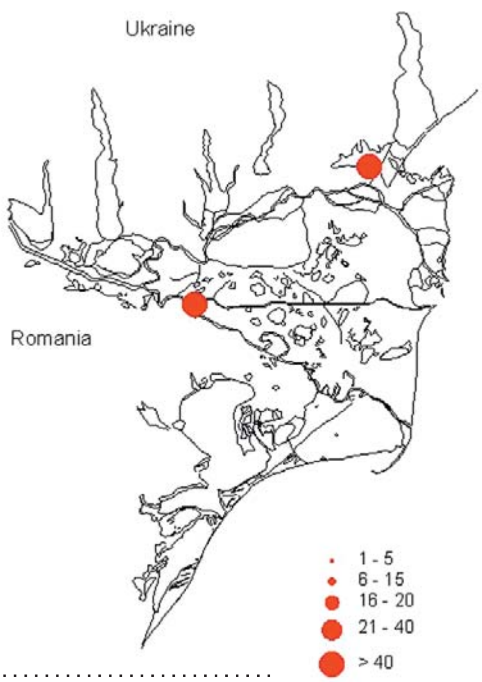
8.2.2 Purple Heron *Ardea purpurea*

General biogeography
The Purple Heron *Ardea purpurea* is an Old World species, distributed in three distinct areas: the western Palearctic (race *purpurea*) including northern Africa, south and south-eastern Asia (race *manilensis*) and sub-

Saharan Africa and Madagaskar (the latter even another distinct race *madagascariensis*) (Del Hoyo *et al.* 1992). Within Europe, the breeding distribution of the Purple Heron is rather patchy, with the main concentrations in S Europe, and almost all breeding nuclei below 53° N. Purple Herons are almost exclusively found in dense marshy vegetation, as formed by freshwater marshes and reed belt-fringed lakes (Hagemeijer & Blair 1997). They may be found feeding as well in more artificial wetland situations such as rice fields and farmland ditches or in swampy river valleys. The entire European population is fully migratory, wintering in sub-Saharan Africa (Cramp & Simmons 1977, Del Hoyo *et al.* 1992).
Its vulnerability to the winter droughts in these parts of Africa have in recent years resulted in some quite alarming declines (Cavé 1983). Thus, the Dutch population has fallen from 900 pairs in the early 1970s via 215 - 300 pairs (1984-93) to 270 pairs in 1993 (Van der Kooij 1994), the French population crashed from 1874 pairs in 1982 to 712 pairs in 1992 (Kayser *et al.* 1994) and the Austrian population dropped from 320 pairs (1970s) to 100 pairs by 1990 (Dvorak *et al.* 1993). A recent population estimate for the whole of Europe is 45,000 - 98,000 breeding pairs (mostly in Russia) (Hagemeijer & Blair 1997). Important national breeding populations are now found in France (2700 pairs), Spain (1100 pairs), Ukraine (1000 - 1500 pairs; Mikhalevich *et al.* 1994), Romania (950 pairs), Hungary (> 800 pairs) and Italy (550 pairs; Barbieri & Brichetti 1992) (Hagemeijer & Blair 1997). Rose & Scott (1997) report the population size of the Black Sea region as of unknown size.

Breeding distribution and numbers in Delta
The Purple Heron is the one species of colonial waterbird in the Danube delta that has almost certainly been severely underestimated, both in

Purple Heron, 2001



Purple Heron, 2002

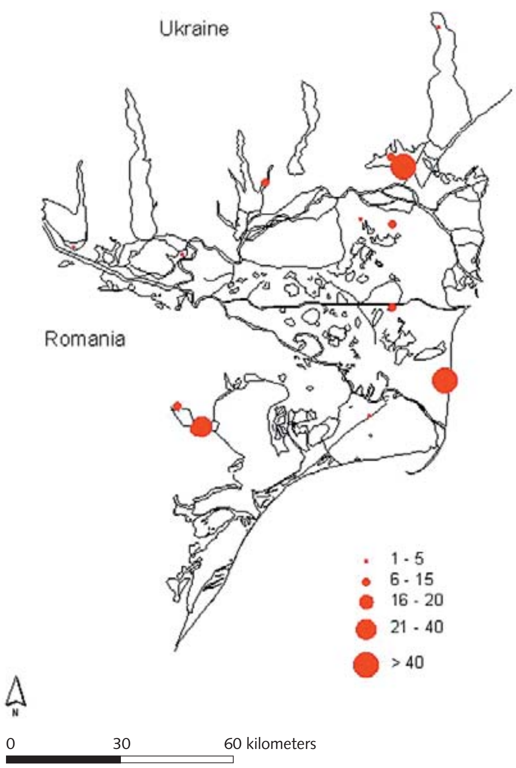


Fig. 8.25.
Breeding distribution of Purple Heron *Ardea purpurea* in the Danube Delta in 2001 and 2002.

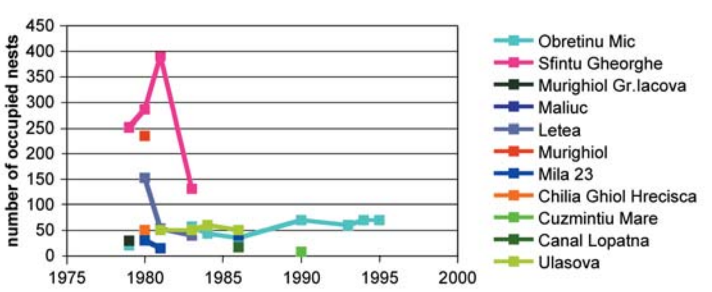
number of colonies located and in number of breeding pairs involved. In 2001 only two colony sites were located, one on the Romanian side with an estimated 100 occupied nests (pers. obs. Paul Cirpaveche) and one on the Ukrainian side with no less than 350 occupied nests (M. Ye. Zhmud) (Fig. 8.25). Although the site located on the Romanian side (at Rusca Balteni) had disappeared by 2002, due to the reclamation of this area for agricultural purposes, the search in 2002 yielded nine colonies in Romania and six in the Ukraine. Most of these sites were occupied only by small numbers (eight colonies with only up to 10 pairs), but in two of them 100 or more pairs were counted (Vadanei in Romania with 147 pairs and Stentsovsko Zhebriansky Plavni in Ukraine with 100 pairs) (Fig. 8.25).

The total population estimates of 450 and 399 pairs for 2001 and 2002 respectively are definitely too low. All colonies were located in inundated Reed beds and proved to be very inconspicuous. Particularly on the Romanian side the total surface area of potentially suitable colony sites is so extensive that neither from the ground nor from the air one can ever be sure to have covered the entire area with sufficient accuracy to find all occupied colonies. In September 2002 in a mere couple of days several 100s of Purple Herons were observed migrating southwards at lake Isacov (pers. comm. J.J. De Leeuw), indicating clearly that the local breeding population is likely to be much higher.

In the past some large Purple Heron colonies (over 100 pairs) have been recorded with certain regularity in the Romanian Danube delta (Fig. 8.26). However, from the mid-1980s onwards no such large colonies were registered anymore and in the 1990s the largest known colony of Obretinu Mic consisted of only slightly over 50 pairs. By 2001 this colony has disappeared and it would seem that, despite the notorious difficulty of reliably estimating presence and size of Purple Heron colonies, this species has, in fact, been declining since the 1980s.

Fig. 8.26.
Numerical developments of some well-known colonies of Purple Heron *Ardea purpurea* in the Romanian Danube Delta in previous years.

Purple Heron *Ardea purpurea,* **several colonies**



Feeding distribution

The Purple Heron proved to be the most elusive of all colonial bird species included in the surveys. Single individuals were seen all over the central delta area, particularly in the area where freshwater lakes are present (Fig. 8.27). Further south, in the Razim-Sinoe area, this species was rather scarce, along the coastline it was virtually absent and in the north, in the Stentsovsko Zhebriansky Plavni area, it was very abundant. This area consists of a vast surface of dense inundated Reed beds, rich in frogs *Rana ridibunda*, and seems to be an ideal habitat for both breeding and feeding Purple Herons.

Fig. 8.27.
Feeding distribution of Purple Heron *Ardea purpurea* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

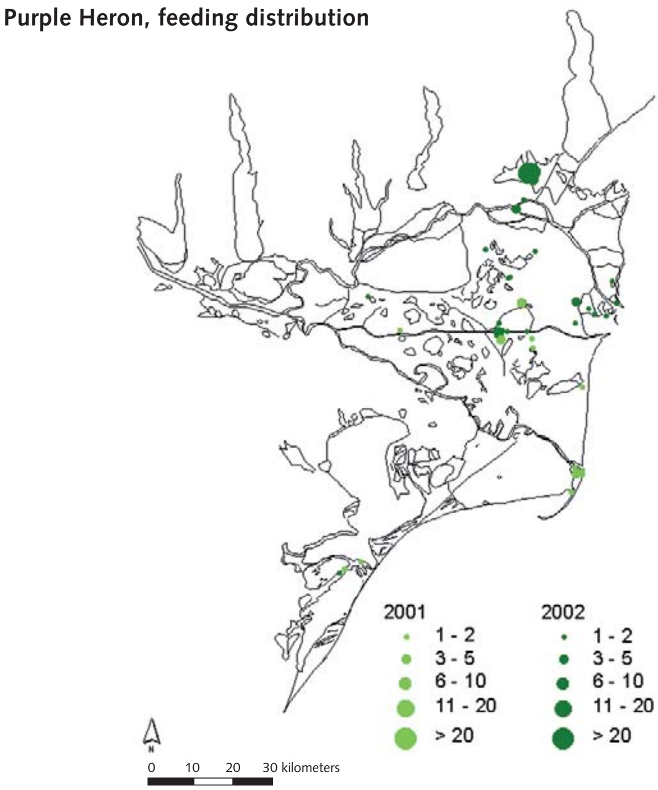
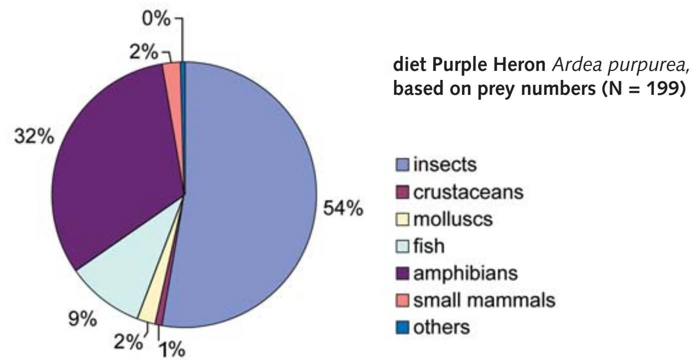


Fig. 8.28.
Diet composition of Purple Heron *Ardea purpurea* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



Food choice and diet

The food choice of Purple Heron in the Danube delta, as based on 224 prey items from 28 stomach contents analysed by J.B. Kiss (unpubl.), consisted for over 50% of insects, for 32% of amphibians and for a mere 9% of fish (Fig. 8.28). Other prey items identified included crustaceans, molluscs and small mammals. In terms of biomass, therefore, it would seem logical to assume that amphibians, mainly frogs, make up the bulk of this species' diet.

A very rough estimate, based on allometric relationships (Aschoff & Pohl 1970) and the assumption that frogs contain as much energy as fish, would suggest a daily food intake by an individual Purple Heron (of 0.9 kg; Cramp & Simmons 1977, Del Hoyo *et al.* 1992) of 233 g of fresh mass.

8.2.3 Great Egret *Casmerodius albus*

General biogeography

The Great Egret *Casmerodius albus* is a truly cosmopolitan species, breeding in lowland wetlands all over the temperate and tropical climate zones of North and South America, Africa, Asia and Australasia (Del Hoyo *et al.* 1992). The species is a year-round resident over much of its breeding range, with the exception of the northernmost populations, both in North America and in Eurasia. In Europe, the bulk of the Great Egrets is found below the 20° C July isotherm, where they inhabit extensive wetland areas that consist of Reed swamps, lake shores, riverine forest, estuaries and marine coastline (Hagemeijer & Blair 1997). As nesting sites, this species tends to use large undisturbed Reed beds, where it nests on the ground, but occasionally it may also be found in bushes or low trees (*e.g.* willow *Salix* spp.). For the Danube Delta, frequent reports have been made of Great Egrets breeding in loosely dispersed groups rather than dense colonies, with inter-nest distances of up to 10-50 m (D. Munteanu, in: Hagemeijer & Blair 1997).

In spite of a period of intense persecution in the 19th and early 20th century for its plumes, and some spectacular population crashes as its result, nowadays the Great Egret is not anymore a globally threatened species (Del Hoyo *et al.* 1992). Particularly in North America, numbers have increased enormously since the ban on the plume trade. In the western Palearctic, however, the Great Egret is still a relatively scarce bird. The size of the European breeding population is estimated by Hagemeijer & Blair (1997) at 3500 breeding pairs, the Russian population at 11,000 breeding pairs and the Turkish population at 225 pairs. The size of the Black and Caspian Sea region population is estimated by Rose & Scott (1997) at 17,000 individuals. Over the past decades, numerical trends in the European Great Egret population have been fluctuating. Traditionally, the strongholds of this population were settled in SE Europe, the Austrian Neusiedlersee being the most north-westerly regular breeding site. Numbers here have fluctuated strongly (*e.g.* 320 pairs in the late 1970s, 152 pairs in 1985, 429 pairs in 1989 and 174 pairs in 1994; Dvorak *et al.* 1993). In Romania up to 150 pairs have been reported in recent years. Moreover, in recent years annual breeding in increasing numbers is being reported from further west (*e.g.* Oostvaardersplassen, The Netherlands; Camargue, France and Ebro Delta, Spain) (Van der Kooij & Voslamber 1997, Hagemeijer & Blair 1997, Voslamber *et al.* in press).

Breeding distribution and numbers in Delta

The highest numbers of breeding Great Egrets are found in inundated Reed beds, breeding either in monospecific colonies or together with Grey Herons. Nevertheless, smaller settlements are also frequently found in mixed-species colonies, both in Reed beds and in trees.

In 2001, a total of 307 breeding pairs was located in 10 different colony sites. Mean colony size was 31 and the largest colony consisted of 70 pairs. In 2002, the more extensive survey, also including the Ukrainian part of the Danube delta (which proved to be very important for this species), yielded no less than 27 different colonies holding a grand total of 730 breeding pairs. The mean colony size was 27 and the largest colony held 100 occupied nests.

The Great Egret showed a marked preference for the borders of the delta

Great Egret, 2001 **Great Egret, 2002**

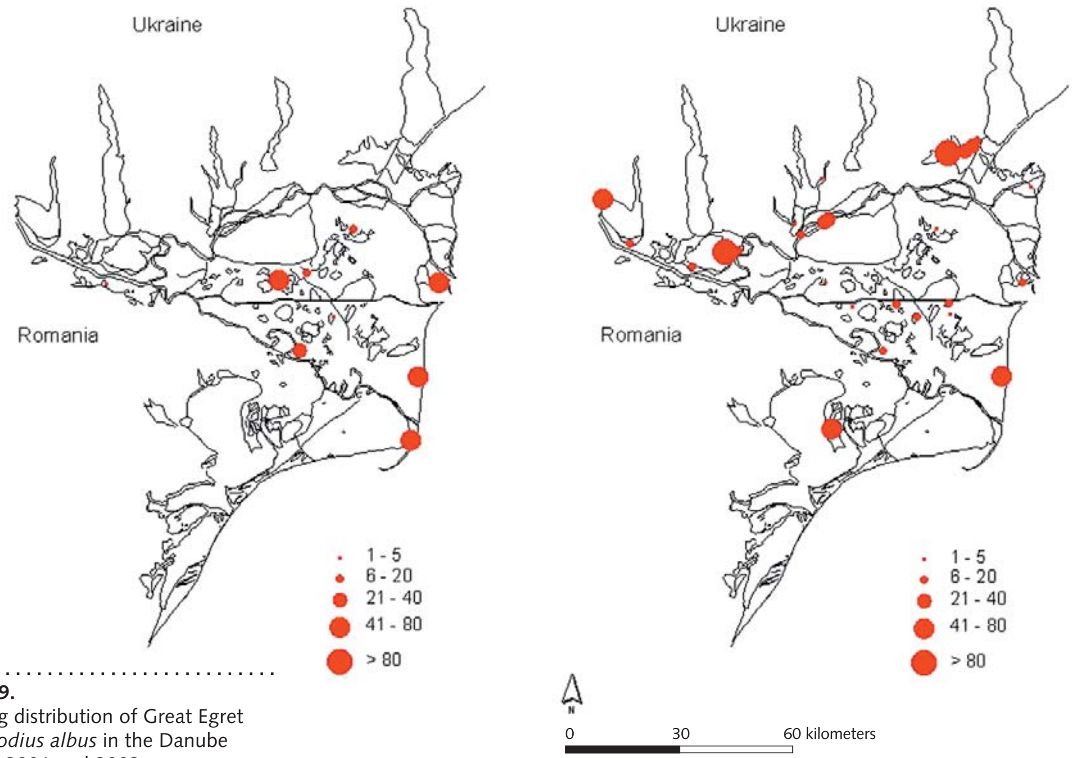


Fig. 8.29.
Breeding distribution of Great Egret *Casmerodius albus* in the Danube Delta in 2001 and 2002.

Great Egret *Casmerodius albus,* **several colonies**

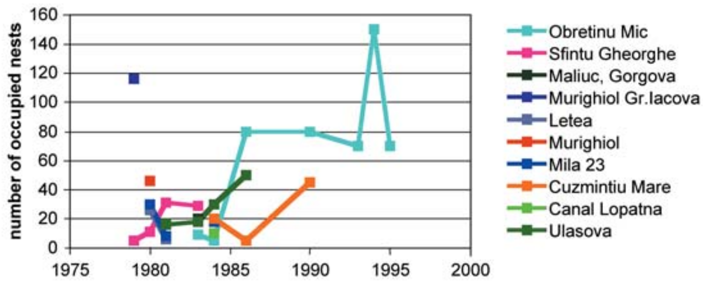


Fig. 8.30.
Numerical developments of some well-known colonies of Great Egret *Casmerodius albus* in the Romanian Danube Delta in previous years.

Great Egret *Casmerodius albus,* **Ukrainian Danube Delta**

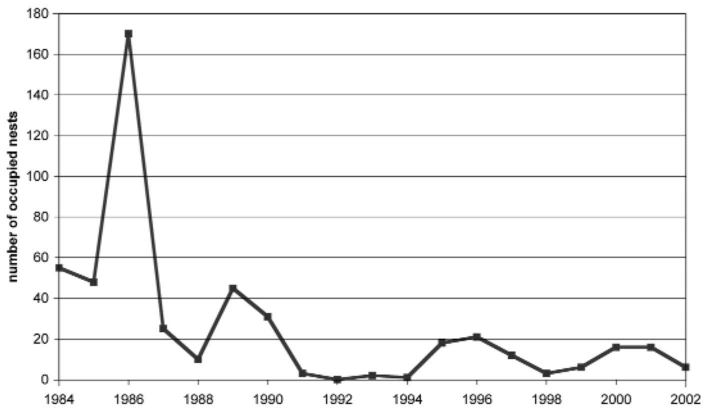


Fig. 8.31.
Numerical development of breeding Great Egrets *Casmerodius albus* in the Ukrainian Danube Delta in previous years.

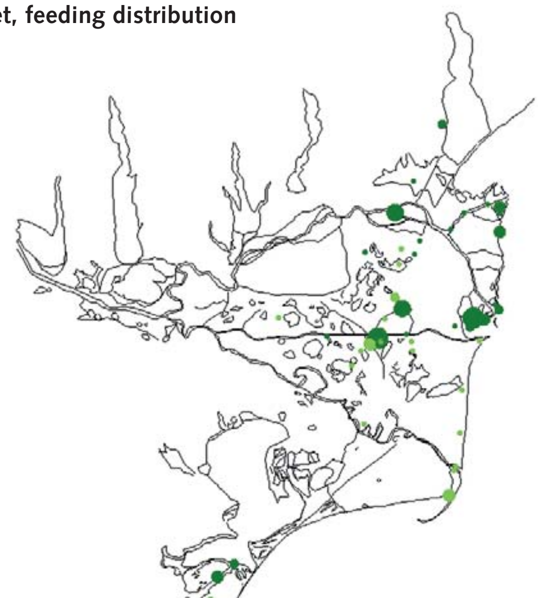
area, both along the Black Sea coast and along the edge of the Ukrainian lakes north of the main Chilia branch of the Danube (Fig. 8.29). In the central, lake-rich triangle composed by the three main Danube branches, settlements were fewer and rather smaller.

An overview of past numerical developments in some selected colonies suggests that the Great Egret is likely to have increased between the late 1970s and the present day (Fig. 8.30). However, while up until the mid-1990s one of the largest colonies, holding up to well over a 100 pairs (Obretinu Mic), was found in the central delta area, the tendency nowadays seems to be that the largest concentrations are found along the edges of the area, closer to larger stretches of open water or cultivated land.
On the Ukrainian side of the Danube delta, the so-called 'secondary delta', the Great Egret seems to have declined significantly since the mid-1980s, when numbers occasionally rose as high as 170 breeding pairs (Fig. 8.31). In recent years, numbers here have oscillated between five and twenty pairs. However, the present survey has clearly shown that, within the Ukrainian part of the Danube delta area, the 'secondary delta' does not belong to the main breeding area for this species. In 2002 no less than 521 breeding pairs were located in the Ukraine, only 16 of which were actually found in the secondary delta.

Feeding distribution
Great Egrets were frequently seen in most of the Danube Delta, but proved to be particularly common in the areas closest to the Black Sea (Fig. 8.32). Generally, higher numbers were seen on the Ukrainian side of the delta. The high concentration inland, close to the central part of the Sulina branch, was caused by one flock of 25 individuals that had gathered along the bank of Canal Magistral, together with a feeding flock of 150 Great

Fig. 8.32.
Feeding distribution of Great Egret *Casmerodius albus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

Great Egret, feeding distribution

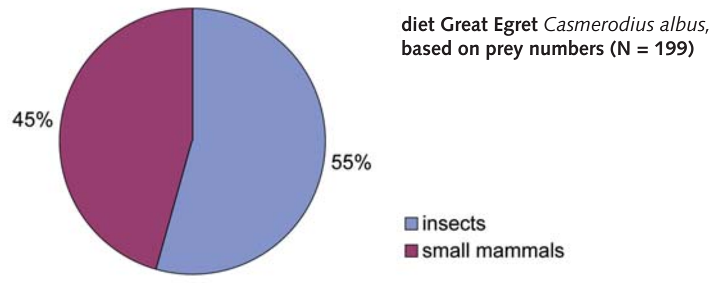


White Pelicans, 260 Great Cormorants and 250 Pygmy Cormorants that were chasing fish towards the shoreline on 23 May 2001. In the southern Razim-Sinoe region, Great Egrets were also frequently seen, occasionally even feeding in more or less terrestrial areas.

Food choice and diet

Based on 22 prey items extracted from four stomach contents, J.B. Kiss (unpubl.) identified 55% insects and 45% small mammals (both mice *Mus* spp. and Field Vole *Microtus arvalis;* Fig. 8.33). Surprisingly, neither fish nor amphibians were found, undoubtedly due to the small sample size. The results, however, clearly show that, just like what has been found elsewhere, this heron species does not rely entirely on aquatic or semi-aquatic feeding habitats. Apart from fish, snakes, amphibians and aquatic insects, also small mammals, birds and lizards are reported (Cramp & Simmons 1977, Del Hoyo *et al.* 1992, Voslamber *et al.* in press).

Fig. 8.33.
Diet composition of Great Egret *Casmerodius albus* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



A rough estimate, based on allometric relationships (Aschoff & Pohl 1970) and the assumption that the Great Egret's food items have about the same energetic values as fish, would suggest a daily food intake by an individual bird (of 1.05 kg; Cramp & Simmons 1977, Del Hoyo *et al.* 1992) of 259 g of fresh mass.

8.2.4 Little Egret *Egretta garzetta*

General biogeography

The Little Egret *Egretta garzetta* is a widely distributed breeding bird over temperate and especially tropical zones of Europe, Asia, Africa and Australasia (Del Hoyo *et al.* 1992). Most of the European breeding birds are migratory, wintering mainly in Africa, but the mildest winters also allow considerable numbers to stay on in the Mediterranean (*e.g.* Nager *et al.* in press). In Europe most Little Egrets build their nests in low clumps of trees (generally willow *Salix* spp. or Alder *Alnus glutinosa*) in inundated Reed stands, or in larger trees along rivers. They often breed in mixed-species colonies, together with other heron species, cormorants or spoon-bills and ibises. The nests are then usually lower down in the trees than those of Black-crowned Night-heron *Nycticorax nycticorax* and Grey Heron *Ardea cinerea* (Fasola & Alieri 1992a). Feeding may occur over a wide range of both natural and artificial (man-made) wetland habitats, ranging from freshwater, via brackish to marine. Colonies in more marine environments tend to be more often mono-specific (Hafner & Fasola 1992). Total breeding numbers may be limited by both food availability and by availability of suitable nesting habitat, depending on locally diffe-rent environmental conditions (Fasola & Alieri 1992b).

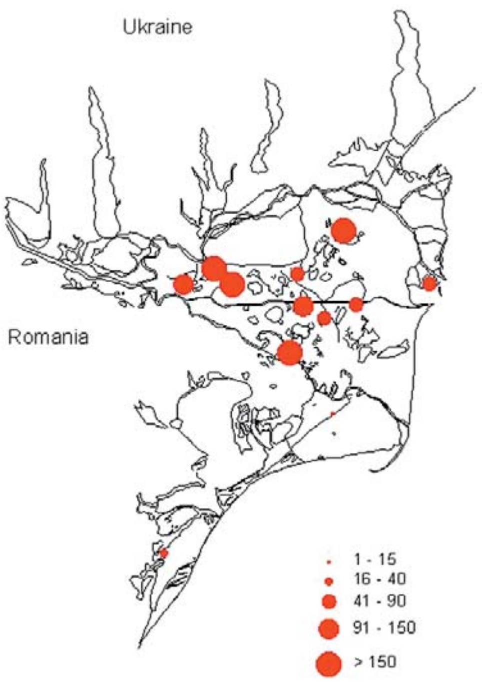
Breeding distribution and numbers in Delta

Little Egrets were almost invariably found breeding in mixed-species colonies in inundated stands of willows, mostly *Salix cinerea*. On the Romanian side the only exception was a large colony on an islet in lake Sinoe, where the nests were built on the ground, among inundated Reed surrounded by a circular sand bank. On the Ukrainian side, some relatively small settlements were also found in inundated Reed beds.

In 2001 a total of 1985 nests of Little Egret was counted in 12 different colony sites. The mean size of these colonies was of 165 breeding pairs, the largest colony was 500 pairs strong. In 2002, although the more extensive survey revealed twice as many colonies (24), the total population proved to be smaller (1725 breeding pairs). Both mean and maximum colony size were also lower in the second year, being 72 and 250 pairs, respectively.

In both years, the vast majority of colony sites as well as the largest colonies were found within the central, lake-rich part of the (Romanian) Danube delta, quite close to the main river branches (Fig. 8.34). Along the more open edges of the delta area, along the Black Sea coast and in the lagoons, this species was much rarer.

Little Egret, 2001



Little Egret, 2002

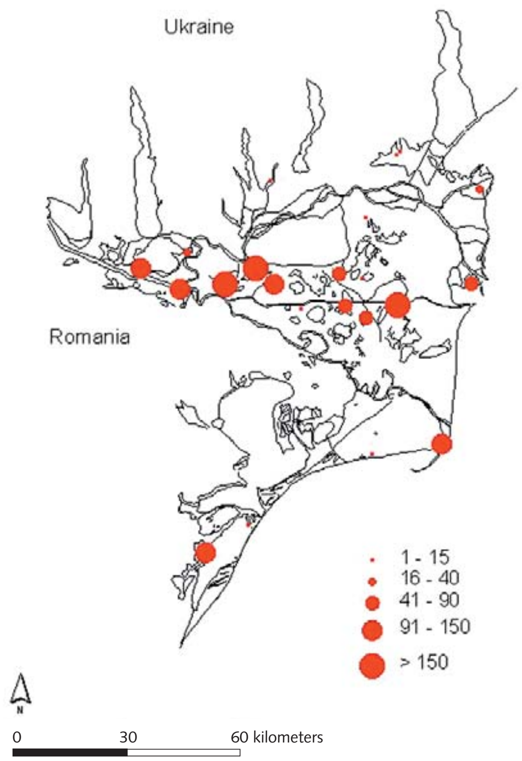


Fig. 8.34.
Breeding distribution of Little Egret *Egretta garzetta* in the Danube Delta in 2001 and 2002.

The available historical data on Little Egret breeding numbers in the Romanian Danube Delta Biosphere Reserve do not convey any clear-cut impression on its numerical development. Some colonies seem to have held extremely high numbers in 1980 (*e.g.* Murighiol and Maliuc) but must have become abandoned since, others, however, have shown clear increases on lower levels between the early 1980s and the mid-1990s (Fig. 8.35).

Little Egret *Egretta garzetta,* **several colonies**

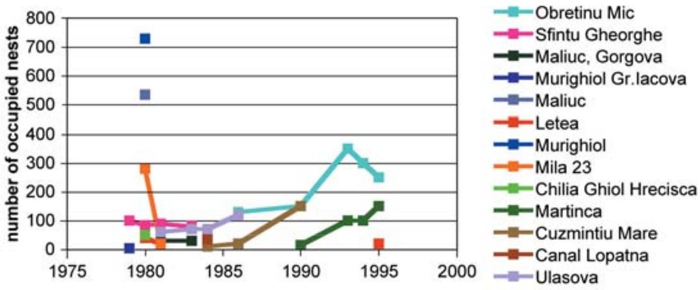


Fig. 8.35.
Numerical developments of some well-known colonies of Little Egret *Egretta garzetta* in the Romanian Danube Delta in previous years.

Little Egret *Egretta garzetta,* **Ukrainian Danube Delta**

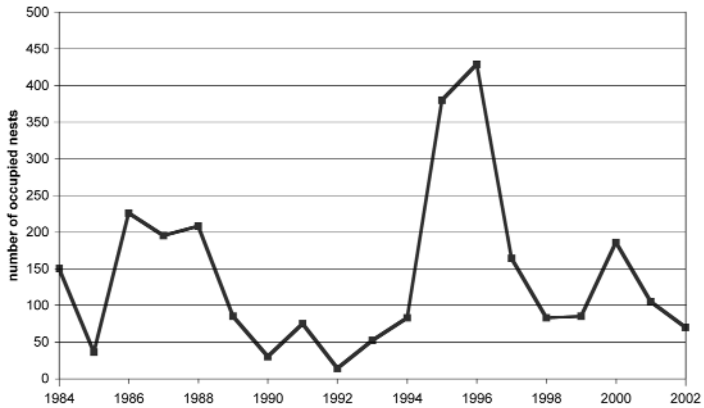


Fig. 8.36.
Numerical development of breeding Little Egrets *Egretta garzetta* in the Ukrainian Danube Delta in previous years.

In the secondary delta on the Ukrainian side of the Danube Delta Biosphere Reserve, Little Egrets have ever been breeding in highly fluctuating numbers since the beginning of the regular counts in 1984. In the late 1980s about 200 pairs bred annually, dropping to around 50 throughout the early 1990s and then again increasing up to over 400 in 1996 (Fig. 8.36). Then numbers dropped again, stabilising around some 100 pairs in recent years. In 2002, 110 pairs were counted in this part of the Ukrainian Danube delta. Including the other areas surveyed, the Ukraine held 341 breeding pairs of Little Egret.

Feeding distribution

The Little Egret was one of the most common and widespread of the wading birds observed. Concentrations of socially feeding birds, however, a quite normal phenomenon in the Camargue (Kersten *et al.* 1991), were never observed. This observation seems to be in line with the situation over most of the species' range (*cf.* Del Hoyo *et al.* 1992). Most records referred to single birds or small parties feeding along the banks of the river or the smaller canals, generally in the central part of the delta (Fig. 8.37). The species was remarkably scarce along the Black Sea coast, but in the Razim-Sinoe area in the south higher numbers occurred.

Food choice and diet

The Little Egret seems to be mainly a piscivorous species in the Danube delta. Of 212 identified prey items from eight birds, J.B. Kiss (unpubl.) found 66% to be fish remains (mostly *Alburnus alburnus*) (Fig. 8.38). Aquatic insects made up another 33% and amphibians accounted for the

Fig. 8.37.
Feeding distribution of Little Egret *Egretta garzetta* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

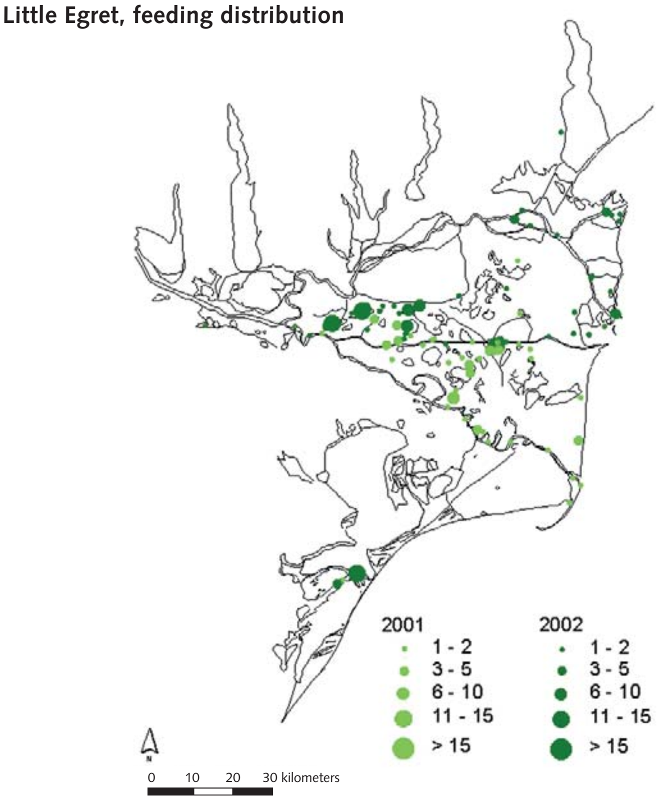
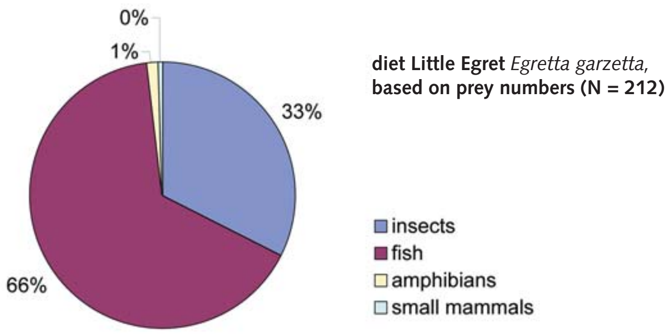


Fig. 8.38.
Diet composition of Little Egret *Egretta garzetta* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



remaining 1%. Other food studies have shown a less prominent place for fish, even within the Danube delta. Andone *et al.* (1969) found 47% of fish, between masses of 0.3-14.6 g. The most important species in this study were *Gobius kessleri, Carassius carassius* and *Rutilus rutilus* (all over 10% by number).

A rough estimate of an individual Little Egret's daily food intake, based on allometric relationships (Aschoff & Pohl 1970), a mean body mass of 0.453 kg (Cramp & Simmons 1977, Del Hoyo *et al.* 1992), a mean caloric value of fish of 4.6 kJ.g-1 (Platteeuw 1985) and an assimilation efficiency of 0.8 (Castro *et al.* 1989) yields an amount of 140 g of fresh food to be ingested each day.

8.2.5 Squacco Heron *Ardeola ralloides*

General biogeography
The Squacco Heron *Ardeola ralloides* is found breeding in S and SE Europe, eastwards into Asia to the region of the Aral Sea and SE Iran (Del Hoyo *et*

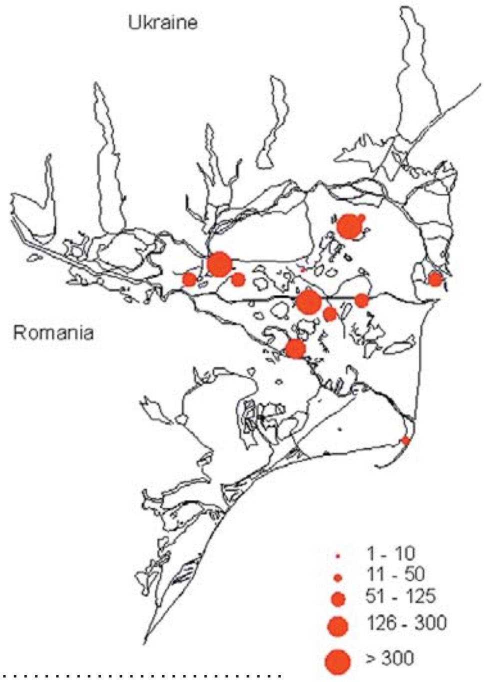
al. 1992). These populations are fully migratory, wintering mostly in Africa, where also resident breeding populations exist both north and south of the Sahara. The breeding distribution in Europe is rather patchy, restricted to extensive freshwater areas, where both natural and man-made wetlands such as rice fields are frequented (Hagemeijer & Blair 1997).

The Squacco Heron is not a globally threatened species. The size of its European population has shown large fluctuations over the years, but recently seems to be increasing in at least Italy (30 pairs in 1950 via 270 pairs in 1981 to 500 - 600 pairs in 1995), Spain (100 - 200 pairs in 1963 to over 800 pairs in 1990) and S France (Fernández-Cruz *et al.* 1992, Del Hoyo *et al.* 1992, Hagemeijer & Blair 1997). In E Europe, however, decreases have been reported, such as in Greece (1400 pairs before 1970 down to c. 250 pairs in 1985/86) and Croatia (from 478 pairs in 1954 down to less than 50 pairs in the mid-1980s) (Hagemeijer & Blair 1997). Total population estimates are 4500 pairs for Europe, 5700 pairs for Russia and 5500 pair for Turkey (Hagemeijer & Blair 1997). Rose & Scott (1997) do not provide estimates for the population size of this species.

Breeding distribution and numbers in Delta

Most Squacco Heron colonies are found in stands of small bush-like willows (*Salix cinerea*) within generally inundated terrain. Here, they almost invariably breed together with other smaller heron species and Glossy Ibis. Only one colony was actually found in the absence of trees, in the inundated Reed bed area of the Stentsovsko Zhebriansky Plavni in the Ukraine. Here too, however, the birds were found in a mixed-species colony.
In 2001 2405 breeding pairs of Squacco Heron were located in 12 colonies. The mean colony size was no less than 200, while the largest one

Squacco Heron, 2001



Squacco Heron, 2002

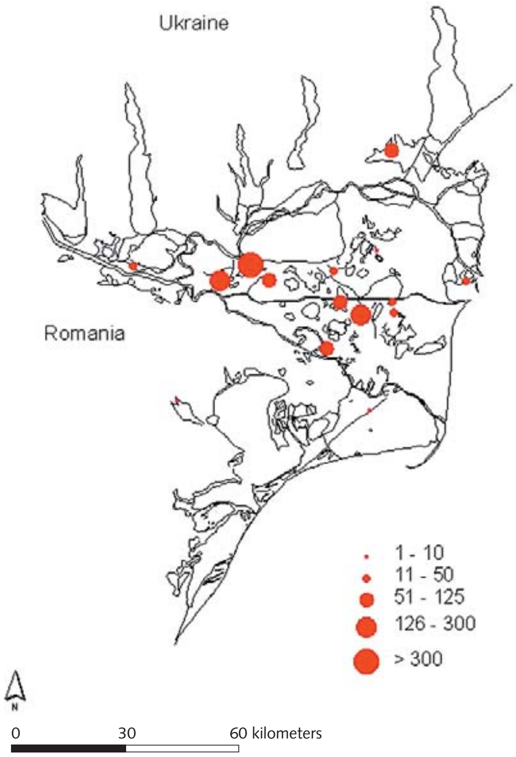


Fig. 8.39.
Breeding distribution of Squacco Heron *Ardeola ralloides* in the Danube Delta in 2001 and 2002.

was as big as 500 breeding pairs. In 2002 this species, like many other smaller herons, was apparently scarcer with only 1279 breeding pairs distributed over 16 colonies, in spite of a much more extensive search. Mean colony size in this season was a mere 80 pairs and the largest colony consisted of 350 pairs.

All important Squacco Heron colonies were situated in the central riverine part of the Danube delta or in the already mentioned freshwater marsh of the Stentsovsko Zhebriansky Plavni (Fig. 8.39). The coastal area was consequently avoided, thus clearly indicating the strong dependence of this species on freshwater conditions, preferably associated with clear water.

Squacco Herons would seem to have been on the increase between the early 1980s and the mid-1990s in the Romanian part of the Danube Delta Biosphere Reserve (Fig. 8.40). Nonetheless, a really huge colony (1600 pairs strong) which existed in Murighiol in 1980 has become abandoned and similar colony sizes have never been recorded since.

In the Ukrainian 'secondary delta', the Squacco Heron has always been distinctly scarcer than on the Romanian side. In the late 1980s between 100 and 120 pairs bred annually, dropping in the early 1990s to between 20 and 60 pairs (Fig. 8.41). In 2002 the secondary delta held one single colony (Kurilski island) of 35 pairs, but thanks to the larger settlement in the Stentsovsko Zhebriansky Plavni and two other small settlements along the banks of lake Kugurluy, the total Ukrainian contribution to this species' population amounted to 150 breeding pairs.

Squacco Heron *Ardeola ralloides*, **several colonies**

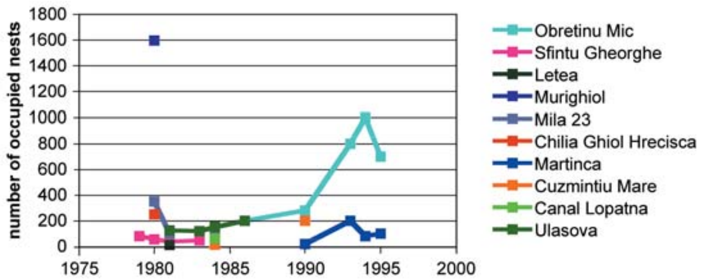


Fig. 8.40.
Numerical developments of some well-known colonies of Squacco Heron *Ardeola ralloides* in the Romanian Danube Delta in previous years.

Squacco Heron *Ardeola ralloides*, **Ukrainian Danube Delta**

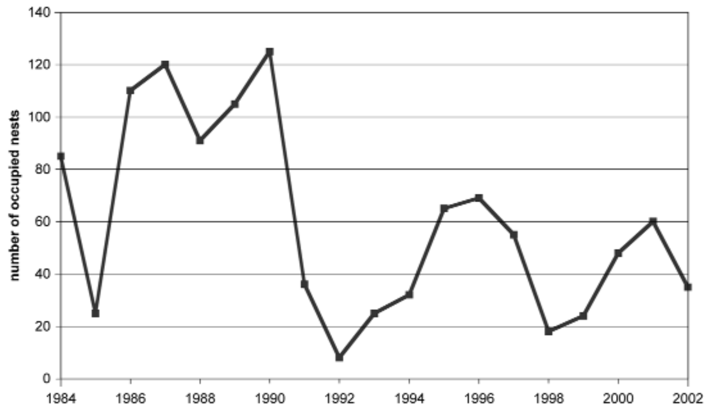


Fig. 8.41.
Numerical development of breeding Squacco Herons *Ardeola ralloides* in the Ukrainian Danube Delta in previous years.

Feeding distribution

The distribution of feeding Squacco Herons rather resembled that of the Little Egret. The vast majority of records came from the central delta area (Fig. 8.42) and almost all birds were seen either along the smaller canals or along small lakes or pools. Unlike the Little Egret, the Squacco Heron was frequently seen walking on the floating leaves of Nymphaeids. The Squacco Heron was virtually absent from the larger water bodies in the south and also proved to be rather scarce in the north on the Ukrainian side of the delta. Observations along the Black Sea coast were virtually absent.

Squacco Heron, feeding distribution

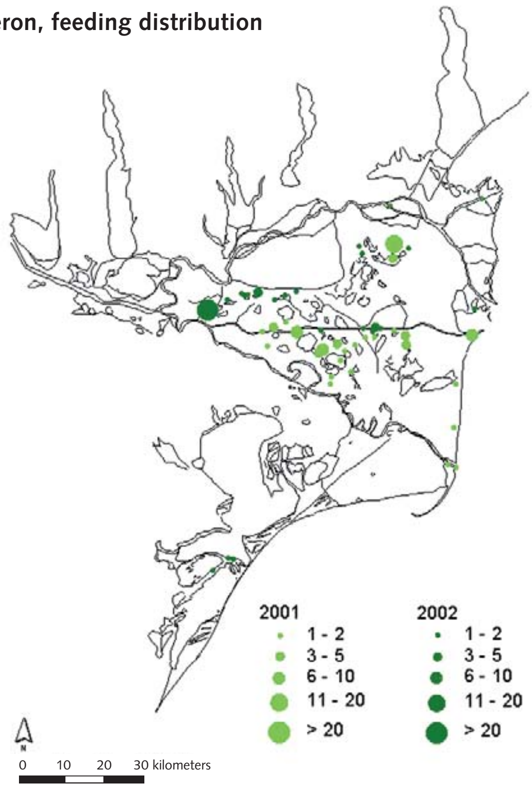


Fig. 8.42.
Feeding distribution of Squacco Heron *Ardeola ralloides* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

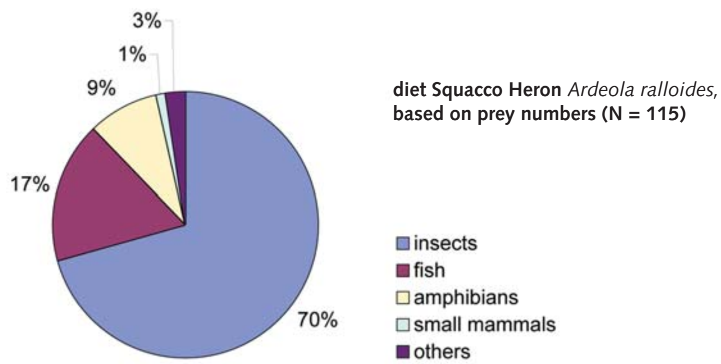


Fig. 8.43.
Diet composition of Squacco Heron *Ardeola ralloides* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).

Food choice and diet

According to the analysis of 115 prey items extracted from 17 stomachs, the Squacco Heron diet in the Danube delta consisted in its majority of insects (J.B. Kiss, unpubl.). A further 17% was made up by fish, while amphibians were third in importance with 9% of the total food remains (Fig. 8.43). This predominance of insects over both fish and amphibians is also mentioned by Cramp & Simmons (1977) and Del Hoyo *et al.* (1992). Direct observations in the field, however, suggest that rather large frogs (generally *Rana ridibunda*) are also taken frequently and, in view of their sheer mass, these may in fact make up a rather more important part of the food spectrum in terms of bulk than what is generally suggested in literature.

The estimate of the Squacco Heron's daily food intake, based on allometric relationships (Aschoff & Pohl 1970) and a body mass of 0.3 kg (Cramp & Simmons 1977, Del Hoyo *et al.* 1992) amounts to 104 $g.day^{-1}$.

8.2.6 Cattle Egret *Bubulcus ibis*

General biogeography

Although originally an Old World species, the spectacular colonising capacity of the Cattle Egret *Bubulcus ibis* has resulted nowadays in a cosmopolitan breeding distribution, generally favouring the warmer temperate and tropical regions (Del Hoyo *et al.* 1992). In Europe and Asia the species is still mainly found in the southernmost regions, where it is sedentary or at most partially migratory. Cattle Egrets are less confined to wetland regions than other heron species and are found as well in open grassy areas with very little or no fresh water (Hagemeijer & Blair 1997).

The distribution of the Cattle Egret in Europe is still marked by a slow but steady colonisation from the southwest. In the 19th century, the species was still only found breeding in Andalucía (Spain). From there it started to spread its range all over the Iberian Peninsula from the early 1960s onwards, where nowadays (1990/91) the total breeding population is estimated at 85,000 pairs (Fernández-Cruz *et al.* 1992), with the largest colony along the river Guadiana numbering over 10,000 occupied nests. In 1969 the first breeding record for France (Camargue) was reported, involving 2 pairs. This population quickly increased to 352 pairs by 1984, dropping to 74 pairs the next year as a consequence of an unusually severe winter, but has recovered since to no less than 3540 pairs by 1996 (Hagemeijer & Blair 1997). Hagemeijer & Blair (1997) estimated the entire European population at 78,000 pairs, the Russian population at 40 pairs and the Turkish population at less than 10 pairs. They do not yet mention the Cattle Egret as a breeding bird in SE Europe. However, in 1996 the first breeding record of Cattle Egret, concerning a single pair in a mixed-species colony, was reported in the Danube Delta (Marinov & Hulea 1999, Kiss & Szabó 2000a). In 1997 two pairs were found there and in 1998 even eight pairs bred.

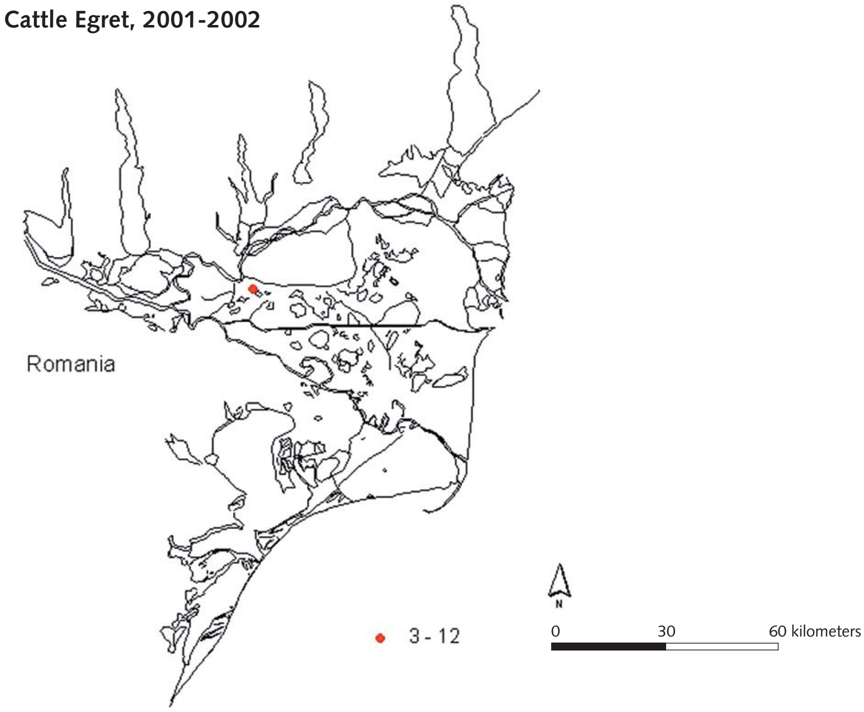
Breeding distribution and numbers in Delta

The Cattle Egret is still a very scarce breeding bird in the Danube Delta. Since its first breeding in 1996, it has been present every year but only in one colony (lake Nebunu, Fig. 8.44) and in low numbers. The 2001 survey revealed 12 pairs, but in 2002 no more than three occupied nests were found. For the time being, the colonisation of the Danube Delta by this heron species seems to have slowed down.

Feeding distribution

Never in either of the periods of fieldwork in 2001 or 2002 have any observations of feeding Cattle Egrets been made. Observations from 1998, however, of both adults and adults with recently fledged young outside the colony (Kiss & Szabó 2000a) suggest that these birds mainly

Fig. 8.44.
Breeding distribution of Cattle Egret *Bubulcus ibis* in the Danube Delta in 2001 and 2002.



forage in the drier polder areas in grassland habitats (Chituc, Sfîntu Gheorghe and Caraorman), which concurs with their general biology. Thus, the choice of its colony site within the Romanian Danube Delta at lake Nebunu would seem quite logical, in view of its proximity to the Pardina polder area, consisting of dry grassland vegetation. Feeding habitat for Cattle Egret would seem to be abundant too on the Ukrainian side of the Danube Delta, particularly outside the limits of the Biosphere Reserve. Nesting habitat here may be limiting, however.

Food choice and diet
Nothing is known about the food choice of the Cattle Egret in the Danube delta area. This species is still so scarce, that no food studies have been carried out to date.

8.2.7 Black-crowned Night-heron *Nycticorax nycticorax*

General biogeography
The Black-crowned Night-heron *Nycticorax nycticorax* occurs as a breeding bird almost all over the world, except in Australasia (Del Hoyo *et al.* 1992). In the western Palearctic it is mainly found in C and S Europe, eastwards to C and S Asia. These populations are fully migratory, wintering mostly in sub-Saharan Africa (less than 1% remaining in the Mediterranean) (Hagemeijer & Blair 1997). Colonies are often shared with other species of heron and are typically located in low trees or clumps of trees (*e.g. Alnus* or *Salix*) on wet or inundated soils or (less commonly) in close Reed beds in deltas (*e.g.* in the Ebro delta) (Hagemeijer & Blair 1997). Normally, colonies exceeding a 100 pairs are situated at sites where at least 500 ha of permanent freshwater marsh for feeding is available within a radius of 5 km (Hafner & Fasola 1992). Feeding areas may also include rice fields, as substitute for natural freshwater wetland. In Italy, and to a lesser extent also in Spain and Greece, rice fields even make up the main feeding habitat (Fasola & Ruix 1996).

The Black-crowned Night-heron is still quite a numerous breeding bird in Europe, in spite of the disappearance of the once flourishing colonies in the Rhine-Meuse delta back in the 17th century, due to massive habitat destruction (Hagemeijer & Blair 1997, Van Eerden *et al.* 1997). The actual breeding population is estimated by Hagemeijer & Blair (1997) at 47,000 pairs for Europe, at almost 10,000 pairs for Russia and at 1700 pairs for Turkey. Rose & Scott (1997) provide an estimate of 200,000 individuals.

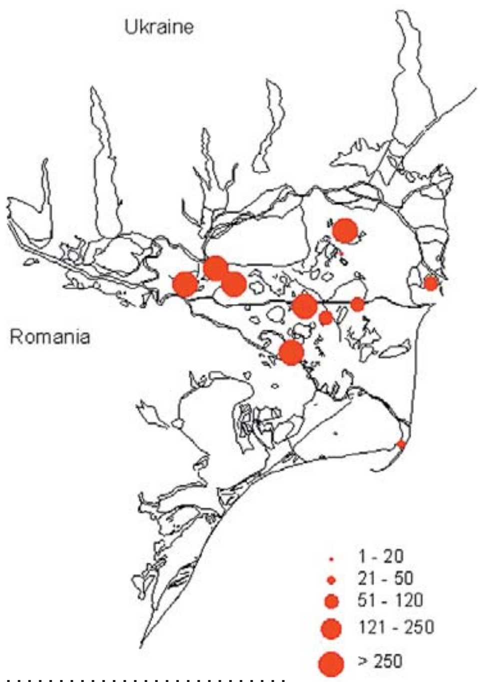
Breeding distribution and numbers in Delta

Like all small heron species, the Black-crowned Night-heron is almost exclusively found breeding in inundated stands of small trees (mostly willows) inside mixed-species colonies. However, occasionally some pairs also join up inside colonies of Great Cormorants in higher trees (*e.g.* Alder *Alnus* spp.) and on the Ukrainian side of the border some colonies were also found in inundated Reed beds.

In 2001 eleven colonies of Black-crowned Night-heron were located, holding 2140 breeding pairs. The largest colony was of 300 pairs and the mean colony size was 195. In 2002 no less than 27 colony sited were found with a total of 2964 pairs. This year the largest colony was 500 pairs strong and the average colony measured 110 pairs.

The Black-crowned Night-heron mostly settled its colonies in the central, lake-rich part of the Danube delta, in close proximity to the freshwater lakes (Fig. 8.45). However, in the Ukrainian secondary delta as well as in the Stentsovsko Zhebriansky Plavni also important settlements occurred. The southern lagoon areas of Razim and Sinoe did not hold any colony of this species.

Black-crowned Night-heron, 2001



Black-crowned Night-heron, 2002

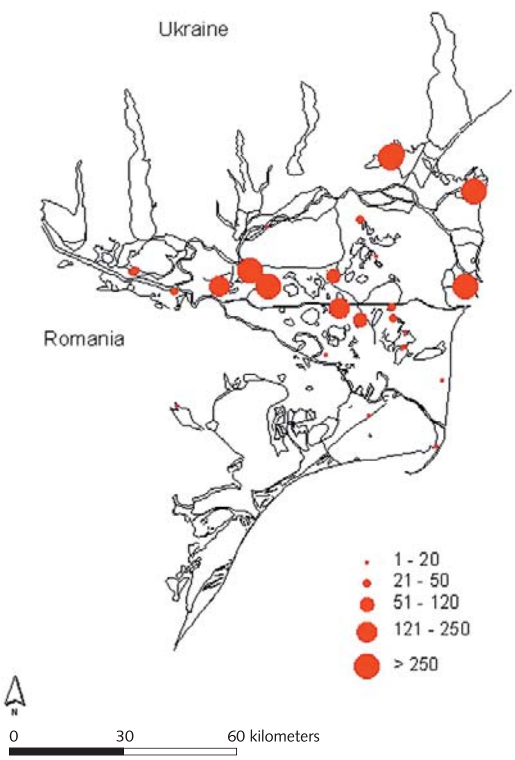


Fig. 8.45.
Breeding distribution of Black-crowned Night-heron *Nycticorax nycticorax* in the Danube Delta in 2001 and 2002.

Black-crowned Night-heron *Nycticorax nycticorax,* **several colonies**

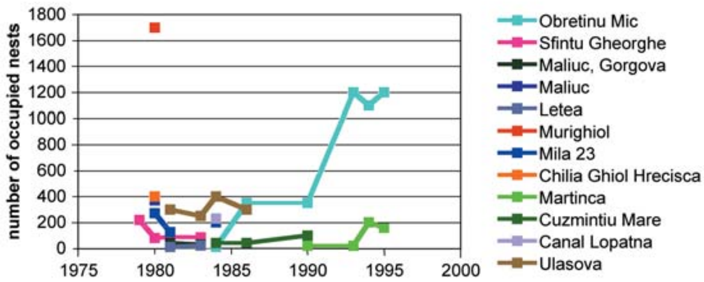


Fig. 8.46.
Numerical developments of some well-known colonies of Black-crowned Night-heron *Nycticorax nycticorax* in the Romanian Danube Delta in previous years.

Black-crowned Night-herons *Nycticorax nycticorax,* **Ukrainian Danube Delta**

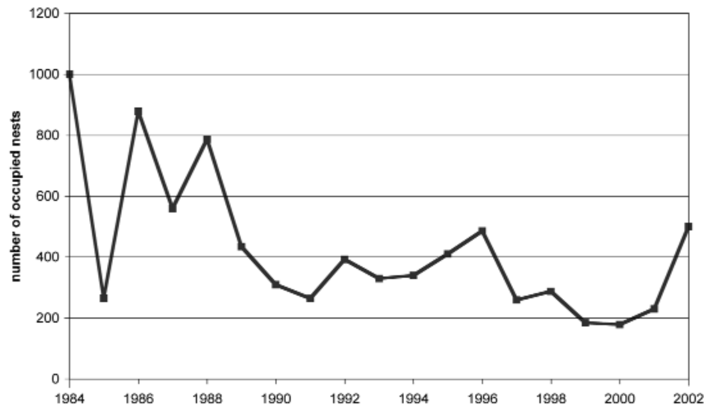


Fig. 8.47.
Numerical development of breeding Black-crowned Night-herons *Nycticorax nycticorax* in the Ukrainian Danube Delta in previous years.

In the past, a huge colony of Black-crowned Night-heron existed in Murighiol (some 1700 pairs in 1980), but colonies of similar sizes have apparently never been found ever since. Other colonies in the late 1980s held between 100 and 400 pairs (Fig. 8.46). One colony (Obretinu Mic) became established in this period and grew until reaching some 1200 pairs by the mid 1990s and then apparently decreased again (the same site holding only 300 and 200 pairs in 2001 and 2002, respectively). About the overall trend in the species, no clear indications were obtained.
In the Ukrainian secondary delta, breeding numbers of Black-crowned Night-heron have been rather stable, fluctuating between 200 and 400 pairs, since the early 1990s (Fig. 8.47). In the late 1980's, this species was occasionally rather more numerous (up to 800-1000 pairs), but in 1985 only slightly less than 300 pairs were found.

Feeding distribution
The Black-crowned Night-heron proved to be most common in the central part of the Danube Delta, between the Chilia and Sulina branches (Fig. 8.48). The most important feeding areas for this species were situated between the reclaimed Pardina polder in the west and the Chilia branch in the east, in the Rosca-Buhaiova region. The species was absent from the coastline and remarkably scarce along the Sfîntu Gheorghe branch. In spite of the presence of a rather large colony in the Ukrainian Stentsovsko Zhebriansky Plavni, no birds were observed here along the transects. This would seem to indicate that this area, although adequate for breeding, does not meet the most profitable feeding conditions for this species.

Fig. 8.48.
Feeding distribution of Black-crowned Night-heron *Nycticorax nycticorax* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

Black-crowned Night-heron, feeding distribution

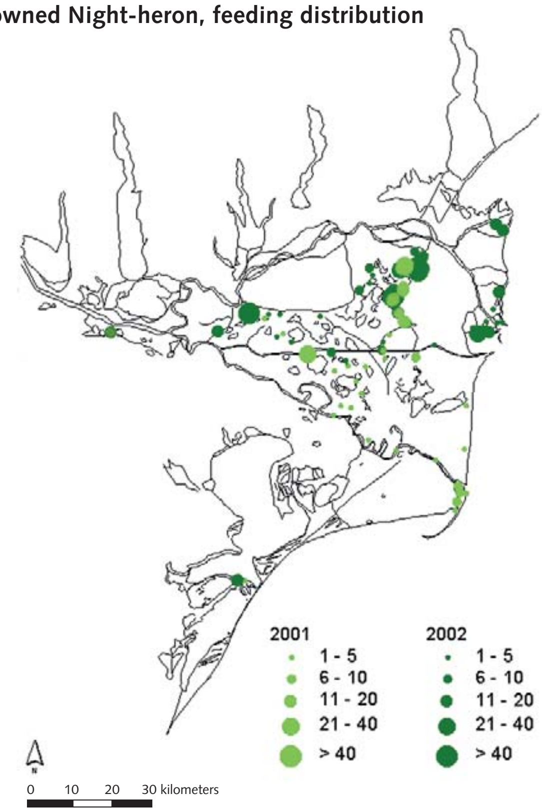
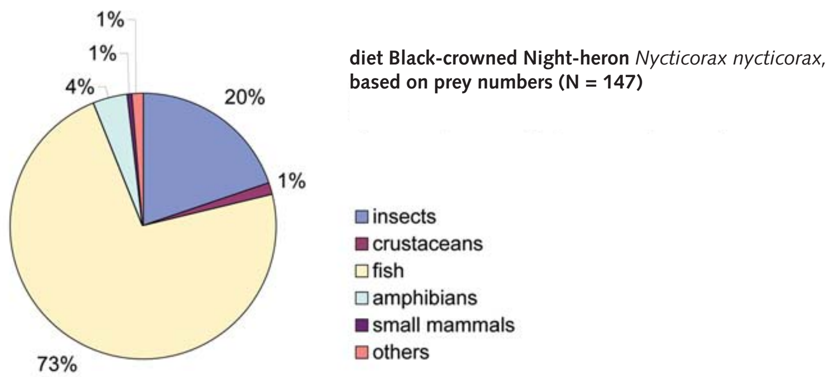


Fig. 8.49.
Diet composition of Black-crowned Night-heron *Nycticorax nycticorax* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



Food choice and diet

The analysis of 33 stomachs of Black-crowned Night-herons in the Danube delta by J.B. Kiss (unpubl.) provided a total of 147 prey items. The vast majority of these (73%) were fish remains (Fig. 8.49), mostly belonging to *Carassius carassius*. Insects were important as well (20% of prey items), while amphibians made up a mere 4%. As in the case of the Squacco Heron, field observations suggested that large individuals of *Rana ridibunda* were frequently taken by Black-crowned Night-herons, so in terms of mass this prey may prove to be more important than the mere numbers would indicate. Andone *et al.* (1969) found 31.7% of fish in 120 stomach contents. Fish species included *Rutilus rutilus, Perca fluviatilis, Carassius carassius, Alburnus alburnus, Abramis brama, Scardinius erythrophthalmus* and *Misgurnus fossilis*. Amphibians, fish and insects are generally mentioned in food studies of the Black-crowned Night-heron all over the world (Cramp & Simmons 1977, Del Hoyo *et al.* 1992).

An estimate, based on allometric relationships (Aschoff & Pohl 1970) and the mean body mass of 0.625 kg (Cramp & Simmons 1977, Del Hoyo *et al.* 1992), suggest a daily food intake by an individual Black-crowned Night-heron of about 178 g of fresh mass.

8.2.8 Eurasian Spoonbill *Platalea leucorodia*

General biogeography

The Eurasian Spoonbill *Platalea leucorodia* has a patchy breeding distribution throughout Eurasia and Africa from the temperate and steppe zones in the north to the dry tropics in the south (Del Hoyo *et al.* 1992, Hagemeijer & Blair 1997). The northernmost populations are fully migratory, wintering both in Northern and sub-Saharan Africa (W European birds mainly in Senegal; Poorter 1982) and E European birds also partly in SE Iran and India. As breeding habitats, the Eurasian Spoonbill uses deltas, river floodplains and extensive marshland areas. Here they nest in Reed beds on islands or in trees, always well protected against terrestrial predators. Feeding areas (up to 25 km away from breeding sites) consist of shallow water bodies, free of up-going vegetation and with high concentrations of aquatic prey (*e.g.* large crustaceans and/or small fish). Generally, the species tends to be more confined to coastal and marine habitats in winter and on migration than during the breeding season (Hagemeijer & Blair 1997).

The Eurasian Spoonbill is not globally threatened. Probably, its breeding distribution in the western Palearctic has always been rather discontinuous, but it has certainly been reduced as a consequence of increased human influence on wetland landscapes (Del Hoyo *et al.* 1992). It is esti-

Eurasian Spoonbill, 2001 **Eurasian Spoonbill, 2002**

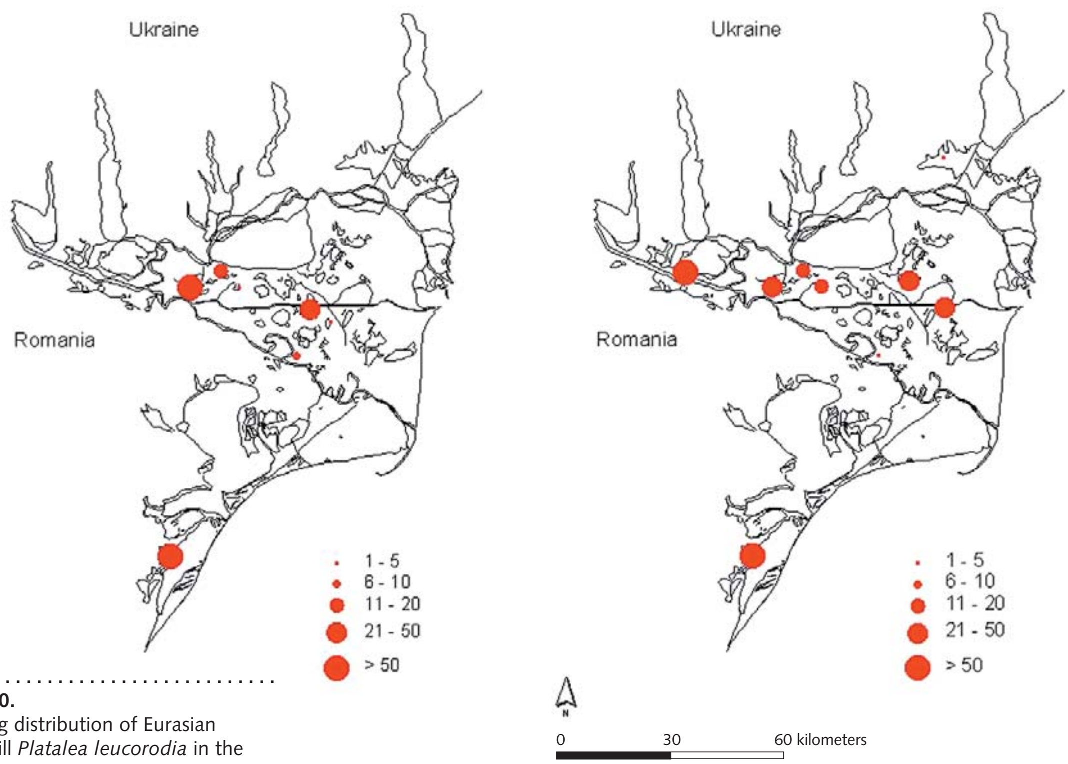


Fig. 8.50.
Breeding distribution of Eurasian Spoonbill *Platalea leucorodia* in the Danube Delta in 2001 and 2002.

mated that more than two thirds of the European breeding sites showed declines between 1970 and 1990 (Borodin 1984). In W and S Europe Eurasian Spoonbills breed in Spain and The Netherlands (1075 - 1200 pairs) and in one colony in France (20 pairs) (Hagemeijer & Blair 1997). These western European populations have been on the increase in recent years, after suffering severe declines over the first half of the 20th century. The species is more widespread in C and E Europe, although here numbers are also low (Balkans 1000 - 1360 pairs, Ukraine and Russia 2600 - 3600 pairs). The major colonies in C and E Europe are found in Russia, Ukraine and Hungary, holding over 67% of the E European population. Population estimates by Hagemeijer & Blair (1997) are 2800 pairs for Europe, 2500 pairs for Russia and 1200 pairs for Turkey. For the Black Sea region, Rose & Scott (1997) provide an estimate of 15,000 individuals.

Breeding distribution and numbers in Delta

Most settlements of breeding Eurasian Spoonbills in the Danube delta were found inside mixed-species colonies in stands of inundated trees in Reed beds. However, these colonies hardly exceeded a mere 50 pairs. Only one larger colony was found, consisting of 80 and 78 pairs in 2001 and 2002, respectively, on an open and isolated islet in the lagoon of Sinoe. Here they bred, together with Little Egrets, in nests among inundated Reed plants surrounded by a circular sand bank.

The Eurasian Spoonbill proved to be a relatively scarce breeding bird in the Danube delta, with only 218 breeding pairs in seven colonies in 2001 and 339 pairs in nine colonies in 2002. The mean colony sizes were of 31 and 38 pairs, respectively, while the largest sizes recorded were 80 pairs in 2001 and 100 pairs in 2002.

Colonies of Eurasian Spoonbill were only found in Romania, mostly along the central Sulina branch of the Danube (Fig. 8.50).

According to the sparse historical data on numbers of Eurasian Spoonbill, this species has always been a rather scarce breeding bird in the Romanian Danube Delta Biosphere Reserve. Only the colony in Obretinu Mic (nowadays still occupied by some 40 pairs) was regularly surveyed in the past and found to hold 10-20 pairs in the first half of the 1990s (Fig. 8.51).

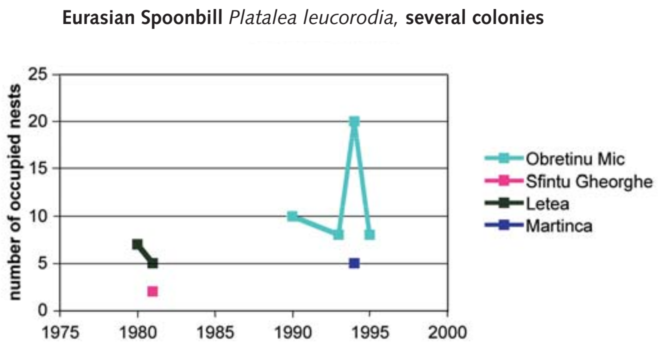
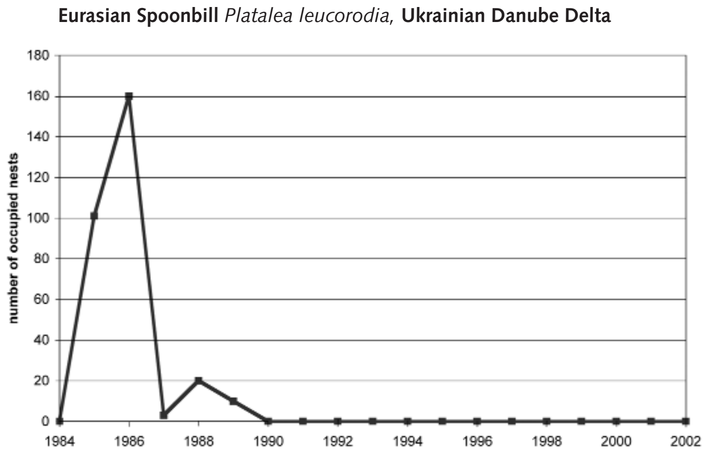


Fig. 8.51.
Numerical developments of some well-known colonies of Eurasian Spoonbill *Platalea leucorodia* in the Romanian Danube Delta in previous years.

In the Ukrainian secondary delta, the Eurasian Spoonbill bred annually between 1985 and 1990, reaching peak number of 100 to 160 pairs in 1985 and 1986 (Fig. 8.52). Then numbers sharply dropped until 1990, after which no more settlements have been recorded.

Fig. 8.52.
Numerical development of breeding Eurasian Spoonbills *Platalea leucorodia* in the Ukrainian Danube Delta in previous years.



Feeding distribution

Feeding Eurasian Spoonbills were only occasionally seen. In fact, the distribution as shown by Fig. 8.53 is hardly likely to be representative because of the very low numbers involved. Generally, spoonbills tend to feed in relatively open wetland areas, with shallow water and little helophyte vegetation. This kind of habitat is rather rare in the Danube Delta, which might explain the relative scarcity of the species.

Food choice and diet

Only one spoonbill stomach was analysed for food items by J.B. Kiss (unpubl.). Three out of four of the food items identified were fish remains and one was an amphibian (Fig. 8.54). Eurasian Spoonbills are well-known

Fig. 8.53.
Feeding distribution of Eurasian Spoonbill *Platalea leucorodia* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

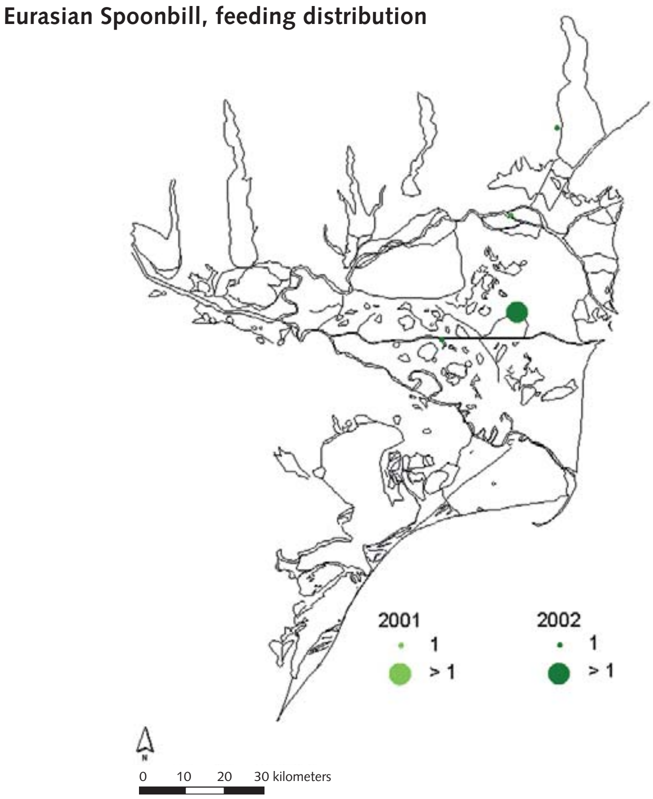
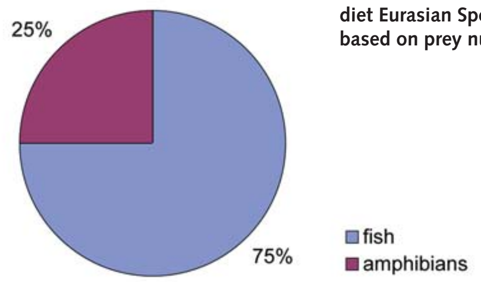


Fig. 8.54.
Diet composition of Eurasian Spoonbill *Platalea leucorodia* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



fish-eaters (*e.g.* Cramp & Simmons 1977, Del Hoyo *et al.* 1992, Voslamber 1994), but are also reported frequently to consume crustaceans and other aquatic invertebrates.

An indication of the daily food intake of the Eurasian Spoonbill, as obtained by allometric relationships (Aschoff & Pohl 1970) and the assumption of a mean body mass of 1.5 kg (Cramp & Simmons 1977, Del Hoyo *et al.* 1992), points to the consumption of about 331 g of fresh fish per day.

8.2.9 Glossy Ibis *Plegadis falcinellus*

General biogeography
The Glossy Ibis *Plegadis falcinellus* has a vast but discontinuous breeding range over the E USA, the Caribbean, the Balkans, the Black and Caspian Sea region, Africa, C Asia, India and Australasia (Del Hoyo *et al.* 1992, Hagemeijer & Blair 1997). Apart from suffering considerable numerical declines during the 20th century (particularly since 1965), the range of this species has also markedly been reduced, especially in W and C Europe. The breeding birds of the Black Sea and the Balkans are migratory, wintering mostly in sub-Saharan Africa (Del Hoyo *et al.* 1992). It is a typical inhabitant of extensive wetlands with deep water and abundant vegetation, occasionally also found breeding in riverine forests. Nests are usually made in willow stands, but may also be found in mono-specific Reed beds. Feeding occurs mainly in shallow waters, marshes and swamps that are rich in invertebrates, wet pastures and flooded meadows, sometimes remarkably far from breeding colonies. The species is often found in mixed-species colonies (Hagemeijer & Blair 1997).

Nowadays, about 99% of the European breeding population of the Glossy Ibis is found to the west and north of the Black Sea and around the Caspian Sea. Population estimates per country are: 6200 pairs for Ukraine, 1000 - 2000 pairs for Romania, 6500 - 8000 pairs for Russia and 100 - 700 pairs for Bulgaria (Hagemeijer & Blair 1997). For the Danube Delta, 1200 pairs were estimated to breed in 1976/77. This figure had increased to 2000 pairs by 1995. Total estimates provided by Hagemeijer & Blair (1997) are: 8100 pairs for Europe, 7200 pairs for Russia and 800 pairs for Turkey. Rose & Scott (1997) estimate the Black Sea population at 40,000 individuals. Recently, some tentative recolonisation of former breeding sites in SW Europe has been taking place, with small (up to 5 - 10 pairs) settlement in both the Camargue (France) and the Ebro delta (Spain) (pers. comm. C. Perennou, A. Espanya).

Breeding distribution and numbers in Delta
The Glossy Ibis typically breeds in closely packed sub-colonies in low trees (mostly *Salix cinerea*) inside mixed-species colonies in inundated stands of

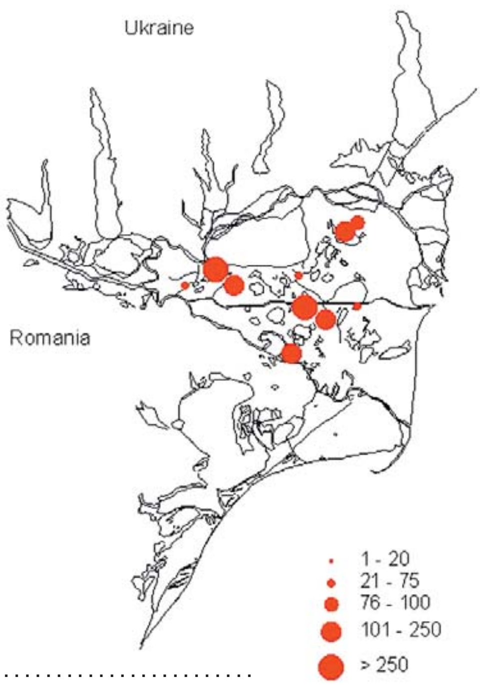
trees. Their relatively small nests are very close together and quite often rather under in the trees. Colonies tend to be rather large, hardly ever under 100 pairs.

In 2001 a total of ten Glossy Ibis colonies was located in the Danube delta, holding 2055 breeding pairs. Mean colony size was 206 and the largest colony consisted of 500 pairs. In 2002 twelve colonies were found with 3340 pairs. This year the mean colony size was of 278 pairs, while the largest colony held 650 occupied nests.

The Glossy Ibis colonies were very close together, all of them in the central, lake-rich part of the Danube delta and quite close to the central Sulina river branch (Fig. 8.55). No other colonial species had such a tightly packed distribution with such short 'nearest-neighbour' distances (*cf.* Fig. 4.16).

Large colonies of Glossy Ibis have been known in the Romanian Danube Delta Biosphere Reserve for many years. In 1980 at least two colonies were known to hold more than 1000 breeding pairs (Mila 23 and Murighiol), but generally colony numbers fluctuated between 200 and 800 (Fig. 8.56). No clear trend emerges from the historical data, but total numbers seem to have declined towards the end of the 20th century. In the Ukrainian secondary delta, the Glossy Ibis has never been a regular or abundant breeding bird. Ever since 1984, no more than 10 breeding pairs have been recorded in a single year and in many years the species has been absent as a breeding bird (Fig. 8.57). In fact, breeding has not been recorded in this part of the Ukrainian Danube delta since 1991. Also in 2002, the only Ukrainian breeding colonies of Glossy Ibis (160 and 320 pairs, respectively) were found in the Reed beds along the fringes of lake Kugurluy.

Glossy Ibis, 2001



Glossy Ibis, 2002

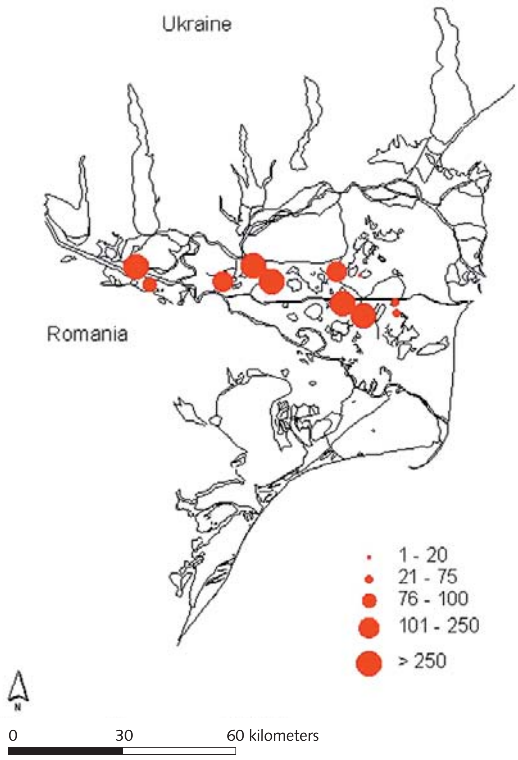


Fig. 8.55.
Breeding distribution of Glossy Ibis *Plegadis falcinellus* in the Danube Delta in 2001 and 2002.

Fig. 8.56.
Numerical developments of some well-known colonies of Glossy Ibis *Plegadis falcinellus* in the Romanian Danube Delta in previous years.

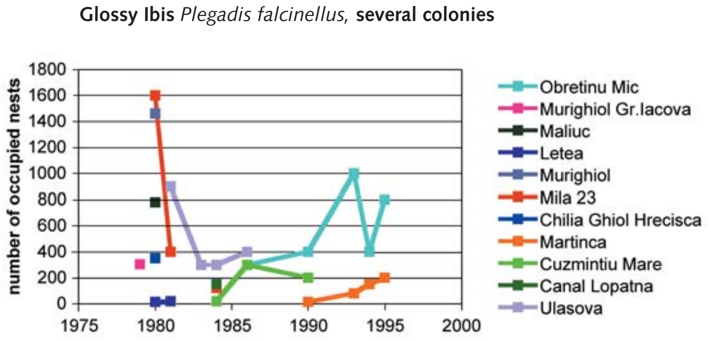


Fig. 8.57.
Numerical development of breeding Glossy Ibises *Plegadis falcinellus* in the Ukrainian Danube Delta in previous years.

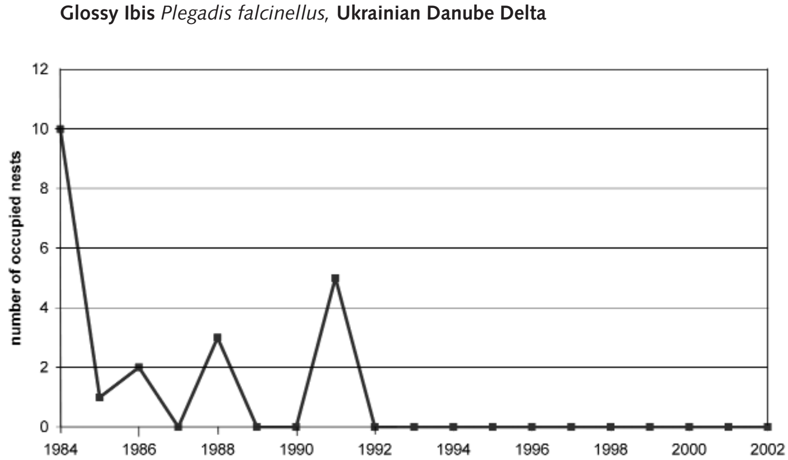
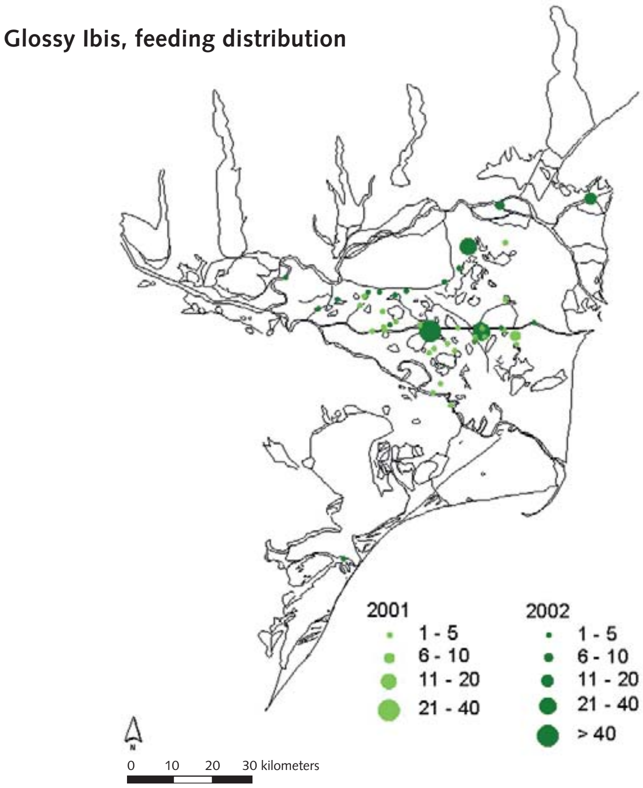


Fig. 8.58.
Feeding distribution of Glossy Ibis *Plegadis falcinellus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.



Feeding distribution
The feeding distribution of the Glossy Ibis in the Danube Delta proved to be rather limited. Almost all of the records came from the central part of the delta (Fig. 8.58), close to the most important breeding colonies. One concentration was found in the Ukrainian 'secondary' delta and another on the island Yermakov in the Chilia branch. Both along the Black Sea coast and in the southern Razim-Sinoe area, the Glossy Ibis was almost absent.

Food choice and diet
Of all colonial pelecaniform and ciconiiform birds of the Danube Delta, the Glossy Ibis is probably the only one of which the diet does not mainly consist of fish. The food analyses carried out by Kiss *et al*. (1978) and J.B. Kiss (unpubl.) on 33 bird stomachs revealed a total of 435 identifiable prey items, of which only a mere 2% was attributable to fish (Fig. 8.59). The vast majority of prey items consisted of insects (65%) and plants (20%). Molluscs (6%), amphibians (4%) and 'other' prey items (3%) made up the rest. Cramp & Simmons (1977) mention as food sources for this species: insects and their larvae, such as Diptera, Coleoptera (particularly waterbeetles like *Hydrophilus*), dragonflies Odonata and caddisflies Trichoptera, besides leeches Hirudinea, molluscs (*e.g. Planorbis* and *Ampullaria*), worms, crustaceans and possibly small amphibians, reptiles and fish. Feeding generally takes place in small flocks in or near wetland habitats (Cramp & Simmons 1977), particularly in wet grassland systems.

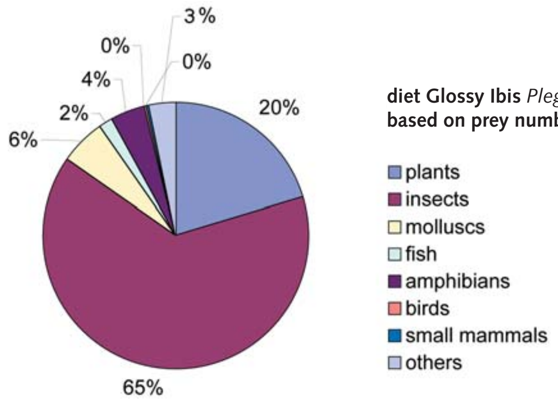


Fig. 8.59.
Diet composition of Glossy Ibis *Plegadis falcinellus* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).

8.3 Waders, gulls and terns Charadriiformes

The breeding colonies of colonially breeding waders, gulls and terns (Charadriiformes) in the Danube Delta were also localised and assessed, but have received less focus than the Pelecaniformes and the Ciconiiformes. Therefore, the specific treatments of these species will be much less extensive, only offering, without further comments, the basic information on distribution (in maps) and breeding numbers (Table 8.1) and on feeding distribution (maps) in both years and, when available some data on local food choice (in Figures).

8.3.1 Pied Avocet *Recurvirostra avosetta*

Breeding distribution in Delta

Pied Avocet, 2001 **Pied Avocet, 2002**

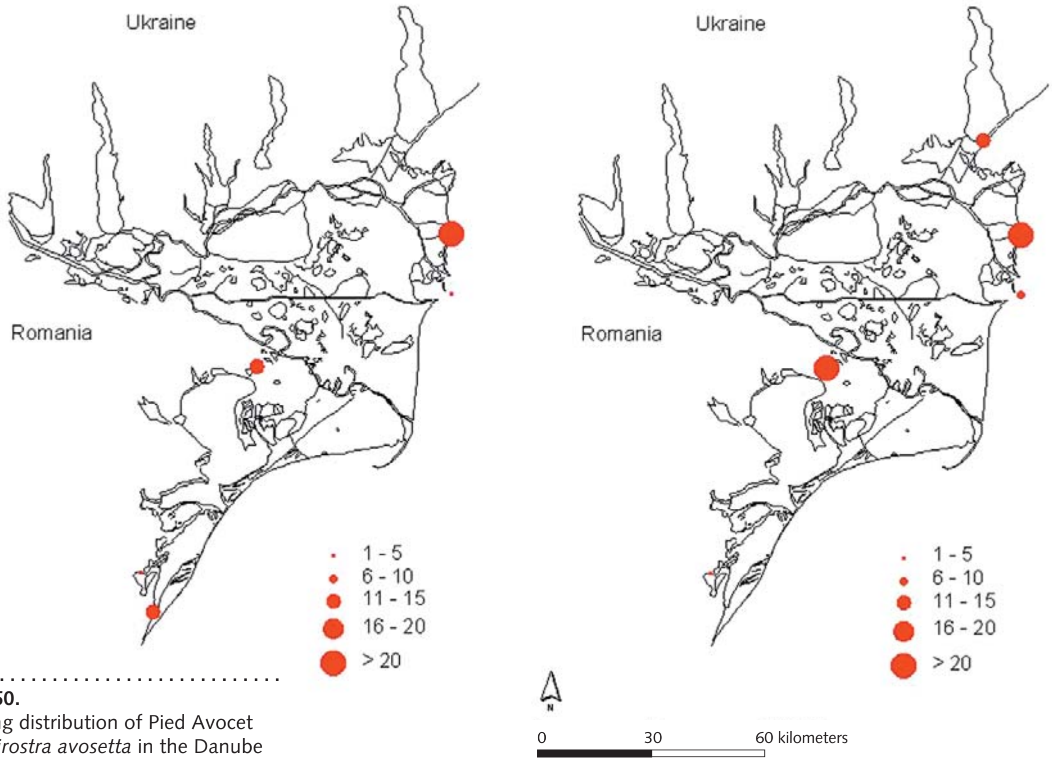
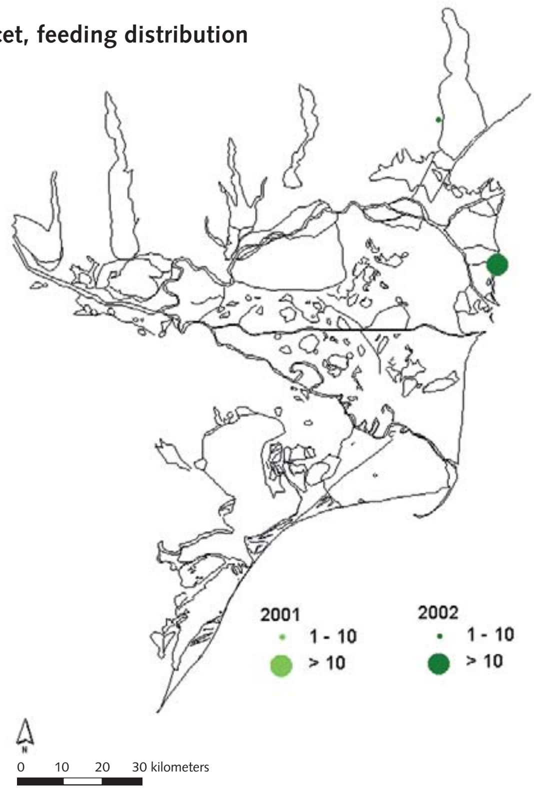


Fig. 8.60.
Breeding distribution of Pied Avocet *Recurvirostra avosetta* in the Danube Delta in 2001 and 2002.

Feeding distribution

Fig. 8.61.
Feeding distribution of Pied Avocet *Recurvirostra avosetta* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

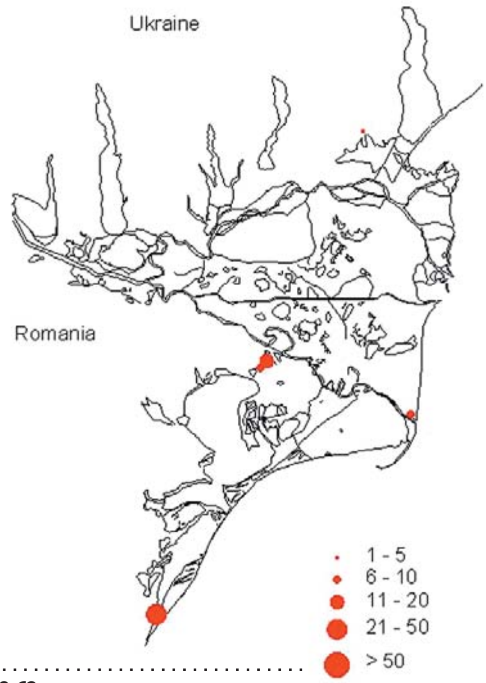
Pied Avocet, feeding distribution



8.3.2 Black-winged Stilt *Himantopus himantopus*

Breeding distribution in Delta

Black-winged Stilt, 2001



Black-winged Stilt, 2002

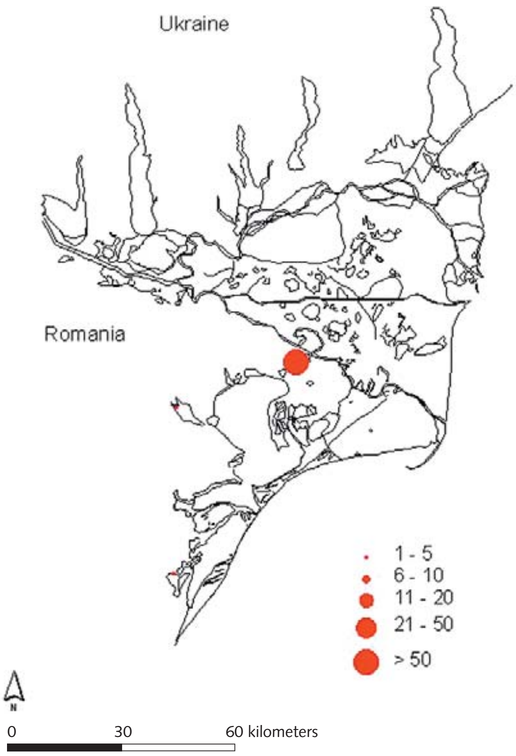
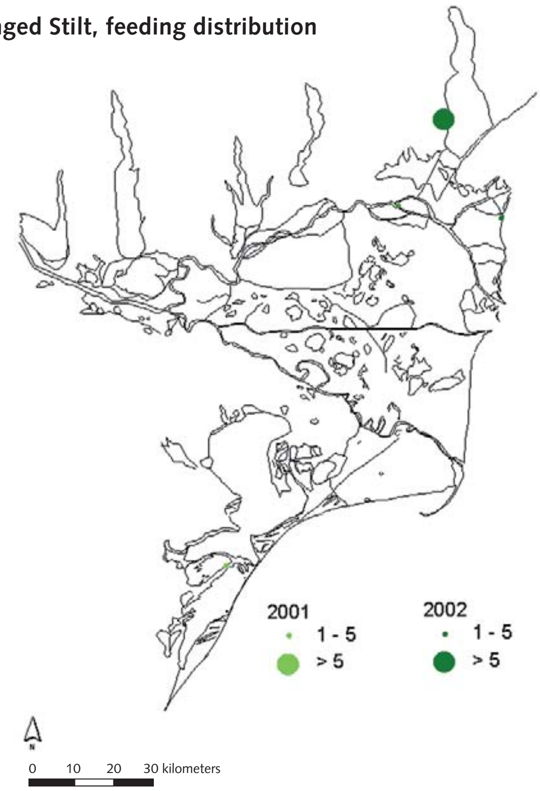


Fig. 8.62.
Breeding distribution of Black-winged Stilt *Himantopus himantopus* in the Danube Delta in 2001 and 2002.

Feeding distribution

Fig. 8.63.
Feeding distribution of Black-winged Stilt *Himantopus himantopus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

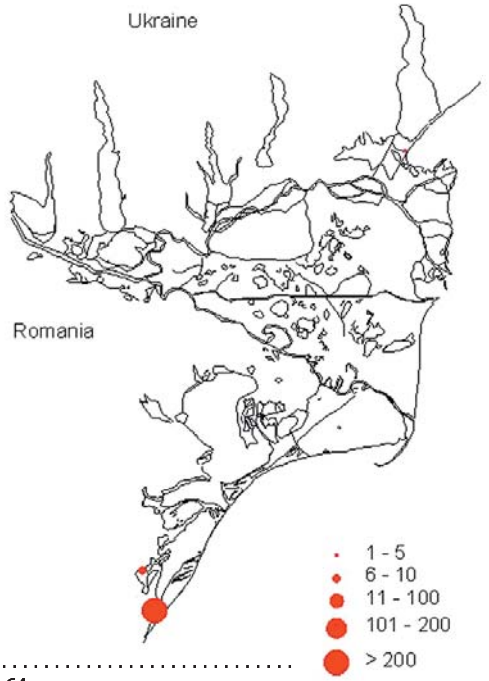
Black-winged Stilt, feeding distribution



8.3.3 Collared Pratincole *Glareola pratincola*

Breeding distribution in Delta

Collared Pratincole, 2001



Collared Pratincole, 2002

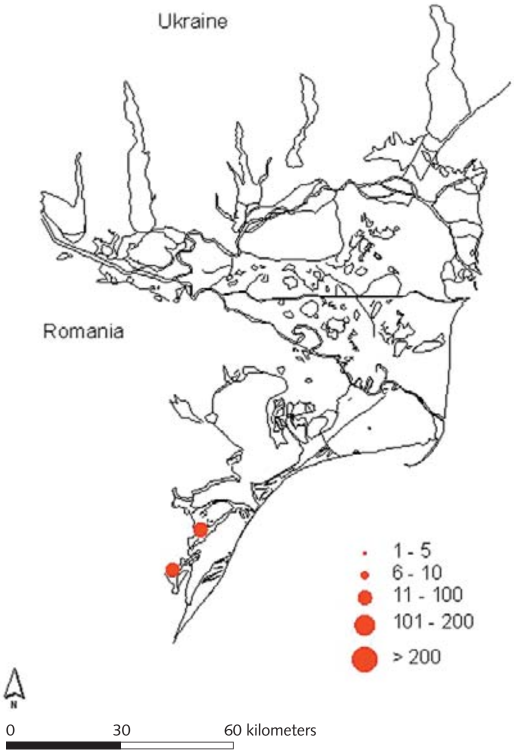
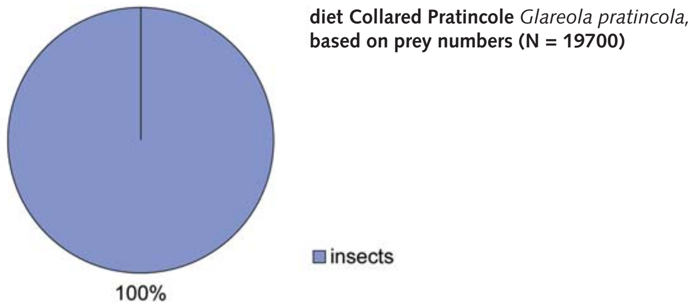


Fig. 8.64.
Breeding distribution of Collared Pratincole *Glareola pratincola* in the Danube Delta in 2001 and 2002.

Food choice and diet

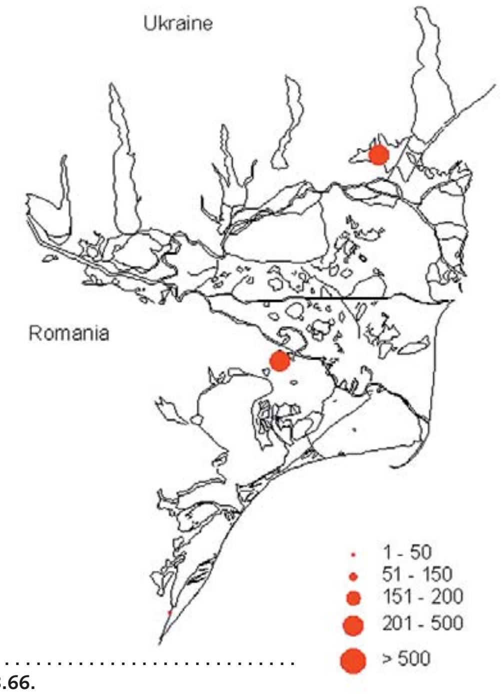
Fig. 8.65.
Diet composition of Collared Pratincole *Glareola pratincola* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



8.3.4 Black-headed Gull *Larus ridibundus*

Breeding distribution in Delta

Black-headed Gull, 2001



Black-headed Gull, 2002

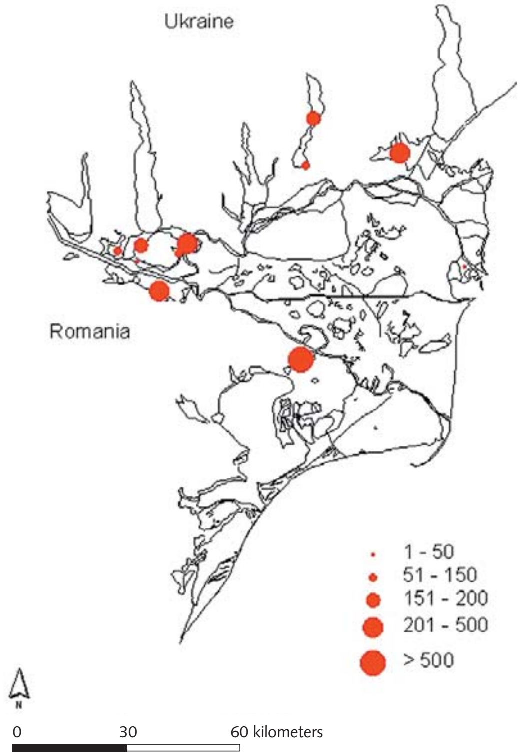
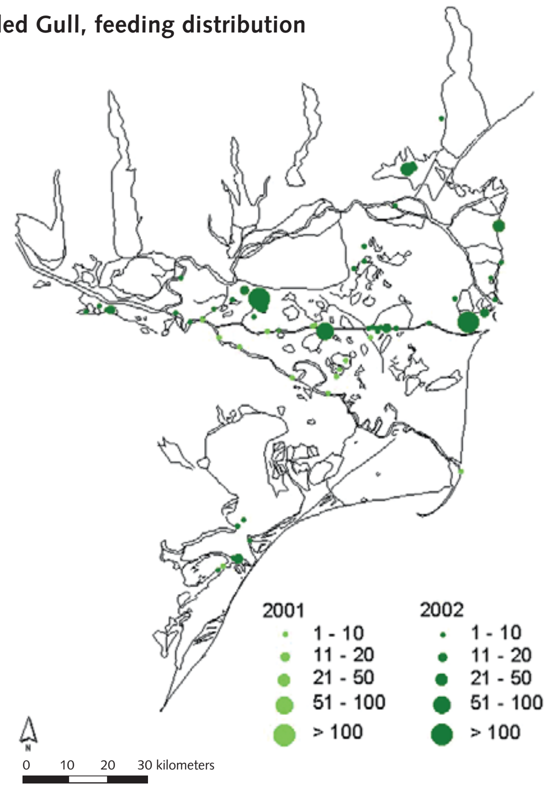


Fig. 8.66.
Breeding distribution of Black-headed Gull *Larus ridibundus* in the Danube Delta in 2001 and 2002.

Feeding distribution

Fig. 8.67.
Feeding distribution of Black-headed Gull *Larus ridibundus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

Black-headed Gull, feeding distribution



Food choice and diet

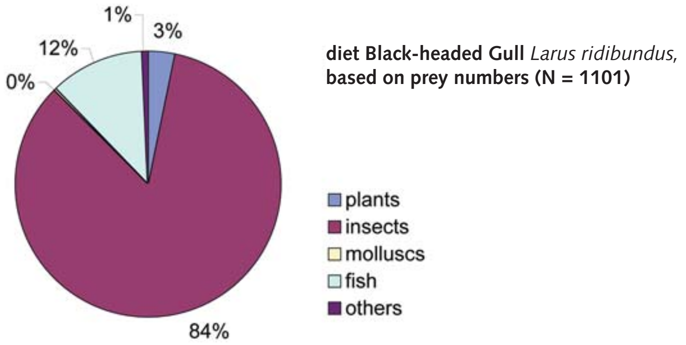


Fig. 8.68.
Diet composition of Black-headed Gull *Larus ridibundus* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).

8.3.5 Mediterranean Gull *Larus melanocephalus*

Breeding distribution in Delta

Mediterranean Gull, 2001-2002

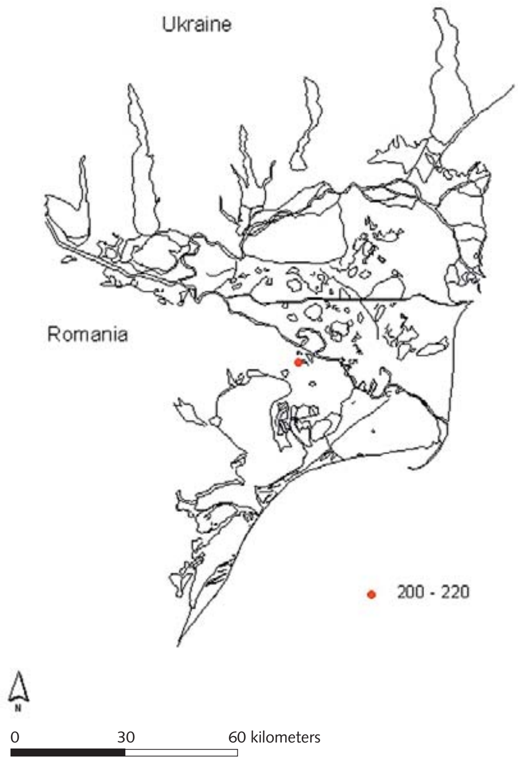
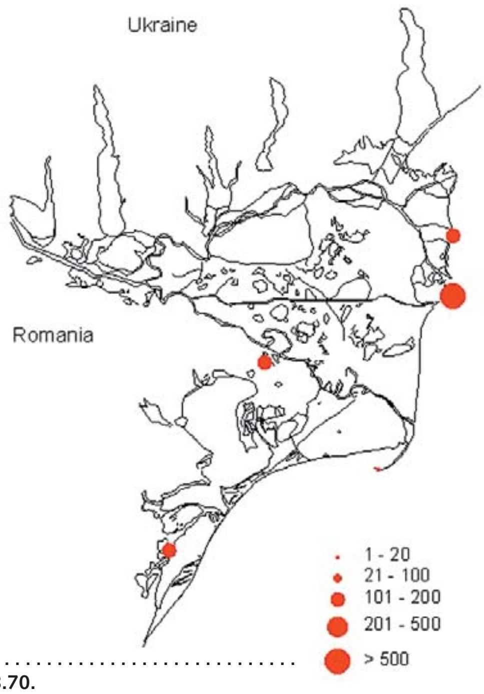


Fig. 8.69.
Breeding distribution of Mediterranean Gull *Larus melanocephalus* in the Danube Delta in 2001 and 2002.

8.3.6 Pontic Gull *Larus cachinnans*

Breeding distribution in Delta

Pontic Gull, 2001



Pontic Gull, 2002

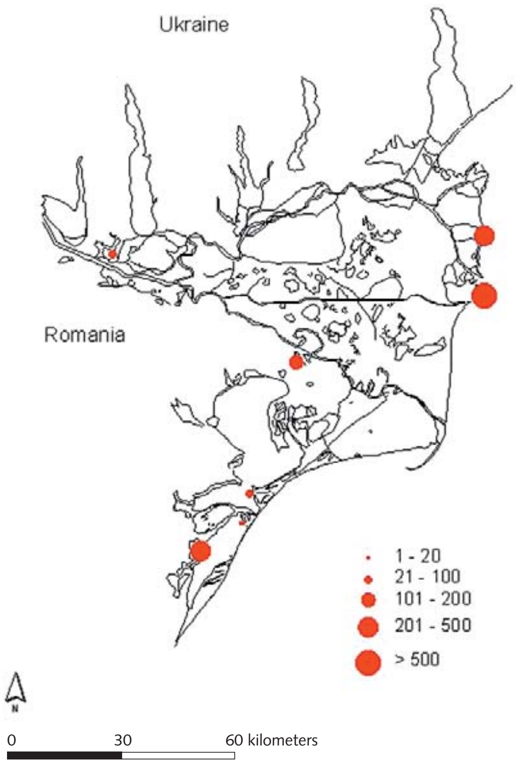


Fig. 8.70.
Breeding distribution of Pontic Gull *Larus cachinnans* in the Danube Delta in 2001 and 2002.

Feeding distribution

Pontic Gull, feeding distribution

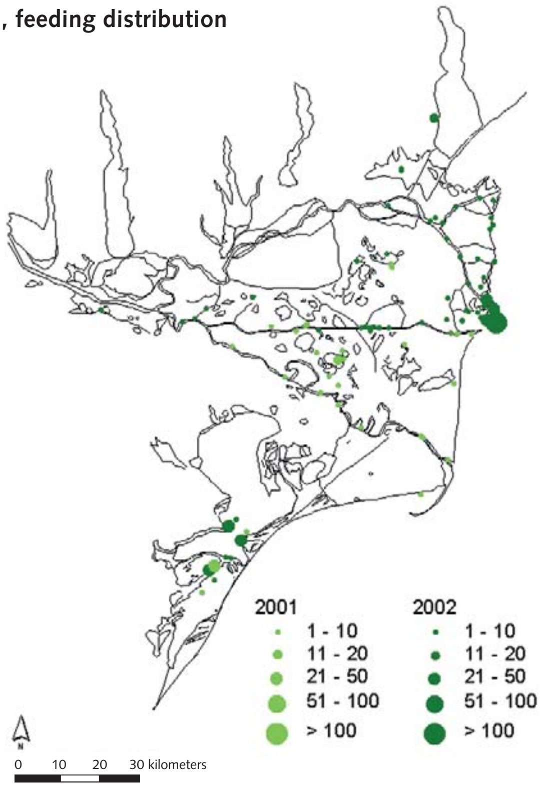
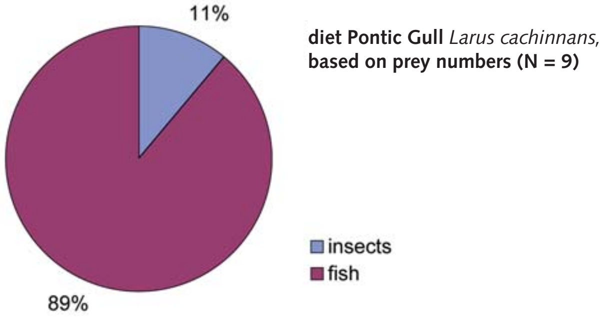


Fig. 8.71.
Feeding distribution of Pontic Gull *Larus cachinnans* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

Food choice and diet

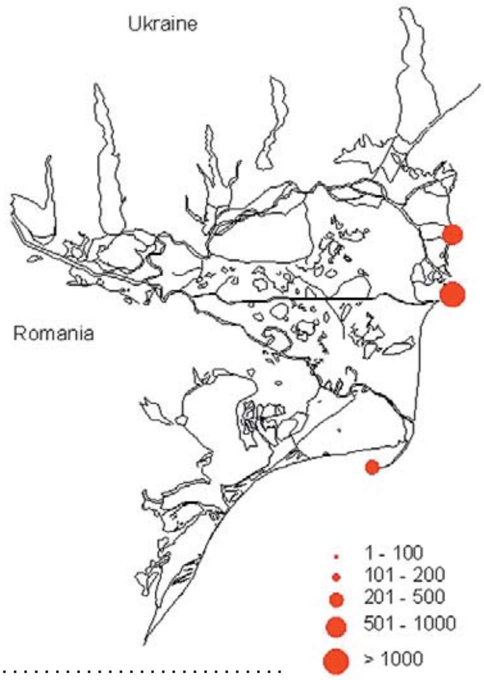
Fig. 8.72.
Diet composition of Pontic Gull *Larus cachinnans* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



8.3.7 Sandwich Tern *Sterna sandvicensis*

Breeding distribution in Delta

Sandwich Tern, 2001



Sandwich Tern, 2002

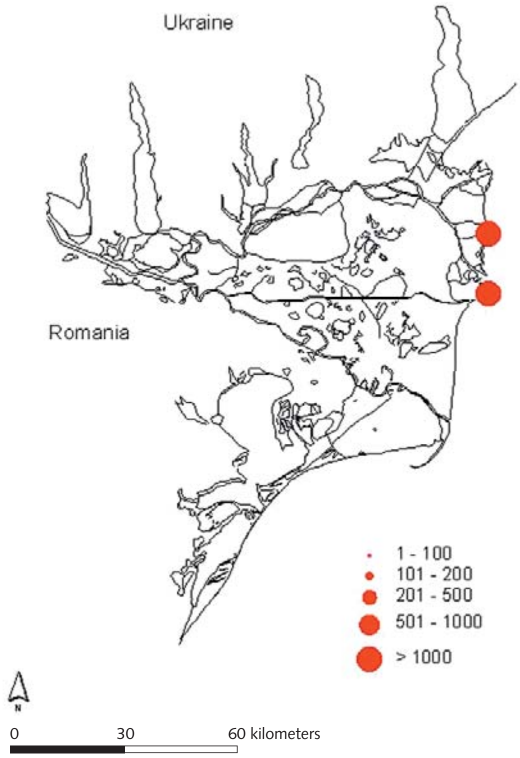


Fig. 8.73.
Breeding distribution of Sandwich Tern *Sterna sandvicensis* in the Danube Delta in 2001 and 2002.

Feeding distribution

Sandwich Tern, feeding distribution

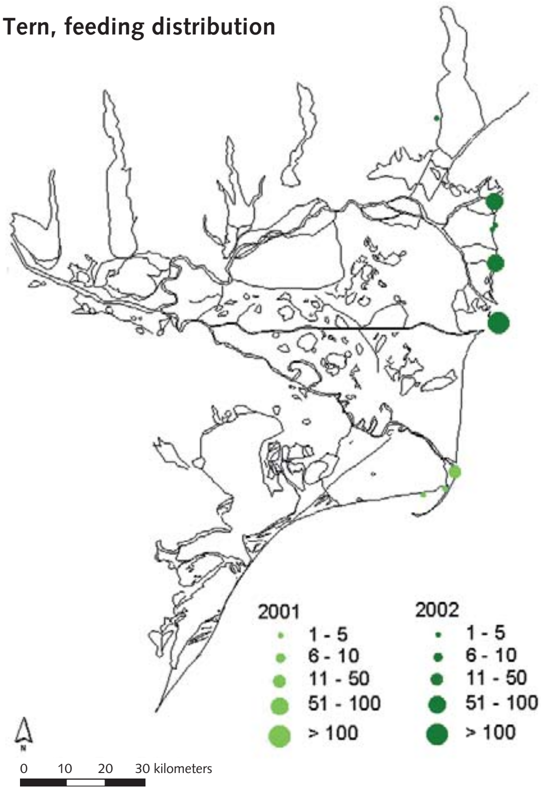
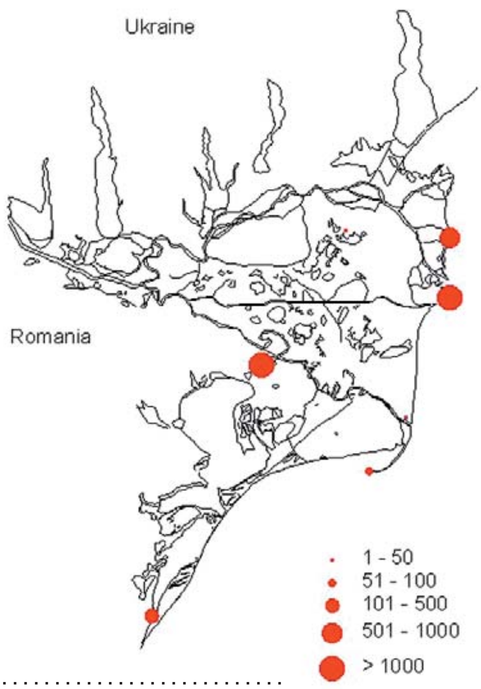


Fig. 8.74.
Feeding distribution of Sandwich Tern *Sterna sandvicensis* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

8.3.8 Common Tern *Sterna hirundo*

Breeding distribution in Delta

Common Tern, 2001



Common Tern, 2002

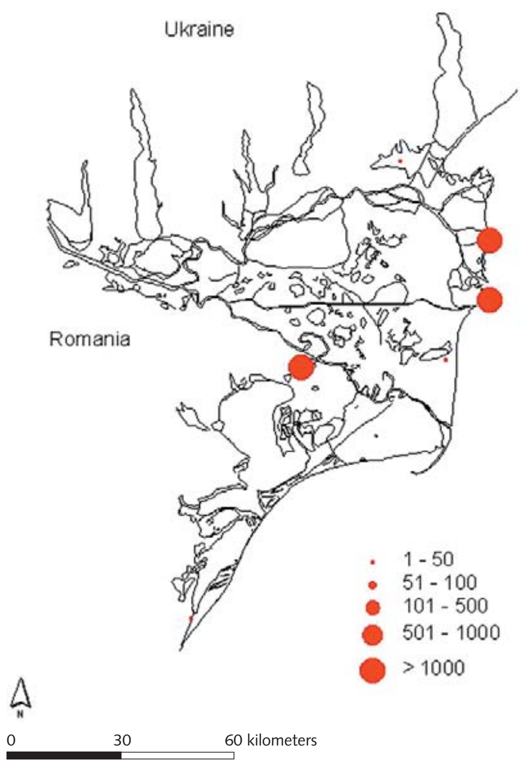
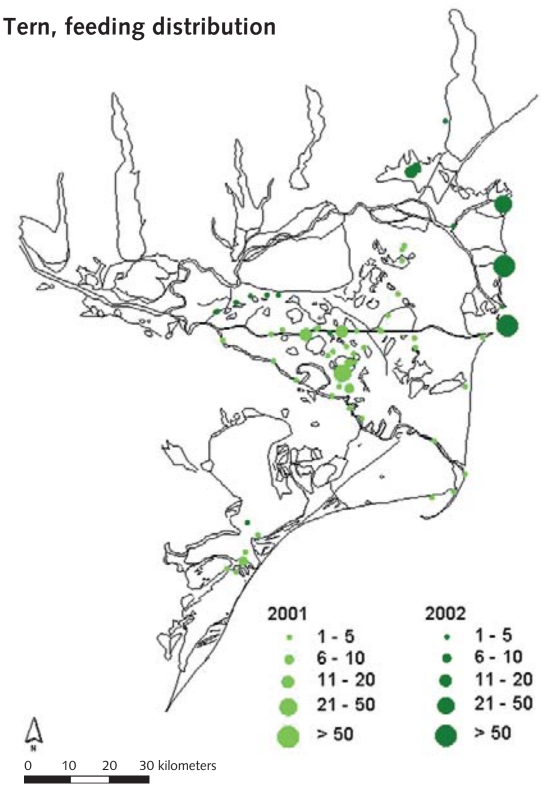


Fig. 8.75.
Breeding distribution of Common Tern *Sterna hirundo* in the Danube Delta in 2001 and 2002.

Feeding distribution

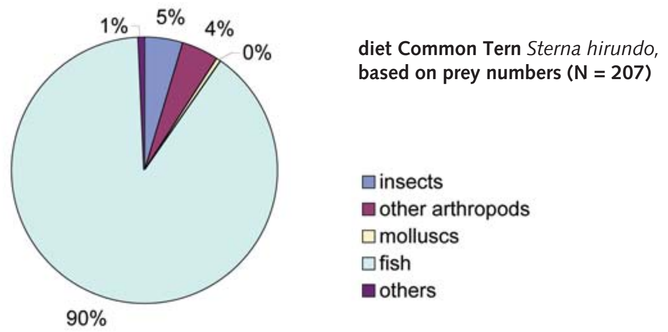
Fig. 8.76.
Feeding distribution of Common Tern *Sterna hirundo* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

Common Tern, feeding distribution



Food choice and diet

Fig. 8.77.
Diet composition of Common Tern *Sterna hirundo* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



8.3.9 Little Tern *Sterna albifrons*

Breeding distribution in Delta

Little Tern, 2001 **Little Tern, 2002**

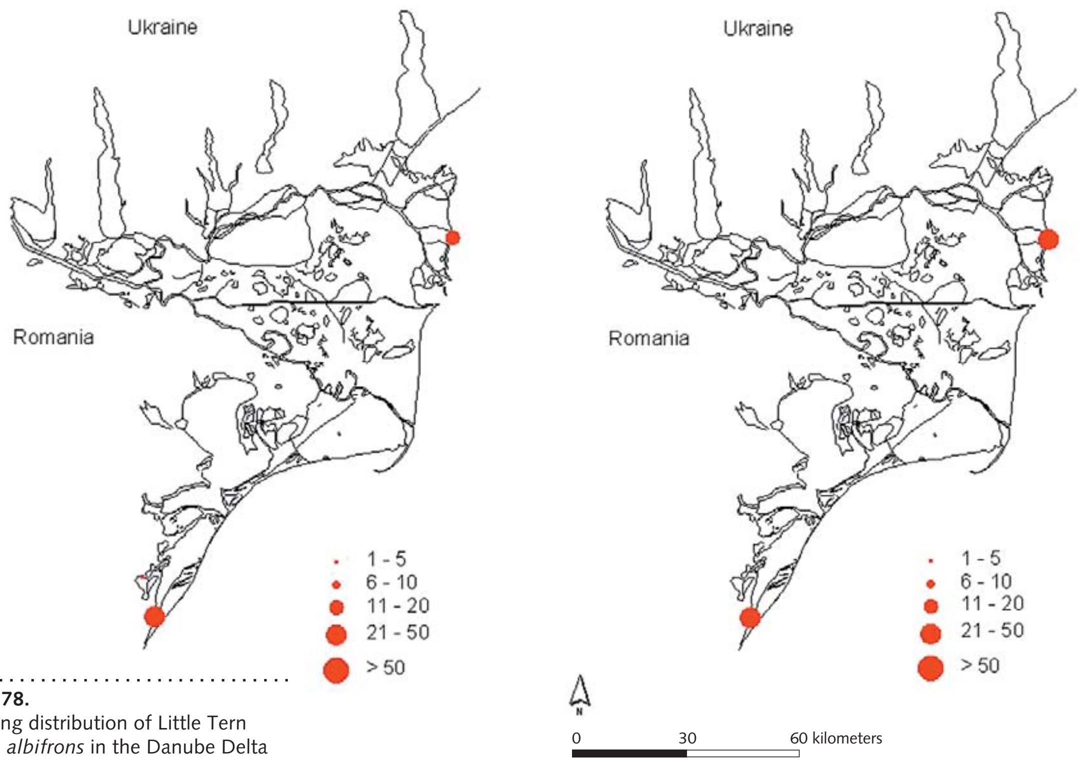
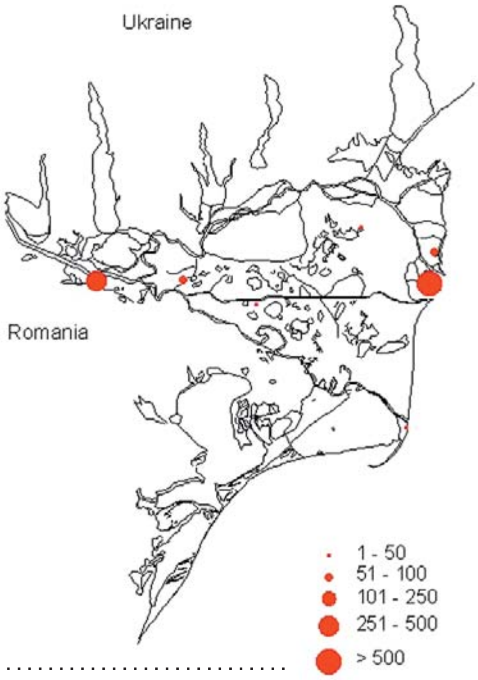


Fig. 8.78.
Breeding distribution of Little Tern *Sterna albifrons* in the Danube Delta in 2001 and 2002.

8.3.10 Whiskered Tern *Chlidonias hybridus*

Breeding distribution in Delta

Whiskered Tern, 2001



Whiskered Tern, 2002

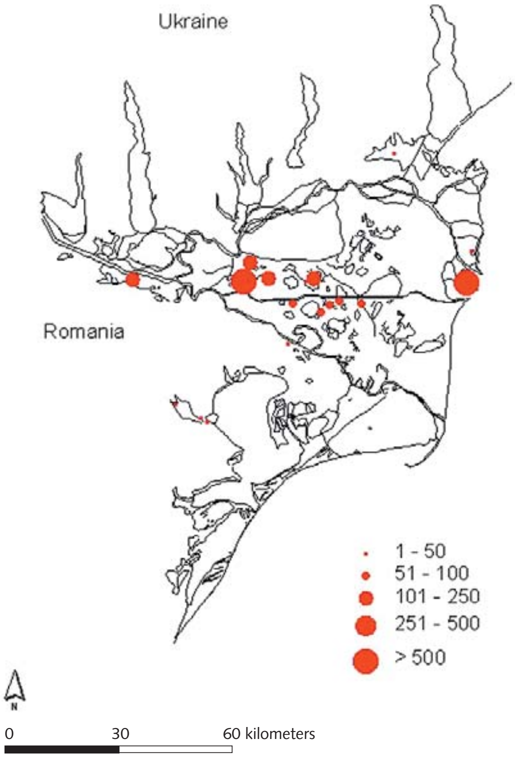


Fig. 8.79.
Breeding distribution of Whiskered Tern *Chlidonias hybridus* in the Danube Delta in 2001 and 2002.

Feeding distribution

Whiskered Tern, feeding distribution

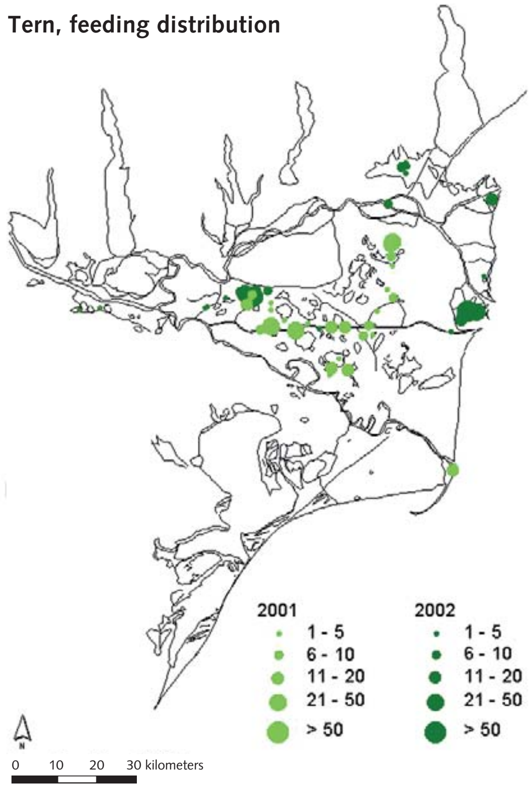
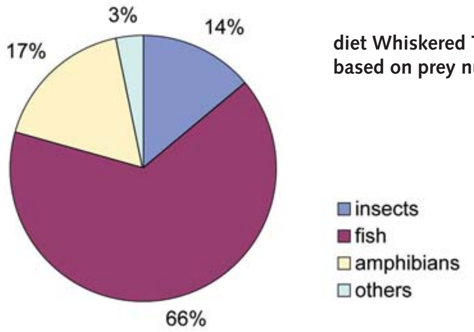


Fig. 8.80.
Feeding distribution of Whiskered Tern *Chlidonias hybridus* in the Danube Delta in 2001 and 2002. Figures expressed represent numbers per km of distance covered during ground surveys.

Food choice and diet

Fig. 8.81.
Diet composition of Whiskered Tern *Chlidonias hybridus* in the Danube Delta, based on stomach analyses by J.B. Kiss (unpubl.).



8.3.11 Rare or former breeding species

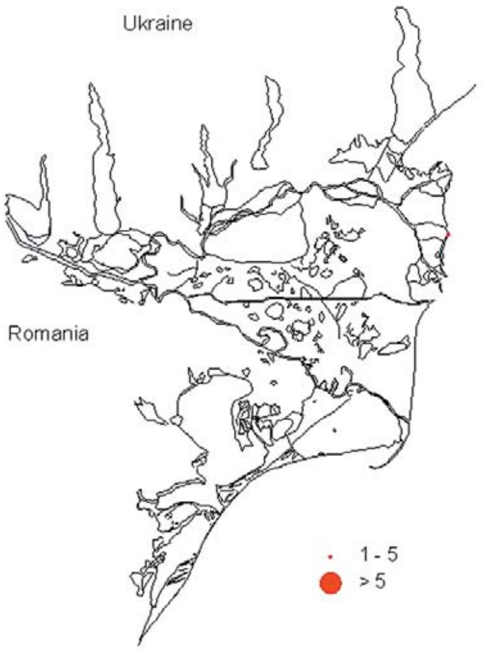
Three more species of colonial Charadriiformes have been found breeding in small numbers during the field surveys of 2001 and 2002, while two others have bred in the recent past. The present status of these five species will be briefly discussed.

Very surprising was the appearance in the spring of 2000 of an influx of White-tailed Lapwings *Vanellus leucurus* along the Black Sea coast of the Danube Delta. This species is generally considered a rare vagrant in Europe and breeding attempts have never before been reported west of the Crimea peninsula (Kiss & Szabó 2000b). Hagemeijer & Blair (1997) mention the occurrence of the White-tailed Lapwing as a rare and occasional breeding bird at the northern Caspian Sea coast, in Armenia and in Azerbaijan. The normal distribution of this species is found in Turkmenistan and Uzbekistan, with some western outposts in Iraq and Iran (Hagemeijer & Blair 1997). While up to a maximum of 61 different individuals were recorded at several sites along the coast from Sulina in the north to Vadu in the south, at the latter site the birds even settled to breed in a Black-winged Stilt colony, where no less than 12 pairs were estimated to be present (Kiss & Szabó 2000a, b, c). In the following year, the first year of our survey, still seven pairs of the species attempted to breed, but by 2002 only one observation of a single bird was made (21 April, one individual calling at Vadu).

The Slender-billed Gull *Larus genei* used to breed in coastal colonies in the lagoon areas of the Danube Delta until at least halfway the 20th century, but has disappeared as a breeding bird in spite of a spectacular overall increase of the population in neighbouring Ukraine (Hagemeijer & Blair 1997). This disappearance is likely to be due to the scarcity of both dynamic and safe coastal breeding sites since the embankments of the southern lagoon systems of Razim and Sinoe. During the entire period of field surveys in 2001 and 2002 only one immature bird was seen, surprisingly well inland on lake Isacov (11 June 2001).

Another typical colonial breeding bird of bare ground or pioneer vegetation, the Gull-billed Tern *Gelochelidon nilotica* has also become a very scarce breeding bird in the Danube Delta. In Romania it has severely declined throughout the 20th century (Hagemeijer & Blair 1997) and we have been unable to find any signs of nesting in any of the two seasons. One observation of a single adult bird on 7 June 2001 at the gull and tern colony of Murighiol might be indicative of the possibility for breeding here, but no further proof was obtained. On the Ukrainian side of the delta, however, the species was found breeding in both years: 5 pairs in 2001 (one colony) and 10 pairs in 2002 (two colonies). Both colony sites were located on the strips of 'new' land, formed by recent sedimentations along the coast of the secondary delta (Fig. 8.82). These areas are characterised by the absence or scarcity of vegetation and their isolation from the mainland and thus offer both the required "openness" and the protection against terrestrial predators.

Gull-billed Tern, 2001



Gull-billed Tern, 2002

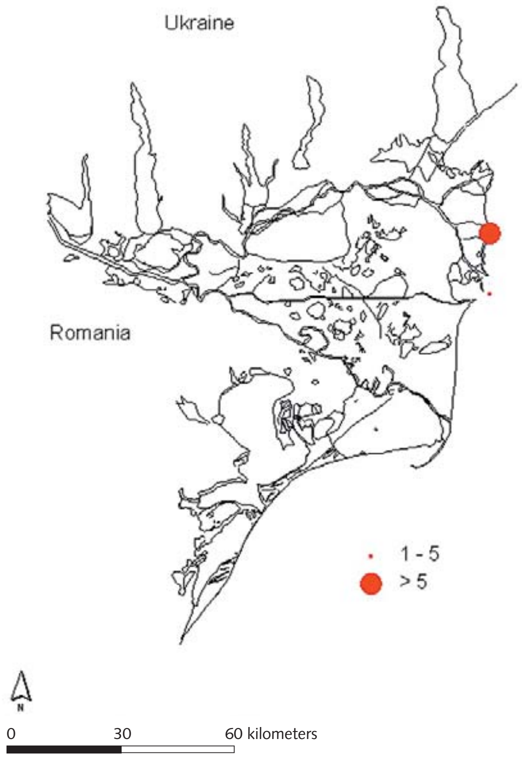


Fig. 8.82.
Breeding distribution of Gull-billed Tern *Gelochelidon nilotica* in the Danube Delta in 2001 and 2002.

Besides the abundant Whiskered Tern, the Danube Delta is also traditionally known as a breeding haunt for the other two species of *Chlidonias* marsh terns (*e.g.* Hagemeijer & Blair 1997). Black Terns *Chlidonias niger* were regularly seen in small or medium-sized flocks in both years, but the vast majority of records undoubtedly referred to migrants on their way further north. Indications for breeding were obtained only at two sites: in Sulimanca canal in 2001 (3 pairs) and in Stentsovsko Zhebriansky Plavni in 2002 (10 pairs). Up to 30 pairs regularly breed in the shoreline vegetation of lake Kugurluy in Ukraine (M.Ye. Zhmud, pers. obs.). It is likely that this species was actually more common, since it is easy to miss. The White-winged Tern *Chlidonias leucopterus* reaches in the Danube Delta its southern and western limits as a breeding bird. Although reported as a regular breeding bird in Romania (Munteanu *et al.* 1994, Hagemeijer & Blair 1997), we have not found any indication of breeding here in either of the two seasons, nor have any other recent reports (J.B. Kiss, pers. obs.). On the Ukrainian side, the bird is, however, still an annual breeding bird in the shoreline areas of the larger lakes (M. Ye. Zhmud, pers. obs.). Though we did not localise any breeding colony here either, it seems reasonable to assume that the species has bred in both years. Hagemeijer & Blair (1997) reported that the southern and western populations of White-winged Tern have been suffering serious decreases in recent years. Observations of this species during the field surveys were extremely few in 2001 (only one single individual at Vadu on 20 May 2001), but remarkably numerous in spring 2002. Large flocks were seen, together with Black and Whiskered Terns, on lake Musura on 24 April 2002 (300 individuals) and on the Chilia branch between Izmail and Tulcea on 9 May 2002 (282 individuals). Several smaller flocks of up to some 15 birds were seen regularly. All these birds were assumed to be migrants.

Appendix

Appendix 1 Name, country and geographical co-ordinates of all colony sites

Name	Country	X-coord	Y-coord
Babadag SE-1	Romania	643606.66000	4975066.53000
Babadag SE-2	Romania	643566.54000	4975347.39000
Babadag West	Romania	636908.70000	4978872.28000
Babintii Mari	Romania	677233.28000	5005313.36000
Bogdaproste	Romania	684307.10000	5013546.36000
Bondar	Romania	693633.67336	5006462.02338
Buhaiova	Romania	689842.56651	5026835.41266
Buhaiova Hrecisca	Romania	690460.69155	5025946.65047
Canal Letienilor	Romania	689324.29787	5019946.48210
Canal Magistral Chilia, p	Romania	685325.99000	5029497.20000
Climova	Romania	676337.47852	4994122.60499
Crasnicol Belciug	Romania	687307.94666	4977939.75475
Crisan canal	Romania	685391.67000	5005375.43000
Cuzmintiu Mare	Romania	668165.90924	5005414.85206
Cuzmintiu Mare 2	Romania	667640.27129	5005409.01712
Dranov-Dunavat 1	Romania	678559.76000	4975467.56000
Enisala Centre	Romania	643880.69000	4974986.25000
Enisala East	Romania	645366.52000	4974529.07000
Enisala West	Romania	642337.71000	4974529.07000
Eraclea	Romania	678300.43167	5014522.22786
Grindul Saele	Romania	636237.12000	4935523.41000
Hrecisca	Romania	691574.96745	5026302.45559
Insula Bisericuta	Romania	656083.23000	4956549.83000
Istria Sinoe North	Romania	643495.37358	4941577.94436
Istria Sinoe South	Romania	643388.65069	4941381.45097
Lejai	Romania	687423.01778	4972954.14251
Lipovenilor	Romania	669025.58000	4981729.66000
Litcov Ceamurlia	Romania	685254.81379	5003062.56644
Lumina Puiu	Romania	697001.48000	4999967.92000
Mahmudia SE	Romania	666274.37000	4995084.97000
Marcova	Romania	693999.02000	5003559.99000
Martinca	Romania	661301.67783	5012074.10566
Mila 23	Romania	682474.58402	5012125.28063
Murighiol South	Romania	668408.54025	4990766.40788
Nebunu	Romania	656471.92459	5015948.63961
Nisipos	Romania	654795.86000	5011274.90000
Obretinu Mic	Romania	679813.56992	5006205.86725
Olguta	Romania	670759.38044	5012555.23002
Olguta canal	Romania	671013.67000	5011421.94000
Olguta-Ligheanca	Romania	673017.15000	5012036.66000
Parches	Romania	625859.90089	5011482.13649
Parches SE	Romania	631248.64000	5008724.31000
Plopu	Romania	666540.79368	4989274.60541
Potocava	Romania	675130.05000	5003385.73000

Name	Country	X-coord	Y-coord
Puiu 1	Romania	696793.00000	4995738.72000
Puiu 2	Romania	696902.20000	4995947.20000
Puiu 3	Romania	696753.29000	4996135.82000
Puiu 4	Romania	696256.90000	4995728.79000
Purcelu	Romania	648516.39000	5011776.15000
Razim NE	Romania	661155.58000	4979946.55000
Razim South	Romania	659320.61260	4958531.26388
Rotund	Romania	619817.05000	5011138.60000
Rusca Balteni	Romania	650573.97000	5007175.45000
Sachalin Roh	Romania	697933.57230	4963089.96362
Sachalin South	Romania	696474.77478	4963085.52663
Sf Gheorghe South	Romania	706866.47602	4973185.20635
Sf Gheorghe Tataru	Romania	706023.95328	4977208.46876
Sinoe E of town	Romania	643497.12000	4945870.83000
Sinoe North	Romania	653936.94982	4949035.60438
Sinoe North mainland	Romania	655125.04000	4950553.56000
Sinoe SE island	Romania	654477.87000	4948904.03000
Somova	Romania	629365.23000	5010874.87000
South Canal Mustaca	Romania	662853.65000	4973500.42000
Sulimanca	Romania	693632.40000	5028319.90000
Sulimanca Canal	Romania	695069.26732	5025769.59000
Tataru Canal	Romania	706500.69000	4987176.05000
Tataru lake	Romania	706059.80000	4992709.82000
Tulcea NW	Romania	636608.17000	5010543.82000
Turceasca	Romania	704902.96987	4970014.84884
Turceasca East	Romania	705490.12060	4970771.27871
Turceasca SE	Romania	706489.87000	4970825.26000
Vadanei	Romania	707295.67899	4987208.42673
Vadu North	Romania	639438.44305	4924742.70864
Vadu South	Romania	639527.87979	4924598.24422
Zatonu Mare	Romania	686690.28000	4967474.87000
Zatonu Mic	Romania	688560.10000	4967599.53000
Zebil	Romania	637076.51000	4980573.52000
Anakin Kut	Ukraine	714338.83000	5019207.84000
Anchulidnov North	Ukraine	716636.03000	5033031.46000
Chitai mid-W	Ukraine	671499.71000	5053740.21000
Chitai NE	Ukraine	672389.71000	5058546.26000
Chitai SE	Ukraine	669601.02000	5041784.41000
Danube Kugurluy Canal	Ukraine	628067.24000	5014134.78000
Izmail National Park 1	Ukraine	661768.93000	5028345.27000
Izmail National Park 2	Ukraine	660908.59000	5027722.26000
Izmail National Park 3	Ukraine	655746.54000	5024488.56000
Izmail National Park 4	Ukraine	654826.86000	5024369.89000
Kagu SE	Ukraine	609881.38000	5022026.20000
Kagu W	Ukraine	602998.64000	5033685.33000
Kartal	Ukraine	620175.82000	5019356.17000
Katlapug E	Ukraine	660344.92000	5039173.72000
Katlapug SW	Ukraine	653343.51000	5027366.26000
Kugurluy SE 1	Ukraine	638421.02000	5021136.19000
Kugurluy SE 2	Ukraine	638539.68000	5020335.18000
Kugurluy SE 3	Ukraine	636166.33000	5018733.16000
Kugurluy SE 4	Ukraine	634860.98000	5019771.51000
Kugurluy SW 1	Ukraine	626346.55000	5016122.47000

Name	Country	X-coord	Y-coord
Kugurluy SW 2	Ukraine	625634.55000	5015914.80000
Kugurluy SW 3	Ukraine	625337.88000	5016270.81000
Kugurluy SW 4	Ukraine	626435.55000	5020513.18000
Kugurluy SW 5	Ukraine	625960.88000	5021343.86000
Kurilski	Ukraine	712619.71000	5012005.49000
Kurilskiye Melkovodiya	Ukraine	713003.82000	5011049.42000
Lebednika	Ukraine	713730.08000	5010332.38000
Limba	Ukraine	711025.13000	5014995.34000
Malaya Novaya Zemlya	Ukraine	717628.93000	5024081.72000
Novaya Zemlya	Ukraine	717619.03000	5008389.92000
Potapovskaya	Ukraine	714950.10000	5036953.54000
Sasikskaya Peresip	Ukraine	707752.76000	5048607.82000
Sasyk NW	Ukraine	705587.07000	5079698.82000
Solonchaky	Ukraine	705201.40000	5045522.45000
Stentsovsko Zhebriansky Plavni 1	Ukraine	696299.30000	5043123.91000
Stentsovsko Zhebriansky Plavni 2	Ukraine	694333.02000	5044829.47000
Stentsovsko Zhebriansky Plavni 3	Ukraine	695158.64000	5045052.17000
Stentsovsko Zhebriansky Plavni 4	Ukraine	701039.69000	5049156.07000
Stentsovsko Zhebriansky Plavni 5	Ukraine	699684.32000	5047330.47000
Stentsovsko Zhebriansky Plavni 6	Ukraine	697831.07000	5046113.41000
Stentsovsko Zhebriansky Plavni 7	Ukraine	693350.07000	5045698.50000
Stentsovsko Zhebriansky Plavni 8	Ukraine	694262.86000	5046915.57000
Stentsovsko Zhebriansky Plavni North Mirnoye	Ukraine	693601.61000	5051366.85000
Ziganka	Ukraine	712747.01000	5011836.71000

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